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Macroeconomic stabilization in the digital age

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Contents

Tables and Figures

Tables

Figures

Abbreviations

AIC	Akaike information criterion
ASEAN	Association of Southeast Asian Nations
AUROC	Area Under the Receiver Operating Characteristic
BBVA	Banco Bilbao Vizcaya Argentaria
BIS	Bank for International Settlements
BVAR	Bayesian vector autoregression
CBCD	central bank digital currency
CBS-IC	Consolidated Banking Statistics- Intermediate Counterparty
CBS-UR	Consolidated Banking Statistics-Ultimate Risk
CCAF	Cambridge Centre for Alternative Finance
CFM	capital flow management measure
CGD	central government debt
COVID-19	coronavirus disease
CPI	consumer price index
CRML	Center for Risk Management
DC/EP	digital currency/electronic payment
DIC	deviance information criteria
DTCC	Depository Trust & Clearing Corporation
ECB	European Central Bank
EME	emerging market economy
EPU	economic policy uncertainty
ERPT	exchange rate pass-through
FDI	foreign direct investment
FEVD	forecast error variance decomposition
FX	foreign currency
G&NFS	goods and non-factor services
GDE	gross domestic expenditure
GDP	gross domestic product
GFC	global financial crisis
GFCF	gross fixed capital formation
GFE	final government expenditure
GMM	generalized method of moments
GST	goods and services tax
GVC	global value chain
ICO	initial coin offering
IIP	index of industrial production
IMF	International Monetary Fund

IPU	India policy uncertainty
IT	information technology
MVA	market value of assets
NBER	National Bureau for Economic Research
NFX	net foreign currency
OECD	Organisation for Economic Co-operation and Development
PBC	People's Bank of China
PFPE	private final personal expenditure
PPD	Paipaidai
PPP	purchasing power parity
PRC	People's Republic of China
P2P	peer-to-peer
PwC	PriceWaterhouse Coopers
RECS	retail electronic clearing service
RER	real exchange rate
RTGS	real-time gross settlement
SAS	safe asset shortage
SFA	stochastic frontier analysis
SMEs	small and medium-sized enterprises
SNA	System of National Accounts
SOE	small open economy
SPF	survey of professional forecasters
SWF	sovereign wealth fund
UK	United Kingdom
US	United States
VAR	standard vector autoregressive
VaR	value at risk
VAT	value-added tax
VIX	implied volatility index

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1

Introduction

John Beirne and David G. Fernandez

The rise of the digital age has created challenges for macroeconomic policy makers around the globe. Early work on this issue by Cecchetti (2006) noted that macroeconomic management becomes more complex in an environment of digitalization given shifting trend productivity and difficulties in estimating potential output. For emerging market economies (EMEs), these policy challenges have been exacerbated by the digital finance revolution in the aftermath of the global financial crisis, and the COVID-19 pandemic, i.e., when many EMEs experienced large and volatile capital flows. Innovations related to payments systems, maturity transformation, and the allocation of capital can hinder macroeconomic stabilization to the extent that they disrupt the efficacy of policy tools used to manage the economy. This book provides an overview of the main issues facing policy makers in the digital age, which was also the focus of the "Macroeconomic Stabilization in the Digital Age"[1] conference that brought together experts from academia, international organizations, think tanks, and central banks. The book is organized into three main areas: 1) digital finance and the macroeconomy; 2) capital flows and systemic risk in the digital age; and 3) macroeconomic uncertainty and new challenges for central banks.

Part I of the book is set against the context that advances in digital finance have led to a shift in financial intermediation away from traditional banks, with large technology firms increasingly providing financial services over the past decade. In addition, the involvement of so-called nonbanks in liquidity transformation and leveraged lending creates systemic financial vulnerabilities, and opportunities for regulatory arbitrage (BIS 2019). These vulnerabilities are amplified given the interconnectedness of nonbanks with the traditional banking

1 The conference on "Macroeconomic Stabilization in the Digital Age", was jointly organized by the Asian Development Bank Institute and the Sim Kee Boon Institute for Financial Economics at Singapore Management University, on 16–17 October 2019, in Singapore.

sector. Furthermore, competition by the traditional banking sector for deposits and funding may lead to excessive risk taking. Therefore, while the ongoing diffusion of digital finance into financial intermediation can spur economic activity and promote financial inclusion, it can lead to rising financial fragility and systemic risk.

Part I comprises five chapters. Chapter 2 provides an overview of macroeconomic challenges and resilience of EMEs in the 21st century. The enhanced use of countercyclical macroeconomic and macroprudential policies by EMEs is highlighted, as well as the challenges and opportunities posed by exposure to financial technology (fintech). In particular, while the adoption of fintech can help EMEs engage in financial intermediation at faster rates across a wider coverage of the economy, policy makers need to be aware of the potential risks to financial stability from the transfer of financial services from regulated banks to shadow banks. Chapter 3 presents a framework for assessing the macroeconomics of de-cashing, where paper currency is replaced with convertible deposits. The analysis indicates that the overall effect should stimulate output growth due to reduced transaction costs, a widening of the tax base, and an improved monetary policy transmission mechanism. Chapter 4 focuses on the implications of digital transformation on financial stability, payment systems, and macroeconomic stability, and discusses the need for changes in regulatory and macroeconomic policies to mitigate the associated risks. It is noted that digital transformation has significant implications for macroeconomic stability due to the resulting increased interconnectedness via regional and global production chains. Chapter 5 examines the macroeconomic implications of fintech development in the People's Republic of China (PRC), where the shift to digital finance has taken place at an extraordinary pace in recent years. In particular, this chapter highlights the need for macroeconomic and macroprudential policies in the PRC to embrace digital technology more directly, particularly in areas related to regulation. While fintech has improved the efficiency of PRC financial services, the sector remains in an early stage of development. Financial regulation, risk management, and controls, such as big data-based credit scoring models, also still need time to develop further. Chapter 6 provides an empirical analysis of the relationship between digital finance and economic growth in India from April 2005 to May 2019. The chapter uses a Bayesian vector autoregression to show that advances in digital payments systems in India have contributed to the development of its financial sector and enhance efficiency, with positive spillovers to economic growth.

Part II focuses on capital flow-related developments in the digital age, and issues pertaining to EMEs having had to deal with large and volatile capital flows in the post-global financial crisis period. While these flows can have substantial benefits for economies in terms of growth and development, they can also pose risks to macroeconomic stability if not properly managed (ECB 2016). Where capital inflows lead to an increased volatility of domestic consumption, currency and maturity mismatches, as well as boom and/or bust cycles in asset prices, achieving macroeconomic stability can be difficult. In such an environment, new approaches to capital flow management and improving resilience to capital flow shocks become ever more important. The onset and growth of fintech and its implications for cross-border capital flows is an issue warranting consideration in this context. On the one hand, reductions in cross-border transaction costs via digital platforms has helped to improve the efficiency of global value chains (McKinsey Global Institute 2019). However, the expansion in cross-border capital flow channels in the digital age places additional challenges on EME authorities in managing capital flows, with potentially a greater exposure to monetary policy spillovers and negative externalities (Prasad 2018).

Part II comprises four chapters. Chapter 7 uses three empirical techniques from the late 1990s to 2014 to show that as financial systems become ever more digital, the impact of banking integration on commercial banks in East Asia has strong benefits in terms of enhancing cost efficiency and reducing default risks. Moreover, in crisis times, the chapter indicates that regional claims in East Asia compensate for reduced deposits, thereby supporting overall macroeconomic and financial stability, and underscoring the importance of regional integration in the digital age. Chapter 8 examines the empirical relationship between fintech and systemic risk using a conditional value-at-risk framework. Using a unique sample of 75 fintech companies quoted on the Nasdaq and Frankfurt stock exchanges from January 2010 to December 2017, Chapter 8 shows that while fintech solutions lead to increased interconnectedness of financial sectors, they also promote greater competition, mitigating negative spillover risks at the systemic level.

Further in Part II, Chapter 9 empirically examines the relationship between safe assets and financial stability, using a newly constructed index of safe assets from 1970 to 2017 across 17 developed economies. The findings indicate that safe asset shortages exacerbate financial stability risks via private sector credit growth implications. In addition, it is shown that a private credit growth boom that derives from safe asset shortages is a significant early warning indicator for crisis events. This chapter has important policy implications related to the need for a coordinated approach to fiscal and macroprudential policy in order to minimize the financial market reaction to a negative fiscal shock. Chapter 10 develops a new high-frequency dataset of capital flow management measures for the Asia and Pacific region, and empirically examines the motivation for their use across macroeconomic stabilization, financial stability, capital flow, and exchange rate objectives. The chapter is set against the context of ongoing and rapid enhancements in fintech development that have resulted in a cheaper, faster, and more decentralized transmission of capital abroad. Overall, the chapter finds that capital flow management and exchange rate objectives appear to be strong predictors of net inflow, easing and tightening measures, while macroeconomic stabilization is an additional driver of tightening measures.

Part III relates the digital age to challenges faced by central banks and the implications of digitalization for the monetary policy transmission mechanism. The emergence of private decentralized cryptocurrencies erodes the ability of central banks to affect the money supply. This has led to global discussions by central banks on whether they should issue their own digital currencies (BIS 2018). While the scale of private cryptocurrencies is at the moment not at a level that would detrimentally affect macroeconomic stability and the conduct of monetary policy, there still remain questions as to how a central bank digital currency (CBDC) would affect traditional bank operations (particularly in times of financial crisis). Academic research indicates that a CBDC would enhance the effectiveness of monetary policy to the extent that these currencies bear interest (Bordo and Levin 2017). The joint Asian Development Bank Institute and Sim Kee Boon Institute for Financial Economics at Singapore Management University October 2019 conference delved further into these issues, with discussions indicating that macroeconomic stability is enhanced when a CBDC bears an adjustable interest and that exchange rate fluctuations are more stable in this environment. This latter point is particularly important for EMEs' central banks that may be subject to bouts of capital flow and exchange rate volatility.

Part III comprises three chapters. Chapter 11 constructs a macroeconomic uncertainty index for India that rises during recessions and in the midst of structural changes such as demonetization, which in India boosted the shift to digital payment systems. Managing macroeconomic uncertainty, particularly in the digital age, is one of the main challenges faced by monetary policy makers, with uncertainty being one of the key drivers of fluctuations in business cycles. Using a vector autoregression approach from 2008 to 2018, this chapter shows how macroeconomic activity responds to uncertainty shocks, such as those linked to demonetization. Chapter 12 assesses the implications of fintech development for the monetary policy transmission mechanism. Using a sample of 25 developed economies from 2001 to 2018 (quarterly frequency), the chapter finds that internet and mobile technologies, as well as the emergence of Bitcoin, significantly affect the money demand equation of the central bank. Moreover, the analysis indicates that in the post-fintech era (2009 to 2018), monetary policy is not a statistically significant determinant of the output gap, thus raising concerns about its effectiveness in the digital age. Chapter 13 examines foreign currency exposures in the Asia and Pacific region, indicating that the financial channel of exchange rates may be eroding the effectiveness of monetary policy in the digital age. In particular, for a panel of 10 Asian economies from 2002 to 2012, it is shown that there are trade-offs for policy makers between financial stability and macroeconomic stabilization, which gives rise to a fear of floating. This fear of floating is notably more pronounced in the presence of foreign currency exposures.

Overall, this book provides several insights for policy makers and, indirectly, for private sector financial technology participants who face regulatory risk. Policy makers need to be aware of the increasing prominence of the digital economy and digital finance, and seek to better understand how continued digitalization will affect policies aimed at managing the economy. In particular, the effect of traditional fiscal and monetary policies for stabilization purposes may be less potent in an era of ongoing digitalization. This calls for national authorities to be vigilant of the effects of digital transformation, and to devise and implement additional targeted policies to aid stabilization, e.g., aimed at the nonbank sector. Finally, international policy co-ordination becomes increasingly important in such an environment.

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PART I

Digital Finance and the Macroeconomy

2

Macroeconomic Challenges and the Resilience of Emerging Market Economies in the 21st Century

Joshua Aizenman

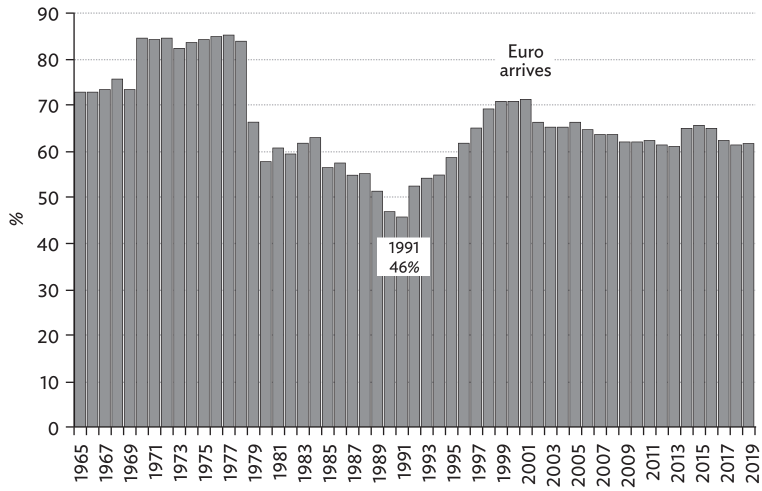
2.1 Overview and Summary

This chapter takes stock of the recent challenges facing emerging market economies (EMEs) in the post-global financial crisis environment. The confluence of four key developments shaped the pre-global financial crisis environment.

First, financial globalization and deregulation, a process that started in the late 1970s in the Organisation for Economic Co-operation and Development (OECD) countries and continued in the EMEs in the 1990s–2000s transformed the global financial system into a complex web of global networks, exposing countries to financial shocks that volatile bursts of capital inflows and outflows of "hot money" transmitted.

Second, despite the emergence of the euro area and the People's Republic of China (PRC) as large hubs of economic activity approaching the real size of the United States (US), the US dollar has retained and even increased its global financial dominance. Somehow paradoxically, a crisis that started in the US in 2007–2008 ended up solidifying and even deepening the global dominance of the US dollar. Remarkably, as the global real gross domestic product (GDP) share of EMEs approached half the total (adjusted for purchasing power parity [PPP] issues) and the US share declined to one-fifth and below, the US dollar's global importance approached two-thirds

Figure 2.1: US Dollar Share of Global International Reserves



US = United States.

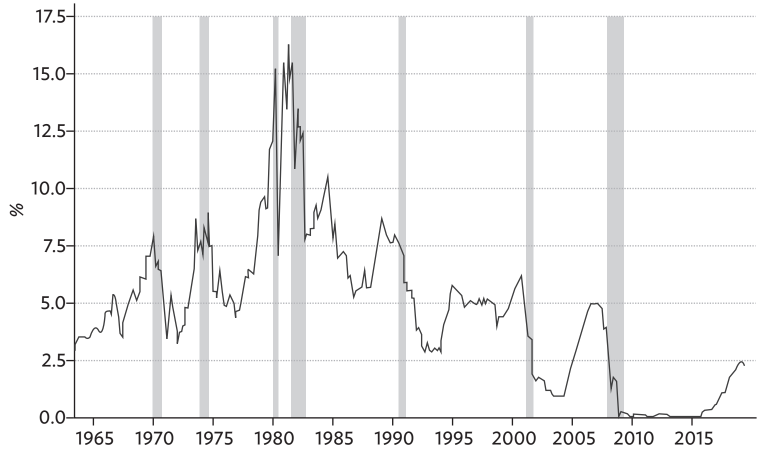
Source: IMF WOLFSTREET.com. https://wolfstreet.com/2018/12/31/us-dollars-status-as-global-reserve-currency/ (accessed 17 August 2020).

in 2019.[1] Figure 2.1 reports the US dollar share of official reserves, showing vividly the drop following the end of the Bretton Woods system from about 85% in the early 1970s to about 46% in 1991, then reversing, reaching about 70% at the creation of the euro area, 1999, and then gently sliding to 62% by 2019.

Third, the quantitative easing policies that followed the global financial crisis and the euro area crisis pushed the nominal policy interest rate of most OECD countries toward the zero lower bound and some below zero. In tandem, the "risk-free" real interest rate maintained its secular trend toward zero and below. This trend started in the mid-1980s, and the 3-month interest rate in the US and Germany during 2009–2019 exemplifies it well (Figures 2.2a and 2.2b). In 2019, more than one-fourth of global bonds offered a negative yield (Figure 2.2c). These developments induced spells of "search for yield," exposing the EMEs to

1 Countries making up 70% of the global GDP use the US dollar as an anchor currency, and about half of global trade is invoiced in dollars. As of March 2018, 73.5% of the international credit to nonresidents was US dollar denominated, followed by 24% that was euro denominated (BIS 2018; Carney 2019).

Figure 2.2a: 3-Month Interest Rate for US Treasury Bill

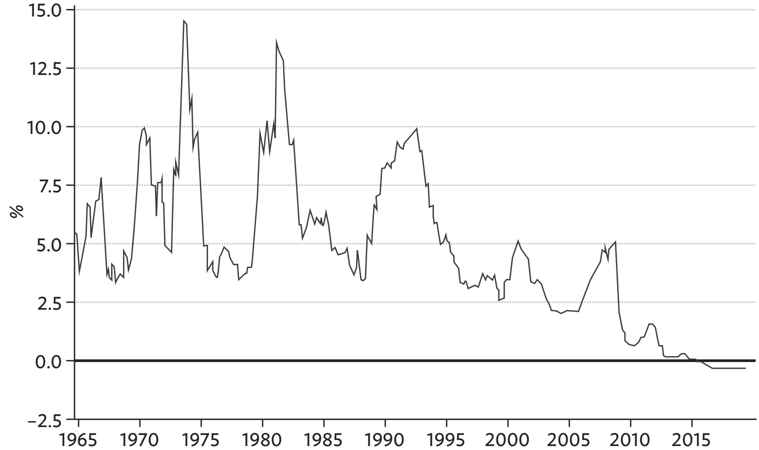


US = United States.

Note: Shaded areas indicate US recessions.

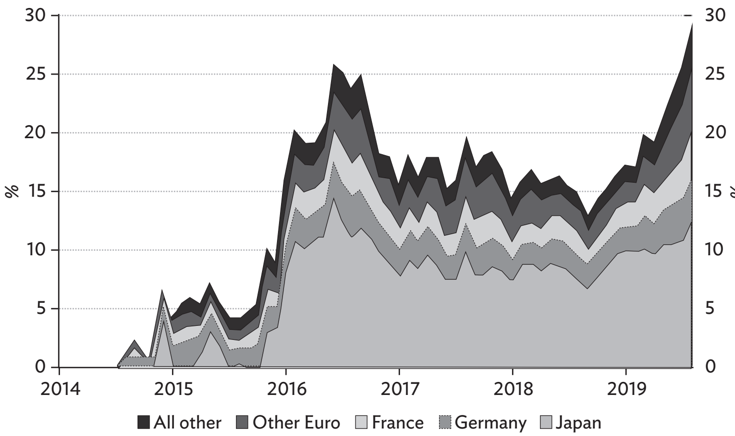
Source: Board of Governors of the Federal Reserve System (US).

Figure 2.2b: 90-Day Interest Rates for Germany



Source: Organisation for Economic Co-operation and Development.

Figure 2.2c: Global Share of Negative Yielding Debt



Source: Bloomberg, Goldman Sachs Global Investment Research.

large and volatile financial flows and later increasing the OECD demand for local currency debt in most emerging markets, as well as application of macroprudential tools, aiming for greater financial stability.

Finally, the acceleration of financial innovations' integration with the information technology revolution (fintech) and the growing globalization of finance imposed new and escalating challenges for regulators aiming to stabilize the formal economy and fight the black and informal economy.

These developments validated the precautionary policies that EMEs adopted after the wave of sudden stop crises in the 1990s, but also brought new policies to the fore and increased their willingness to experiment with new defensive measures. Below is a summary of the main points that this chapter advances:

(i) EMEs increased the use of inflation targeting, a regime that has shown its resilience over the past 20 years. By 2018, 23 countries used inflation targeting de jure, 18 of which had adopted it by 2002. About half of these countries are EMEs. With the European Central Bank (ECB), the number of countries living with their currency following inflation targeting is much larger. In addition, a growing number of countries are de facto following a hybrid version of inflation targeting. A significant share of EMEs under inflation targeting, dominated by commodity countries, adjust the policy interest rate as part of a broader policy with real exchange rate (RER) management. Under these circumstances, the RER and international reserve changes also affect the policy interest rate.

(ii) Inflation targeting works well with independent central banks, yet fiscal dominance concerns may hinder the efficacy. This suggests experimenting with the integration of monetary rules—like inflation targeting—with fiscal rules, possibly linking these rules with the operations of buffers like international reserves and sovereign wealth funds (SWFs). The global financial crisis validated the benefits of counter-cyclical management of international reserves and SWFs in the context of stabilizing the RER. Buffer policies may also benefit from applying macroprudential regulations that manage the balance sheet exposure of the financial system to foreign currency debt and the risk of sudden stops and capital flight.

(iii) A growing share of EMEs are experimenting with fintech as part of their adaptation to the information technology revolution. The growing fintech diffusion is profoundly changing the use of cash and transfer payments and the nature of financial intermediation. Fintech's major impact has been the massive scaling up and consolidation of financial services, approaching the "winner takes (almost) all" syndrome. In principle, national borders do not bound the scaling dynamics associated with fintech. Nevertheless, the nation states may, at a cost, limit this scaling.

(iv) The fintech revolution imposes growing pressure on traditional banks, providing consumers with the promise of cheaper and faster financial services. However, it may also undermine monetary policy and reduce the tax base. Finding the proper regulatory response to fintech's impact on monetary policy transmission and on the tax base is a work in progress. While a nation state may focus on financial stability and its tax base, the fintech sector is mostly aiming for rent maximization, overlooking possible adverse externalities associated with its activities. Thereby, we may witness an accelerated arms race between the state and the fintech sector.

(v) An example of these forces is the advance of cryptocurrencies, promising anonymized financial intermediation. In contrast to the success of inflation-targeting regimes, there is no feasible path toward stability for a decentralized currency. This instability reflects "the tragedy of the commons" associated with cryptocurrencies—the public good aspect of stable valuation conflicts with the possible interests of "whales" (the large holders of the currency that may benefit from endogenous volatility). The chances are that most nation states will aim to contain these activities to a small-scale niche of finance. The nation state may ignore niche financial innovations but will regulate or even "nationalize" them once their size and instability become a systemic threat. Thereby, efficient scalability of a successful decentralized currency will survive as long as the private sector coordinates its policies with the nation state. States may opt to follow a dual goal of encouraging the diffusion of efficient financial intermediation in ways that benefit consumers and simultaneously augment the government's control while restricting anonymized exchange and global monies in ways that minimize the threat of a shrinking tax base and the state's ability to control financial intermediation.

2.2 Emerging Markets in the Past Decades—A Brave New World?

The short history of macroeconomics during the 21st century is a humbling experience to policy makers, scholars, and practitioners. Lucas (2003) summarized the buoyant assessment of the state of macroeconomics in his American Economic Association address, Macroeconomic Priorities: "Macroeconomics in this original sense has succeeded: Its central problem of depression prevention has been solved, for all practical purposes, and has in fact been solved for many decades. ... The potential gains from improved stabilization policies are on the order of hundredths of a percent of consumption."

At the dawn of the 21st century, a growing share of economists credited the US Federal Reserve (the Fed) with contributing to the "Great Moderation" associated with the large decline in the volatility of key macroeconomic indicators and lower risk premia. The Great Moderation period mostly overlapped the tenure of Alan Greenspan, who headed the Fed from 1987 to 2006. His views gained prominence and captured well the zeitgeist of the late 1990s and early 2000s—growing optimism about the stabilizing effect of market forces and the ability of the Fed to deal with adverse tail risk events, the importance of financial liberalization, and the view of regulations as cumbersome and ineffective: "As we move into a new century, the market-stabilizing private regulatory force should gradually displace many cumbersome, increasingly ineffective government structures" (Greenspan, 1997). Governor Ben Bernanke, the

Fed chairperson who replaced Alan Greenspan from 2006, attributed the Great Moderation to improved monetary policy in 2004, including the adaptation of the Taylor rule.[2]

Notable exceptions to these buoyant views included Shiller (2005), warning in the early 2000s that the bubble dynamics had migrated from the "dot com" technology sector in the late 1990s to the housing market. Rajan (2005) asserted that growing endogenous exposure to undervalued tail risk developments in the financial sector led to an expansion of its ability to spread risks, thereby creating much greater access to finance for firms and households. Rajan attributed this to the emergence of a whole range of intermediaries ("shadow banking"), the size and appetite for risk of which may expand over the business cycle. These intermediaries can also leave themselves exposed to certain small probability risks that their own collective behavior makes more likely. Applying principal–agent arguments and distance-from-default analysis, Rajan attributed these trends to the financial liberalization and banking deregulation processes that took off from the 1980s, concluding that the US economy became more exposed to financial sector-induced turmoil than in the past.

The global financial crisis validated Rajan's 2005 conjectures, challenging Greenspan's assertion that bubbles are impossible to detect in advance, and easier to clean after.[3] Specifically, Jordà, Schularick, and Taylor (2015) concluded that history has shown that not all bubbles are alike. Some have enormous costs for the economy, while others blow over. They also demonstrated that what makes some bubbles more dangerous than others is credit. When credit booms fuel asset price bubbles, they increase financial crisis risks; upon collapse, deeper recessions and slower recoveries tend to follow. Credit-financed housing price bubbles have emerged as a particularly dangerous phenomenon. They also showed that runaway credit growth increases the odds of reaching

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2 "The finding that monetary policymakers violated the Taylor principle during the 1970s but satisfied the principle in the past two decades would be consistent with a reduced incidence of destabilizing expectational shocks." … "The Great Moderation, the substantial decline in macroeconomic volatility over the past twenty years, is a striking economic development. … I have argued today that improved monetary policy has likely made an important contribution not only to the reduced volatility of inflation (which is not particularly controversial) but to the reduced volatility of output as well" (Bernanke, 2004).

3 "It was very difficult to definitively identify a bubble until after the fact—that is, when its bursting confirmed its existence. Moreover, it was far from obvious that bubbles, even if identified early, could be preempted short of the central bank inducing a substantial contraction in economic activity—the very outcome we would be seeking to avoid" (Greenspan 2002).

the zone of costly financial instability. The global financial crisis and the subsequent euro area crisis were watershed events, shifting the policy and research focus vis-à-vis the search for strategies that better fit the era of heightened volatility and interest rates approaching the zero boundary, as well as the growing threat of secular stagnation. The outcome has been a richer application of principal–agent, asymmetric information, behavioral, and other approaches.[4] This chapter focuses on the current debates dealing with recent developments, occasionally in the context of these past macro contributions.

2.3 Emerging Markets' Trilemma Choices: From Fixed Exchange Rate and Financial Autarky to Inflation Targeting and Managed Financial Integration, Buffered by Reserve and Macroprudential Regulations

The 1960s and 1970s induced profound changes: the collapse of the Bretton Woods regime reflected the recovery of Western Europe from World War II and the search for a global order that fit the aspirations of the core of Europe better. The greater exchange rate flexibility of key currencies and the acceleration of financial liberalization put new forces in motion. The remarkable recovery of Japan after World War II provided a vivid example of export-led economic takeoff, a process that, with a lag, inspired the takeoff of the Republic of Korea, the PRC, and more than a dozen other countries forming the block of EMEs. Within 50 years, the EMEs became the hub of global growth, increasing their global GDP share toward half of the total and above (adjusted by PPP). Remarkably, in the early 1990s, the EMEs opted to embrace greater financial integration, a trend that Mexico, in the aftermath of the North American Free Trade Agreement, illustrated, as well as the Republic of Korea, Thailand, and others. This came at the end of the lost decade of the 1980s, a time when most EMEs experienced exposure to the debt overhang crises that excessive borrowing in the 1970s generated,

4 Stiglitz and Tirole were among the earlier contributors in this domain, although policy makers in the late 1990s and early 2000s mostly overlooked them. There has also been growing recognition of the need to refresh past macro-paradigms, including Mundell–Fleming's trilemma, Triffin's paradox, the zero lower boundary challenges, the paradox of thrift, the redundancy problem (aka the n − 1 problem), the inequality of the number of policy instruments and the number of targets at the international level, which Mundell (1969) suggested, an example of Tinbergen's 1952 analysis of targets and instruments, and other mostly overlooked concepts.

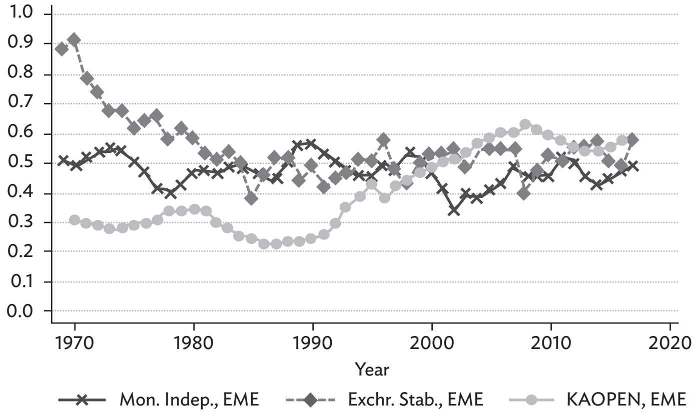
funded by recycling the petro-dollar that the quadrupling of the price of oil generated in the early 1970s. The renewed hard currency borrowing of EMEs in the early 1990s, still mostly operating under a fixed exchange rate, promoted a brief "honeymoon", with upbeat assessments of Mexico, the Republic of Korea, and other EMEs. These developments, however, set the stage for new types of banking and balance of payment crises.

Mexico's history illustrated the hazard of EMEs' attempts to keep pegging their currency at times of greater financial integration while maintaining a proactive monetary policy. Simply put, this configuration contradicted the Mundell–Fleming trilemma, putting in motion forces that induced the fully blown Tequila Crisis of December 1994. Intriguingly, Mexico adopted a flexible exchange rate regime after the crisis, while increasing its financial integration over time. The crisis also came at a time when people viewed the choice of deeper financial integration as a way to encourage the continuation of foreign direct investment inflows into Mexico that the North American Free Trade Agreement triggered, viewing this trend as the key to Mexico's future. The Mexican crisis of 1994 turned out to be the first in a wave of more than a dozen similar crises, the most notable being the East Asian, the Russian Federation's, and the Brazilian crises during the second half of the 1990s (Eichengreen 2019b).

A common script of the dynamics leading to these crises was greater external borrowing in hard currencies that greater financial integration induced, an economic boom inducing RER appreciation, and current account deterioration pressures. Incipient capital flight that concerns about dwindling international reserves triggered frequently terminated the ensuing economic boom within several years. Calvo (1998) dubbed these crises "sudden stop crises," in which the sudden stopping of external funding induces exchange rate, balance of payment, and banking crises. Most of the affected countries followed a similar adjustment, moving over time toward the middle ground of the Mundell–Fleming trilemma: controlled exchange rate flexibility, growing but controlled financial openness, and viable though limited monetary independence, which hoarding and managing growing buffers of international reserves supported (Figure 2.3).

This trend also reflected the recognition that flexible exchange rates among key global currencies in the post-Bretton Woods world (US dollar, German mark, British pound, Japanese yen) expose EMEs to greater exchange rate flexibility, since pegging to one of these currencies implies floating against the others. The sudden stop crises also induced precautionary hoarding of international reserves, and EMEs tripled their international reserves/GDP in a decade, from

Figure 2.3: EMEs' Convergence to the Trilemma Middle Ground



EME = emerging market economy, KAOPEN = Chinn-Ito index; an index measuring a country's degree of capital account openness.

Sources: Adapted from http://web.pdx.edu/~ito/trilemma_indexes.htm; see the overview in Aizenman (2019b).

about 8% in the early 1990s to about 30% in the early 2000s (Aizenman and Lee 2007). This trend was more pronounced in countries in East Asia with a high savings rate, which "precautionary motives" that aimed at reducing the probability and the damage of sudden stop crises induced. Arguably, some of this trend also reflected "mercantilism"—the proactive policy of delaying the real appreciation associated with a successful manufacturing export-led growth strategy, which the PRC exemplifies. Observers also noted the possibility of affected countries carrying out competitive hoarding, aiming to protect market shares, and "keeping up with the Joneses" dynamics (Cheung and Qian 2009). The empirical research that Aizenman (2019b) overviewed validated the emergence of a continuous version of the trilemma, in which most EMEs converged to its middle ground. However, it modified the original trilemma in several other important ways.

First, financial stability was added as a key policy goal, morphing the trilemma into a possible quadrilemma. While financial stability was an implicit goal during the Bretton Woods system, the tight controls of capital flows (mostly prohibited, with few exceptions needing the state's approval) implied limited exposure to financial fragility due to external factors. The overall tight regulation of banks, an outcome of the Great Depression, limited domestic banks' leverage and risk taking, taming exposure to domestic financial fragility. The sudden stop crises of the 1990s vividly illustrated the cost of greater financial integration and hard currency external borrowing in the form of growing susceptibility to capital flight crises associated with real depreciations, inducing sharp increases in the real cost of serving the external hard-currency debt, a destabilized domestic banking system, and occasional costly sovereign defaults, banking crises, and restructuring.

Second, the increasing global share of the GDP coming from the euro area and EMEs, along with the global financial crisis and subsequent euro area crisis, led to the paradoxical trend of increasing the global role of the US dollar as the dominant currency for invoicing international trade, supplying about two-thirds of international reserves and the deepest and most liquid market of "safe assets," all at a time when the global GDP share of the US declined and reached parity with that of the euro area and the PRC (adjustment by PPP). These developments and the global financial crisis led Rey (2013) to conjecture that the trilemma had morphed into a dilemma over the past decades. Specifically, independently of exchange rate regime choices, countries adopting open capital markets experience exposure to the global financial cycle, a cycle that US monetary and financial policies dominate, substantially weakening their monetary independence. The only effective way to regain monetary independence in Rey's dilemma is to shut down financial integration, control private flows heavily, and prohibit flows that countries deem to be too destabilizing.

The ongoing debate propagated by the dilemma conjecture outlined several challenges to Rey's view. While the financial importance of the US dollar and US monetary policies increased, exchange rate regimes still mattered in the presence of balance sheet exposure associated with external borrowing in hard currency. With proper management of financial policies, exchange rate flexibility provides greater monetary autonomy at the margin, though the GFC and the changing conduct of monetary policies amidst the challenges of quantitative easing and policy interest rates approaching the zero lower bound have affected the actual trilemma trade-offs, thereby increasing the global importance of the US financial and real cycles. Taking this perspective, Aizenman, Chinn, and Ito (2016) investigated how the movements in the central economies—the US, Japan, the euro area, and the PRC—affect the trilemma choices and financial conditions of developing countries and EMEs (dubbed peripheral countries). In the 2000s–2010s, the strength of the links with the central economies were the dominant factor. The movements of the policy interest rate also appear to have been sensitive to global financial shocks around the EME crises of the late 1990s and since the global financial crisis. Research has found that the exchange rate regime and financial openness have a direct influence on the sensitivity to the central economies. The weights of major currencies, external debt, and currency debt compositions are significant factors.[5]

Klein and Shambaugh's insightful 2015 analysis concerned whether partial capital controls and limited exchange rate flexibility allow for full monetary policy autonomy. They found that partial capital controls do not generally allow for greater monetary control than open capital accounts unless the capital controls are quite extensive. However, a moderate amount of exchange rate flexibility does allow for some degree of monetary autonomy, especially in emerging and developing economies. Empirically, they observed that, while some countries have long-standing, pervasive capital controls, a substantial subset of countries uses limited controls on an episodic basis.[6] In this context, Obstfeld, Ostry, and Qureshi (2019) found that countries with fixed exchange rate regimes are more likely to experience financial vulnerabilities—faster domestic credit and house price growth and increases in bank leverage—than those with relatively flexible regimes. The transmission of global financial shocks is likewise magnified under fixed exchange rate regimes relative to more flexible (though not necessarily fully flexible) regimes. The authors attributed this to both reduced monetary policy autonomy and greater sensitivity of capital flows to changes in global conditions under fixed rate regimes.

Among the important developments influencing the conducting of monetary policy has been the emergence of inflation targeting as the new paradigm of monetary policy. The curious history of inflation targeting dates back to New Zealand in the early 1990s, which Archer (2000) reviewed. The emerging inflation targeting regime in New Zealand is based on four pillars: the inflation rate as the medium-term objective for monetary policy; the use of a tightly specified inflation target to implement the medium-term objective; a clear institutional structure and typically an independent central bank; and heavy reliance on transparency to support the inflation targeting arrangement. By 2019,

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5 More specifically, having a greater weight on the dollar (or the euro) makes the response of financial variables more sensitive to a change in key variables in the US (or the euro area, respectively), such as policy interest rates, exchange rate market pressure, and the RER. Thus, the degree of exchange rate flexibility continues to affect the sensitivity of developing countries to policy changes and shocks in the central economies.

6 Their results are in line with Klein (2012), who classified the capital control of these regimes into "walls" and "gates," respectively, and showed that walls are more effective than gates in limiting asset price booms and swings in the value of the RER. In addition, in any given year, there is a wide scope for employing capital controls, generating an extensive middle ground between open and closed capital markets.

23 countries have de jure adopted inflation targeting, of which 18 had adopted it by 2002. More than half of these countries are current (or prior) EMEs. With the ECB following a rule akin to inflation targeting, the number of countries living under a de jure regime is approaching 40.[7] Inflation targeting gained momentum in tandem with the growing popularity and adoption of the Taylor Rule.[8]

This remarkable yet short history of inflation targeting led Rose (2007) to publish "A Stable International Monetary System Emerges: Inflation Targeting is Bretton Woods, Reversed." According to Rose,

> A stable international monetary system has emerged since the early 1990s. A large number of industrial and a growing number of developing countries now have domestic inflation targets administered by independent and transparent central banks. These countries place few restrictions on capital mobility and allow their exchange rates to float. The domestic focus of monetary policy in these countries does not have any obvious international cost. Inflation targeters have lower exchange rate volatility and less frequent 'sudden stops' of capital flows than similar countries that do not target inflation. Inflation targeting countries also do not have current accounts or international reserves that look different from other countries. This system was not planned and does not rely on international coordination. There is no role for a center country, the IMF, or gold. It is durable; in contrast to other monetary regimes, no country has been forced to abandon an inflation-targeting regime. Succinctly, it is the diametric opposite of the post-war system; Bretton Woods, reversed.

This characterization of the successful diffusion of inflation targeting was an insightful snapshot of the state of inflation targeting prior to the global financial crisis. Nevertheless, inflation targeting is not a panacea, and the global financial crisis triggered a debate

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7 The ECB is the Central Bank of 19 countries, with a mission statement of "The primary objective of the ECB's monetary policy is to maintain price stability. The ECB aims at inflation rates of below, but close to, 2% over the medium term." https://www.ecb.europa.eu/mopo/html/index.en.html (accessed 17 September 2020).

8 Taylor's 1993 rule was estimated for the Paul Volcker disinflation, 1984–92, as a linear policy rule adjusting the policy interest rate to the evolving inflation gap and the output gap. A key result of the calibration is that the semi-elasticity of the policy interest rate with respect to inflation shock is about 1.5, significantly above 1 (i.e., the way to deal with an inflationary shock is to increase the real interest rate by about half of the inflationary shock).

about the effectiveness and desirability of the Taylor Rule type. Critiques noted that a growing share of OECD countries, including the US, Japan, and the euro area, are undershooting their targets. This observation, and the collapse of the US policy interest rate toward zero and into the negative domain across several European countries in the aftermath of the GFC, led to the concern that inflation targeting may be too conservative a rule, overlooking the challenges associated with debt deflation and zero boundary concerns. Specifically, Blanchard, Dell'Ariccia, and Mauro (2010) advocated that central banks should announce a higher inflation target, around 4% or 5%, raising the possibility of increasing the target in turbulent times and considering alternative rules like price-level targeting that will compensate periods of inflation below the target with periods of tolerating the overshooting of the target, as well as other ideas (Frankel 2012).

Another concern has been that, in the aftermath of the global financial crisis, a growing share of central banks are losing their independence. Furthermore, some of the de jure inflation targeting countries follow policies that differ sharply from the original "four pillars" New Zealand variety to a degree that the targeted inflation is losing its credibility and relevance, as the country approaches the "collapsing regime" syndrome. Examples of this trend include the recent history of Turkey and Argentina. The case of Turkey illustrates vividly the hazard of losing central bank independence and the de-anchoring of inflation that may follow fiscal dominance.[9] To recall, the distinction between fiscal and monetary dominance regimes is due to Sargent and Wallace (1981). If the government adjusts the primary deficit to limit debt accumulation, it does not force the central bank to inflate away the debt, allowing the central bank to focus on inflation targeting, in line with monetary dominance. Long periods of large fiscal deficits and high public debt-to-GDP ratios have raised concerns over growing fiscal dominance by heightening the links between fiscal policy, monetary policy, and government debt management. This may be the case when higher policy interest rates or depreciating currencies raise concerns about debt sustainability, limiting monetary independence. Possible manifestations of these concerns include the "fear of floating," fiscal pressure to mitigate rises of policy interest rates, financial repression, and the like. The fiscal dominance argument may apply to both hard currency public and private debt (Ahmed, Aizenman, and Jinjarak

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9 As of August 2019, the Turkish central bank stated a target of 5% from 2012. It missed this target significantly, and inflation accelerated non-linearly from 10% in 2012 to 20% in 2018. (Turkish Central Bank 2019).

2019).[10] In the case of large private debt exposure, stabilizing the RER through large sales of international reserves that are necessary to fund the servicing of the private debt may prevent a banking and financial crisis, a crisis that may induce the socialization of private losses, as was the case in Ireland and Spain during the euro area crisis.

Countries facing large net hard-currency external debt face an open economy version of fiscal dominance in the form "fear of floating" (Calvo and Reinhart 2002). Specifically, RER depreciation increases the costs of serving their external debt by the external debt/GDP times the depreciation rate (the cost measured as a fraction of the country's GDP). Under these circumstances, the central bank may put greater weight on stabilizing the RER to reduce the cost of serving the external debt and may limit the increase in the policy interest rate, hoping to delay a recession and adjustment. While this "gambling for resurrection" policy may provide some policy space in the short run, it may backfire over time.

In principle, the successful management of international reserves and the exchange rate in the context of large debt overhang is possible as long as the central bank is committed to following the necessary counter-cyclical buffers and regulatory policy consistently over the business cycle. For example, consider the Central Bank of the Russian Federation's management of its commodity-intensive economy during the period 2000–2019. The Central Bank of Russian Federation hoarded large portions of the hard-currency oil revenue when the Russian Federation's terms of trade improved during the oil price rise prior to the global financial crisis from about $40/barrel in 2000 to about $140/barrel in 2008. It used about one-third of these reserves to stabilize the RER when the price of oil subsequently collapsed. This policy of hoarding reserves for stormy days and selling them at times of collapsing revenue mitigated the Russian Federation's RER's appreciation at times of rising oil prices and probably prevented a full-blown banking and financial crisis in the Russian Federation following the drop in oil prices (Aizenman, Jinjarak, and Zheng 2019).

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10 Ahmed, Aizenman, and Jinjarak (2019) reported that, in EMEs under non-inflation targeting regimes composed mostly of exchange rate targeters, the interest rate effect of higher public debt is non-linear and depends both on the ratio of foreign currency to total public debt and on the ratio of hard-currency debt to GDP. For these EMEs, RER depreciation and international reserve accumulation are significantly associated with higher interest rates. EMEs with high commodity exposure show the most persuasive evidence of debt levels influencing policy interest rates.

Arguably, the Russian Federation's successful international reserve buffer management during 2000–2019 is a second-best policy. The first-best policy may include macroprudential regulations and possibly external borrowing taxes scaling down the Russian Federation balance sheet exposure by raising the costs of borrowing in good times. Proper application of these policies may reduce the need for large-scale hoarding to support the bailouts of systemic borrowers in bad times (Rodrik 2006). Political economy considerations suggest that the Russian Federation central bank, probably operating with limited ability to impose macroprudential regulations on powerful insiders, saved the country in the 2000s–2010s from a much costlier exposure to sudden stops of the 1998 crisis variety. In contrast, Turkey in the 2010s did not adopt a systematic buffering policy, to its own peril (see Kalemli-Özcan [2019] for a critical assessment of EMEs' capacity to deal with the international spillover effects of US policies and Alfaro, Kalemli-Özcan, and Volosovych [2008] for the importance of the quality of institutions in stabilizing the patterns of capital flows and the credibility of implementing desirable macroprudential policies).

Asian countries have made significant use of macroprudential tools, especially housing-related measures. Zhang and Zoli (2016) found that housing-related macroprudential policies, particularly loan-to-value ratio caps and housing tax measures, have helped to curb housing price growth, credit growth, and bank leverage in Asia.[11] Aizenman, Jinjarak, and Zheng (2019) found that, although house price appreciation is positively associated with output growth, house price depreciation may either undermine or stimulate growth, depending on the depth of correction and the market environment. Large house price depreciation is associated with strong recovery in growth in the absence of banking crises, and this is stronger in countries with a relatively weak safety net.[12] Thereby, regulations reducing the risk of banking crises during periodic corrections of the real estate market are associated, on average, with a higher and more stable growth rate. Macroprudential policies also mitigated the growing balance sheet exposures associated with more volatile flows of

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11 Research has reported similar results in other regions (Vandenbussche, Vogel, and Detragiache 2015).

12 These results are consistent with the conjecture that delaying adjustment to large valuation losses induces deeper and more prolonged stagnation. Faster realization of losses combined with income support that deals with poverty mitigation may be superior to adjustment delays. The legal system and personal bankruptcy laws and the prevalence of mortgage insurance also affect the association between house price depreciation and economic growth.

"hot money" in the aftermath of the global financial crisis (Korinek 2011; Shin 2011; Ostry 2012; Cerutti, Claessens, and Laeven 2017).[13]

While the original inflation targeting and Taylor Rule ignored the RER as a policy goal in OECD countries, the research dealing with EMEs brought it to the fore (Aizenman, Hutchison, and Noy 2011; Berganza and Broto 2012; Ghosh, Ostry, and Chamon 2016; Ahmed, Aizenman, and Jinjarak 2019). Indeed, it is possible to accomplish exchange rate targeting (also known as exchange rate stabilization) by putting greater policy weight on stabilizing the RER, possibly through proactive management of sizable buffers of international reserves and SWFs. Concerns about fiscal dominance led to the augmentation of inflation targeting rules with fiscal rules. Chile and Norway provide vivid examples of the possible benefits associated with such rules, helping to reduce the pro-cyclicality of the fiscal policy and providing greater fiscal and monetary spaces (Frankel, Vegh, and Vuletin 2014). Time will tell the degree to which other countries with more limited institutional capacities and policy stability will follow similar policies.

2.4 Fintech Diffusion, Financial Intermediation, and the Future Role of Central Banks and Regulators—Work in Progress or Regress?

A growing share of EMEs are experimenting with fintech innovations. The diffusion of fintech profoundly changes the use of cash and transfer payments and the nature of financial intermediation. Fintech may be especially attractive in EMEs, as it allows countries with limited and inefficient banking services to leapfrog into the 21st century, utilizing the penetration of cell phone services in countries that limited phone line services historically constrained. The International Monetary Fund and World Bank report, *Fintech: The Experience So Far* (2019) described

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13 Aizenman, Chinn, and Ito (2020) found that more extensive implementation of macroprudential policies would lead EMEs to regain greater monetary independence from central economies (the US, the euro area, and Japan) when the central economies implement an expansionary monetary policy; when EMEs run a current account deficit; when they hold lower levels of international reserves; when their financial markets are relatively closed; when they are experiencing an increase in net portfolio flows; and when they are experiencing credit expansion. Macroprudential policies negatively affect the interest rate connectivity between the central economies and the EMEs especially in periods when the central economies implement an expansionary monetary policy. The results also suggest that macroprudential policies and international reserve holding are substitutes, in line with Rodrik (2006).

the benefits of financial inventions. The report's highlights included the following:

> Asia is ahead of other regions in many aspects of fintech. In China, the massive scale of its markets and a regulatory 'light touch' in the early years supported fintech development, with China emerging as a global leader. In India, large-scale adoption of mobile payments and an increase in money transfers have driven growth in mobile payments ... Sub-Saharan Africa is a global leader in mobile money innovation, adoption, and usage. The region leads the world in mobile money accounts per capita (both registered and active accounts), mobile money outlets, and volume of mobile money transactions. In Africa, close to 10 percent of GDP in transactions are occurring through mobile money, compared with just 7 percent of GDP in Asia and less than 2 percent of GDP in other regions. Across Africa, the adoption and use of technology in the provision of financial services is changing the way in which financial service providers operate and deliver products and services to their customers.

While some view the wave of fintech as the path to a brave new world, supplying cheaper and faster financial services, it also involves disruptive forces. Fintech's easier scalability has consolidated financial services, approaching the "winner takes (almost) all" syndrome. In principle, national borders do not bound fintech scaling dynamics, yet nation states may, at a cost, limit this scaling. Deeper fintech diffusion may redirect financial intermediation from regulated banks to emerging fintech "shadow intermediaries," some of which may have a global reach. Fintech's disruptive power also leads to complex agency problems, whereby the growing market clout of fewer dominant suppliers aiming at profit maximization may increase social costs.

To put fintech's disruptive effects into the proper context, note that history is loaded with innovations with double-edged features. The diffusion of phone networks via costly landlines during the 20th century induced powerful network externalities, leading to the emergence of "natural monopolies."[14] The benefits of fast and reliable communication that a few suppliers provided led regulators to view phone companies as "utilities," regulating their pricing and mergers and acquisitions.

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14 The percentage of housing units with telephones in the US in 1920 was 35%, reaching 78% in 1960 and 95% by 1990. https://www.statista.com/statistics/189959/housing-units-with-telephones-in-the-united-states-since-1920/ (accessed 20 September 2019).

Oil and coal provide plentiful cheap energy but lead to environmental degradation, polluted air, and accelerated climate change. A common feature across these examples is that scalability frequently leads to externalities and requires proper policies to curb the forces that it unleashes.[15] These concerns led Rajan and Zingales (2004) to warn about the gloomier side of under-regulated capitalism in *Saving Capitalism from the Capitalists.*[16]

Financial innovations provide growing benefits to underserved populations at low costs and with improving efficiency. However, the growing market clout of a few global giant suppliers of inflation targeting and fintech services may induce them to compromise privacy as part of their business model. The data that the suppliers of financial and commercial services relying on scalable inflation targeting services gather become a traded commodity.[17] While the benefits of cheaper, faster financial services are frontloaded, the possible costs of diluting the existing regulatory capabilities of the nation state are lurking, increasing the exposure to more disruptive tail risks and financial instability (Rajan 2005). The arrival of cryptocurrencies promising anonymized liquidity services further up the ante. Scalable cryptocurrencies may undermine monetary policy, channeling financial intermediation into shadowy networks facilitating tax dodging. Finding the proper regulatory response to fintech's impact on monetary policy transmission and on the tax base is a work in progress.

While nation states have focused on financial stability and securing the tax base after the global financial crisis,, the fintech sector is mostly

15 With Bitcoin, the analogy of fintech's social effects to energy's pollution is by now a reality: in September 2019, Bitcoin's capitalization was $182 billion, about 0.2% of the global GDP, at times when managing bitcoin transactions consumed 0.3% of global electricity. This probably explained the PRC authority's declaration of April 2019, "Bitcoin is Wasteful Activity". (Wired 2019).

16 They noted that the capitalist economic order receives frequent praise for its efficiency, yet this efficiency holds as long as competitive forces dominate and powerful agents do not use their economic clout to bend the rules of the game in favor of their narrow benefits, inducing what some have dubbed "crony capitalism." Underregulated large corporations have no interest in the creation of a modern and flexible financial system with free entry of competitors, as that would provide opportunities for newcomers to challenge the incumbent dominance. Left to its own devices, a market that powerful corporations dominate is not self-regulated, and maintaining efficiency needs government regulation. This is not without risk either, as insider corporations have incentives to invest in capturing and keeping governments in their service, suppressing the market. Therefore, securing the full advantages of capitalism requires the right balance of regulations enacted by governments that are not following narrow corporate interests.

17 It may also open the door for predatory states to engage in "social engineering," with big data providing real-time feedback, possibly in the form of a "social score" and the like.

aiming for rent maximization, paying little regard to the possible adverse externalities associated with these activities. Thereby, we may witness an accelerated arms race between the state and the fintech sector. Putting this arms race into the public finance perspective, financial stability is a public good providing the infrastructure supporting faster growth. Financial innovators may overlook this public good aspect. Thus, an underregulated fintech sector leads to moral hazard—financial instability increases the odds of costly financial crises. As the global financial crisis, illustrated, at a time of peril, even governments that championed "no bailouts" prior to the crisis socialize private-sector losses.[18]

The growing number of cryptocurrencies illustrates the large private demand for anonymized, decentralized financial innovations. The history of cryptocurrencies dates back to the Bitcoin mission statement, "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto 2008).[19] With a short lag, this paper inspired growing trade in the "electronic cash" bitcoin. Figure 2.4 plots the volume and price history of Bitcoin. Notable are the high volatility and the positive co-movements of prices and volume. Other cryptocurrencies have similar features. This price volatility has intensified the debates about the stability problems of decentralized currencies.[20] Believers have argued that smarter software managing future cryptocurrencies will solve these issues and that it is only a matter of time until a stable, decentralized currency emerges. Accordingly, inflation targeting has illustrated the viability of stable currency regimes.

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18 The bailing out by "market-friendly governments" is not an accident—the modern US more than quintupled the average federal tax/GDP in comparison to the tax burden in the era of Free Banking (1837–62) and National Banking (1863–1913). In exchange, the taxpayer expects the state to provide financial and economic stability, frequently punishing administrations that overlook the need to stabilize the economy at times of peril. This modern social contract is the outcome of evolutionary forces that led the US to converge from the Free and National Banking eras and the absence of federal level regulations of the 19th century to the New Deal era that emerged after the Great Depression. A key example of this evaluation is the 1933 formation of the Federal Deposit Insurance Corporation, "backed by the full faith and credit of the United States," (i.e., backed by the taxpayer), ultimately relegating to the Treasury and the Federal Reserve the task of securing financial stability.

19 Specifically, "A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution. We propose a solution to the double-spending problem using a peer-to-peer network. The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work…."

20 The analysis below expends and update the arguments outlined in the "VoxEu" column of Aizenman (2019a). See also the overview of these issues in Eichengreen (2019a), Roubini (2018), and Cukierman (2019).

Figure 2.4: Bitcoin Daily Price (right axis, $/BTC) and Volume (left axis, $ billion)

BTC = Bitcoin.

Source: https://data.bitcoinity.org/markets/price_volume/5y/USD?r=day&t=.

However, an extrapolation from inflation targeting to the feasibility of a stable cryptocurrency suffers from the fallacy of composition. Due to a systemic coordination failure, akin to the tragedy of the commons, there is no feasible path toward a global central bank that would ensure the stability of a decentralized currency. The successful diffusion of inflation targeting has shown that a nation state can stabilize the purchasing power of its currency in terms of the country's price level. Competent and relatively independent central banks can achieve this. In 2019, inflation targeting countries produced most of the global GDP. In contrast, countries that have limited the independence of their central banks have found, with a lag, that their currencies have lost value. This increases the likelihood of capital flight, financial fragility, and banking crises. Under inflation targeting, the national central bank has clear ownership and the duty to stabilize the national currency, using the tools under its control. It can adjust the policy interest rate to keep inflation low, manage key monetary aggregates, and communicate the central bank's policies.

In contrast, there is no clear central ownership and management of a decentralized cryptocurrency with the duty of keeping it stable and taking responsibility for it. Consequently, its valuation is unstable, as gaming among various stakeholders may lead to multiple equilibria, bubbles, and crashes. This instability reflects the tragedy of the commons associated with cryptocurrencies—the public good of stable valuation conflicts with the interests of anonymous large holders of the currency ("whales") who can influence its value. Whales may benefit from the endogenous instability associated with exploiting their market influence (Gandal et al. 2018).[21] Instability may also reflect the multiple equilibria associated with gaming decentralized cryptocurrencies (Biais et al. 2019). Their valuations experience exposure to the excessive optimism or pessimism of traders and possible market manipulation. Cryptocurrencies do not change the rules of finance and the agency problems that accompany financial intermediation. The anonymized nature of the exchange only magnifies these problems.

National currencies are, of course, exposed to similar speculative attacks, yet the clear allocation of duties to the central bank, and its willingness to adopt policies for financial stability and stable currency valuation, provide the public good services associated with scalable safe currency. This is part of a complex system that may include deposit insurance schemes (akin to the Federal Deposit Insurance Corporation), backstopped by the nation's taxpayers. Again, there is no comparable allocation of duties and "property rights" in a decentralized currency. Therefore, one can expect relative instability to be the rule, not the exception. The combination of a decentralized currency and the anonymity associated with cryptocurrencies makes the use of stabilizing forces, as large players used during the era of "national banking" in the US, impossible. To recall, during the financial panic of 1907, J. P. Morgan pledged large sums of his own money and convinced other New York bankers to act accordingly to shore up the banking system. They operated as de facto lenders of last resort. The whales of that time clearly owned the rents associated with stable financial intermediation, so they chose to provide stabilization services as long as that would minimize their expected losses. The crisis of 1907 also illustrated the risks of private bailouts—the balance sheets of financial institutions constrained their credibility, and they required a leader who could convince other financial whales to join the bailout. Furthermore, private bailouts reflected the wish of whales to maximize their rents more than their concerns about households, small banks and firms, and national welfare. Indeed, the dynamics of the 1907 crisis led to the formation of the Federal Reserve System, which the Federal Reserve Act of 1913 created. In contrast to the bailout that J. P. Morgan coordinated, the anonymity of cryptocurrency holders means that there is a lack of agency and no stabilizing forces of the type that the 1907 private bailout exhibited.

It is no surprise that there is no clear path toward a global central bank with responsibility for the price stability of a decentralized

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21 On 6 September 2019, the top 10 Bitcoin addresses accounted for 5.6% of the total supply, the top 100 14.7%, and the top 1,000 34.6%.

currency. Among national central banks, there is reluctance to cooperate in normal times, as the mandate of each central bank prioritizes domestic goals that focus on domestic price stability and not on the global value of its currency. The observation that, in normal times, deeper macro-cooperation among countries is associated with welfare gains akin to Harberger's second-order magnitude triangle, thus making the odds of cooperation low, compounds this coordination failure. When bad tail events induce imminent threats of financial collapse, the perceived losses have a first-order magnitude of terminating the total Marshallian surpluses. The apprehension of these losses in perilous times may elicit rare and beneficial macro cooperation (Aizenman 2016). In contrast, the anonymity of cryptocurrency owners may magnify the volatility, as there is no reason to expect the cryptocurrency's whales to provide stabilization in bad times (Aizenman 2019a).[22] Indeed, the market clout of Bitcoin whales provides ample opportunities to induce bubbly dynamics that insiders may exploit to their own benefits. These observations are consistent with the curious correlation patterns of bitcoin valuation that Baur, Hong, and Lee (2018) reported, noting that Bitcoin "is uncorrelated with traditional asset classes such as stocks, bonds and commodities both in normal times and in periods of financial turmoil. The analysis of transaction data of Bitcoin accounts shows that Bitcoins are mainly used as a speculative investment and not as an alternative currency and medium of exchange."[23]

Taking the public finance perspective, one may conjecture that successful scalability of decentralized cryptocurrencies would breed private failure—the nation state may ignore niche financial innovations but would regulate or even "nationalize" them if their size and instability became a systemic threat. Efficient scalability of a successful decentralized currency is possible as long as the private sector coordinates its policies with the nation state. Scalable financial innovations that challenge the nation state's ability to enforce law and order would trigger an "arms race" between users and the nation state's law enforcement. A well-functioning nation state has access to deep, scalable resources. OECD countries, the PRC, and other efficient centralized regimes find ways to control scalable financial innovations.

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22 An example is the recent "fork fights"; see "Bitcoin Cash Hard Fork Battle: Who Is Winning the Hash War?", *Cointelegraph Column*, 18 November 2018. https://cointelegraph.com/news/bitcoin-cash-hard-fork-battle-who-is-winning-the-hash-war (accessed 20 September 2019).

23 The close to zero correlation of Bitcoin with other assets induced some to conclude that it may provide diversification opportunities. Without controlling for the cost of these "opportunities," this argument is akin to viewing casino gambling as investment in portfolio diversification.

If the decentralized currency is scalable, nation states and central banks will face growing competition. They will react by either imposing regulations or reducing scalability and encryption. Either course of action crushes the emerging competition. Alternatively, they may compete directly with cryptocurrencies by offering their own e-money, as Lagarde (2018) articulated.[24]

To put it in a historical perspective, the supplier of currencies benefits access to significant resources, aka seigniorage. History provides ample examples of regimes oversupplying the means of exchange, resulting in runaway inflation. Similar dynamics may occur in a weak federal system, in which the states compete for a greater share of seigniorage (Aizenman 1992; Cukierman, Edwards, and Tabellini 1992). By now, most nations have converged to a social contract in which the state has the monopoly on supplying currency and controlling the banking system and the seigniorage and, in exchange, is responsible for the provision of financial stability, deposit insurance services, and a battery of regulations aiming to reach these goals.[25] The wave of fintech of the 2010s imposed clear risks on the monopoly of the state, shifting the bulk of financial intermediation to "virtual shadow banks" associated with anonymized intermediation.

The PRC provides an example of the feasibility and ability of the state to follow a dual goal of encouraging the diffusion of efficient fintech exchange in ways that benefit private uses and augment the

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24 "What if, instead, central banks entered a partnership with the private sector—banks and other financial institutions—and said: you interface with the customer, you store their wealth, you offer interest, advice, loans. But when it comes time to transact, we take over. This partnership could take various forms. Banks and other financial firms, including startups, could manage the digital currency. Much like banks which currently distribute cash. Or, individuals could hold regular deposits with financial firms, but transactions would ultimately get settled in digital currency between firms. Similar to what happens today, but in a split second. All nearly for free. And anytime. The advantage is clear. Your payment would be immediate, safe, cheap, and potentially semi-anonymous. As you wanted. And central banks would retain a sure footing in payments ... Putting it another way: the central bank focuses on its comparative advantage—back-end settlement—and financial institutions and start-ups are free to focus on what they do best—client interface and innovation. This is public–private partnership at its best." (Lagarde 2018).

25 An exception to these are states that chose to adopt a foreign currency as their legal tender, frequently as a mechanism to reduce the past instability associated with their currency, or joined a monetary union like the euro area, delegating the supplying of local currency to the central bank of the currency area.

government's controls,[26] while restricting anonymized exchange in ways that minimize its threats to shrink the tax base and to the state's ability to control financial intermediation.[27] The chances are that other states will choose their own menu of policies aiming at achieving these dual goals.

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26 "The landscape of Chinese fintech is dominated by two players: Ant Financial, an affiliate of Alibaba, and Tencent ... Mobile transactions in China reached nearly $18.7trn last year, 100 times more than in 2013—and more than all transactions handled worldwide by Visa and MasterCard combined. Regulators are more conflicted. By making spending easier, the fintech duo boost consumption, which has long been too low as a share of China's GDP. They bring financial services to poorer people and force state-owned behemoths to up their game. But their popularity is also an economic risk ... 'Customers are leaving banks' ... A bigger exodus might destabilise the financial system. So over the past year, regulators have put speed bumps in their way ... Ant has capped the amount of cash users can invest or withdraw in a day. The online banks launched by Tencent and Ant—respectively, WeBank and MYBank—have also been hindered by deposit caps. And the central bank called off a trial in which Ant and Tencent were developing credit scores on individuals. Instead, they were given stakes in Baihang, a state-owned credit-rating system. Potentially most significant is the launch in July of NetsUnion, a clearing house for online payments. Although it should make mobile payments safer, it will also stand between fintech firms and banks, making it more difficult for Ant and Tencent to drive a hard bargain over fees ... it is only a matter of time before it is used to limit mobile transactions, ostensibly to address concerns such as money-laundering but also protecting banks from competition. All this is the backdrop for the decision by Ant and Tencent to play up technology offerings instead of financial services ... The idea for both is that, with their vast user bases and data troves, they can help banks identify smaller borrowers and manage lending risks. Banks put up the capital; Ant and Tencent get 'technology fees.'" "Ant and Tencent As Regulators Circle, China's Fintech Giants Put the Emphasis on Tech." The Economist 2018).

27 On 4 September 2017, a PRC government announcement stated: "initial coin offerings (ICOs) financing that raises so-called 'virtual currencies' such as Bitcoin and Ethereum through the irregular sale and circulation of tokens is essentially public financing without approval, which is illegal. The announcement warned that tokens or virtual currencies involved in ICO financing are not issued by monetary authorities and therefore not mandatorily-accepted legal tender, and thus do not have equal legal status with fiat currencies and cannot and should not be circulated and used in the market as currencies."

"As early as December 3, 2013, a notice declared banks and payment institutions in China are prohibited from dealing in bitcoins. Financial and payment institutions are prohibited from using bitcoin pricing for products or services or buying or selling bitcoins, nor can they provide direct or indirect bitcoin-related services, including registering, trading, settling, clearing, or other services." (*Library of Congress 2008*).

See also "Starting January 2019, non-bank payments companies must place 100 percent of their customer deposit funds under centralized, interest-free accounts as Beijing moves to rein in financial risks. In the past, third-party payments firms were allowed to hold pre-paid sums from buyers for a short period of time before transferring the money to merchants. This layout allowed companies like Alibaba's payments affiliate Ant Financial and Tencent to earn interest by depositing customer money into bank accounts." https://techcrunch.com/2019/01/17/policy-squeezes-at-china-payments-firms/ (accessed 20 September 2019).

We close the section with a short overview of Libra, which Facebook introduced in 2019. Libra's white paper provided preliminary details of the mission and its design:

Libra is a simple global currency and financial infrastructure that empowers billions of people. Libra is made up of three parts that will work together to create a more inclusive financial system:

(1) It is built on a secure, scalable, and reliable blockchain.
(2) It is backed by a reserve of assets designed to give it intrinsic value.
(3) It is governed by the independent Libra Association tasked with evolving the ecosystem.[28]

While Libra's promised design differs from that of Bitcoin, the two share similar agency problems, and there are concerns about their impacts on the potency of the state's monetary and financial stability. First, Libra is accountable to its shareholders, with limited accountability to the actual users and the citizens of the countries experiencing its ultimate effects. A successful Libra will weaken the potency of monetary policy and dilute the state's seigniorage, and it may increase countries' financial instability resulting from foreign shocks, like capital controls, global web disruptions, etc. Depending on the design of the future Libra, it may also shrink the state's tax base. Thereby, there is no clear reason why central banks and treasuries will support the outsourcing of financial intermediation and the payment system to a globalized private platform. The public finance logic is clear: privatize scalable and globally successful Libra profits, but socialize any future losses associated with financial instability and crisis. Consequently, states may

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28 International reserves buffer the promised stability of the future Libra:

"What are the actual assets that will be backing each Libra coin? The actual assets will be a collection of low-volatility assets, including bank deposits and government securities in currencies from stable and reputable central banks. As the value of Libra will be effectively linked to a basket of fiat currencies, from the point of view of any specific currency, there will be fluctuations in the value of Libra. The makeup of the reserve is designed to mitigate the likelihood and severity of these fluctuations, particularly in the negative direction (i.e., even in economic crises). To that end, the above basket has been structured with capital preservation and liquidity in mind. On the capital preservation point, the association will only invest in debt from stable governments with low default probability that are unlikely to experience high inflation. In addition, the reserve has been diversified by selecting multiple governments, rather than just one, to further reduce the potential impact of such events. In terms of liquidity, the association plans to rely on short-dated securities issued by these governments, that are all traded in liquid markets that regularly accommodate daily trading volume in the tens or even hundreds of billions." (Libra Association 2019).

impose clear regulations akin to or more stringent than the one that they have presently invoked on globalized financial institutions.

The list of other concerns is long, stating that reliance on the "scalable, and reliable blockchain" is speculative, as only time will tell us the convergence of blockchain into this Promised Land. Backing up Libra with reserve accounts composed of a basket invested "in debt from stable governments with low default probability that are unlikely to experience high inflation" raises serious currency valuation risks, inflationary risks, and agency issues related to real-time monitoring of the adequacy of this coverage. To illustrate, the dollar/euro exchange rate swings in the past 20 years included several spells of 25% changes in 2 years. Similarly, the Swiss franc/US dollar experienced even larger fluctuations after the global financial crisis. This suggests that the basket valuation will be far from stable. History has shown that even "stable governments" occasionally impose capital controls at times of peril and crisis and renege on past promises (Edwards 2018). Furthermore, the balance sheet of a private supplier of money constrains its ability to back its commitment, as well as the will of its shareholders to undertake what is necessary to provide the promised services. By contrast, the state's ability to monetize liabilities (i.e., to print money) and to tax its citizens backs its ability to support financial stability. In the US, the Federal Deposit Insurance Corporation covers the banking system, but one doubts the willingness of the US and its taxpayers to support Libra's type of global arrangements.[29]

2.5 Concluding Remarks

The winds of trade and currency wars of recent years are vivid illustrations of the growing scarcity of global cooperation in the late 2010s, validating the need for EMEs to put their house in order. The sudden stops of the 1990s, the global financial crisis, and the euro area crisis induced EMEs to adopt defensive strategies, experimenting with new policy tools. The convergence to the middle ground of the trilemma helped. Greater monetary space has emerged through the proper precautionary management of international reserves, with the supplement of prudential regulations aimed at reducing the exposure to hot money inflows at times of "risk on," thereby mitigating the cost of hot money outflows at times of "risk off." Nevertheless, these steps are not sufficient to deal with the looming challenges, including the growing

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29 See Eichengreen (2018) and Niepelt (2019) "VoxEu" columns for further discussion of Libra.

exposure of EMEs to fiscal dominance; the need to adjust policy to fast-moving endogenous fintech innovations; and deglobalization trends. Greater application of SWFs as buffers integrated with fiscal rules may help. Experimentation with modified inflation targeting schemes and dynamic macroprudential regulations aiming to mitigate pro-cyclical leverage cycles and fintech shadow banking may be essential to reduce EMEs' exposure to costly future volatility. These defensive postures may be EMEs' second-best response to the limited global international coordination.

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3

The Economics of De-Cashing

Alexei Kireyev[1]

3.1 Introduction

De-cashing is defined as the gradual phasing out of currency from circulation and its replacement with convertible deposits. This initiative does not in any way target the abolition of money as an institution, but is, rather, a sweeping reduction of the role of currency, i.e., its cash component, in favor of transferrable deposits, i.e., its noncash component. The monetary authorities in many countries have already taken steps towards de-cashing. These steps include abolishing large denomination bills, imposing ceilings on cash transactions, introducing declaration requirements on the carriage of cash in and out of the country, reporting requirements for cash payments exceeding a specified amount, and even taxing cash transactions.

The purpose of this chapter is to suggest a simple framework for the analysis of the macroeconomic implications of de-cashing. Starting from a traditional savings–investment balance, the chapter develops a four-sector macroeconomics framework, which allows for the tracing of key implications of de-cashing for any country. The macroeconomic framework is then disaggregated into the real, fiscal, monetary, and external sectors of the national economy and the rest of the world. This analytical presentation allows for the study of sector-specific implications of de-cashing and the ability to highlight possible positive and negative effects of de-cashing in the sectors of particular importance for a specific country.

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The chapter is not meant to either endorse or condemn de-cashing in the ongoing debate. A recent and detailed overview of the positions on both sides of this heated debate is included in, among others, Sands (2016) and Rogoff (2014). The starting premise of this chapter is to examine effects of de-cashing from a macroeconomic perspective. Also, the chapter does not review recent money reforms (demonetization in India and some other countries); neither does it take a view on the role of de-cashing in reducing illegal cash-financed activities, nor on the ethical, legal, and political aspects of de-cashing.

The rest of the chapter is organized as follows. Section 3.2 briefly reviews the use of cash in the world and highlights some of the recent trends of de-cashing, including a few case studies of individual countries. Sections 3.3 and 3.4 analyze the statistical treatment of cash in the macroeconomics accounts, and, on this basis, propose a traceable accounting model of de-cashing. Finally, Section 3.5 includes conclusions and policy recommendations.

3.2 The Use of Cash

Cash is still used extensively across the world, in particular for small transactions. A study of payment habits in Australia, Austria, Canada, France, Germany, the Netherlands, and the United States (US) has shown that in terms of the number of transactions, currency accounts for more than half everywhere, except the US. Since the introduction of the euro, cash in circulation has more than quadrupled in the euro area. In 2016, cash stood at more than €1 trillion, with both banknotes and coins still popular mediums of payment. Cash continues to play an important role in lower-value transactions. The 2012 survey of the US suggests that if the amount of the transaction is less than $20, the probability that it will be settled in cash is over 90%. If the transaction is larger than $20, the probability decreases to 57% (Deutsche Bundesbank 2014).

Cash remains popular for technical and symbolic reasons. Technically, cash is seen as a simple, safe, and private medium of payment that helps control spending and plan a budget. Cash can be used to pay anonymously and directly without any sophisticated technical infrastructure, even without electricity, and is largely seen as irreplaceable in emergency situations. Historically, cash is the most convenient form of money, and carrying it in the wallet is often perceived as a fundamental human right. On the international scale, common money has often been seen as the most discernable sign of integration, in particular in the euro area or the African Financial Community franc zones.

The use of cash differs substantially depending on the denomination. Low denomination banknotes are used mainly for small daily transactions, whereas high denomination banknotes represent the bulk of currency in circulation, but are not generally used for cash transactions. High denomination banknotes, although dominating the cash turnover, mainly store value. Such banknotes ($50 to $100 in the US, €50 to €500 in the euro area, ¥5,000 to ¥10,000 in Japan, and SKr500 to SKr1,000 in Sweden) represent 80%–90% of currency in circulation, although are rarely used in daily cash payments.

Large denomination banknotes pose institutional risks. First, they are a vehicle often used for money laundering. The larger the value of the banknote, the easier it is to transport larger amounts of money. As an example, $1 million in currency in $100 bills weighs 22 pounds, whereas the same amount in €500 notes would weigh less than 3 pounds. Second, large denomination banknotes are more often forged. The US Treasury considered re-issuing a $500 banknote when €500 banknotes began circulating. However, after the recognition that this would fuel worldwide criminals, this option was not pursued. Third, high denomination banknotes are most likely used for overseas circulation with no supervision from the respective central bank. One estimate for the US suggests that about 65% ($580 billion) of all banknotes are in foreign circulation. Several countries are officially dollarized, which could explain this high percentage.

Cashless transactions have also gained importance across the world. The US Federal Reserve estimates that in 2016 cashless transactions amounted to $617 billion, up from $60 billion in 2010. In Germany, 33% of consumer transactions are cashless. Sweden is fast becoming a cashless society: in 2015, cash transactions made up barely 2% of the value of all payments and may drop to 0.5% by 2020. In shops, cash is now used for barely 20% of transactions, half the number from 5 years ago, and well below the global average of 75% (Riksbank 2015). A similar trend toward de-cashing is clearly observed in Norway, Denmark, and Finland.

Many countries have already taken steps to limit cash in transactions, initially deciding to abolish large denomination bills. In 2016, the European Central Bank (ECB) abolished the €500 banknote, mainly out of concern for counterfeiting and money laundering. In other countries, some high denomination notes have been eliminated in recent years, such as Canada's Can$1,000 note in 2000, and Singapore's S$10,000 note in 2014 (Sands 2016). In Sweden, all older banknotes and coins, except the SKr10 coin, became invalid in 2017, and some will not be replaced by new ones. Calls to scrap the $100 bill—the most widely used currency note in the world—have been heard in the US (Summers 2016). Second, restrictions on cash payments are currently in place in 12 of the 28 European Union (EU) member states (Deutsche Bundesbank 2016). In the euro area, an idea of imposing a ceiling of €5,000 on cash payments has been discussed. Restrictions were also put on the use of cash for specific purposes, such as paying rent (Sands 2016). In Israel, a special committee recommended a three-phase plan to restrict the use of cash, limit the use of checks as a means of payment and exchange for cash, and promote electronic payments. Any violation of these limits would be a criminal offense (Alonyi 2014). Third, the reporting and declaration requirement on carrying cash has been in place in many countries. For example, in the US, it is contrary to Title 26 of the tax code to carry more than $10,000 into the country without reporting it. A similar requirement is now in place for the EU, as all sums exceeding €10,000 in cash must be declared to customs authorities.

The private sector also seems to prefer to do away with cash. Many businesses in the euro area have self-imposed the policy of not accepting large denomination bills for payments, in particular €500 and €200 bills, out of fear of counterfeit money. In the US, getting change from a $100 bill may pose a problem at a small business. In Sweden, banks no longer accept or dispense cash; further, about 900 of Sweden's 1,600 bank branches no longer keep cash on hand or take cash deposits, and many, especially in rural areas, no longer have ATMs. Swedish buses have not taken cash for years, it is impossible to buy a metro ticket with cash, retailers are legally entitled to refuse coins and notes, and street vendors—and even churches—increasingly prefer card or phone payments (Henley 2016).

3.3 Macro-Analytics of De-Cashing

3.3.1 Cash Economics: Primer[2]

In monetary statistics, cash is synonymous to currency. In the strict sense, currency refers to notes and coins, which are financial instruments of fixed nominal values issued or authorized by central banks or governments (IMF 2016b). Domestic currency is given the status of a legal tender by the constitution or other relevant law, which generally requires its mandatory acceptance in the country. The value and credibility of a currency depend on the ability of the state to support

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2 The discussion is based on definitions and concepts from the Monetary and Financial Statistics Manual (IMF 2016b).

it.[3] Currency in circulation is the amount outside the central bank held by all residents and nonresidents.

Currency is part of money; money is a broader concept than currency. In addition to notes and coins, money also includes assets or instruments that are readily convertible into such, for example, transferrable deposits and short-term deposits. Money is issued generally by central banks, and can take the form of increasing a commercial bank's deposits at the central bank or transporting currency to the vaults of a commercial bank. Transferrable deposits, which are similar to currency, are exchangeable for currency on demand at par, without penalty or restriction, and directly usable for making payments to third parties by check, draft, giro order, direct debit and/or credit, or other direct payment facility.

Both currency and transferrable deposits are part of broad money and, as any money, has four basic functions. Currency is i) a medium of exchange—a means for acquiring nonfinancial assets (goods, merchandise, equipment, etc.), services, and financial assets without resorting to bartering; ii) a store of value—a means of holding wealth; iii) a unit of account—a standard for denominating the prices of goods and services, and the values of financial instruments and nonfinancial assets, thereby providing a means for comparisons of values and for preparation of financial accounts; and iv) a standard of deferred payment—a means for settling liabilities.

The amount of currency placed into circulation relative to deposits is determined by demand. Currency demand is determined by the bank's clients, who establish the amount they would like to have in the form of deposits and cash. The central bank places currency into circulation when it transports it to a commercial bank.[4] To account for this transaction in its balance sheet, the central bank reduces the "transferrable deposits" of the commercial bank and increases "currency in circulation." The commercial bank in its balance sheet increases "domestic currency" and decreases its transferrable deposits at the central bank. However, as long as this currency stays in the vaults of the commercial bank, it does

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3 This is not the case in all countries. For instance, the Indian rupee is legal tender in Nepal and Bhutan, in addition to their own domestic currency.

4 Transportation is not always the point where cash becomes currency in circulation. Some countries (e.g., in the euro area with the "Notes Held to Order" practice, and some Commonwealth countries with the practice of "currency chests") have arrangements with commercial banks where non-circulated "banknotes" (i.e., paper) are transported from the central bank to vaults of commercial banks. These (partitioned) vaults are physically in commercial banks, and maintained but them, but are to be seen as extensions of the central bank's vault. "Notes" being transported to those commercial banks are still listed as assets on the central bank's balance sheet, and will only turn into a liability and/or banknotes when transferred out of this vault.

not perform the role of money. Currency only starts performing this role and is included in broad money when the bank's clients exchange their deposits for currency. Upon demand from its clients for cash, the bank reduces its currency in vault cash in exchange for a reduction in their transferrable deposits. As an accounting entry, this currency in circulation is labeled "currency outside banks" and is included in broad money liabilities.

Electronic money is a special case of transferrable deposits and is classified as deposits rather than currency. All types of electronic money issued by residents that can be used for direct payments to third parties are included in broad money as transferrable deposits. Electronic money is a payment instrument whereby monetary value is electronically stored either on a physical device or remotely at a server. To qualify as electronic money, the payment instrument must be usable for making payments to third parties. While currency has only physical security features, electronic money uses cryptography to authenticate transactions and to protect the confidentiality and the integrity of the data processing. Examples of electronic money include an electronic purse where monetary values are stored on cards for small payments; prepaid cards, except those designed for specific needs and that can be used only in a limited way; web-based electronic money, such as PayPal; and money accessible on a mobile phone (e.g., M-Pesa in Kenya and Tanzania). Not all electronic payments involve electronic money. For instance, credit cards or debit cards are not electronic money because no monetary value is stored on them, and neither are store cards because they are similar to credit cards, but with use limited to only the issuing stores. Internet-based currency, such as Bitcoin, is not electronic money because it does not meet the definition of currency. Bitcoin is not issued by a central bank and is not widely accepted as a medium of exchange.

Therefore, currency and transferrable deposits are similar and both meet the definition of broad money; both can be used as a medium of exchange, are immediately exchangeable on demand at par to acquire financial or nonfinancial assets, and can be considered legal tender if the legal framework (likely the central bank act) indicates that. Currency is accepted for domestic transactions because of its status as legal tender. Transferrable deposits are accepted for transactions because recipients perceive them as a medium of exchange. Both currency and transferrable deposits have fixed nominal (face) value. The nominal values of currency and non-interest-bearing transferrable deposits are fixed, with real values changing with movements in the price level. Both currency and transferrable deposits can be used to make direct payments to a third party, and both have no or very low transaction costs. Payment by currency has no fees or other transaction costs, and the use of transferrable deposits usually bears very small fees. Both currency and transferrable deposits are divisible financial assets and are suitable for making small transactions; further, they do not have maturity and are immediately accessible by their holders. Finally, currency and transferrable deposits earn no or low interest. Their usefulness as a medium of exchange compensates the holder for the forgone interest that could have been received by holding other types of financial assets. There is no surprise, therefore, that central banks stand ready to convert transferrable deposits into currency in unlimited amounts.

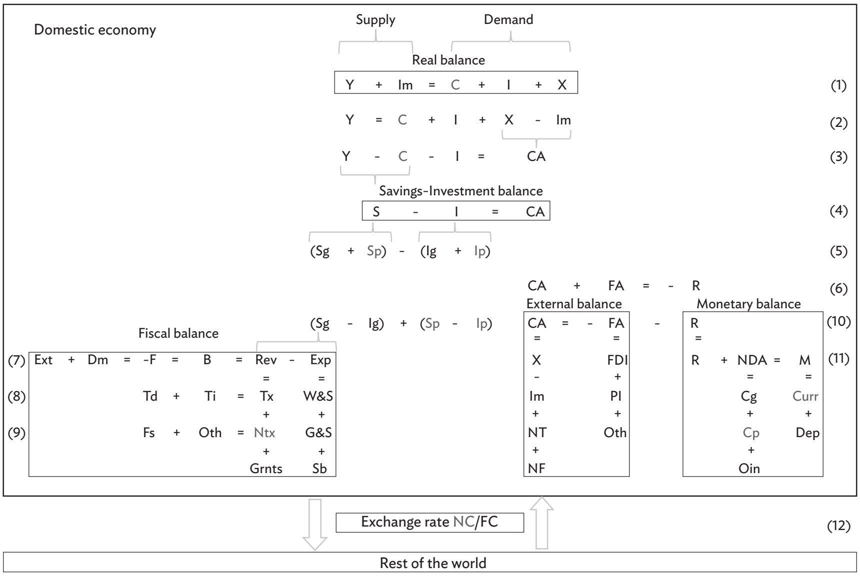
The differences between currency and transferrable deposits are also remarkable. They are often used by both sides of the debate on the pros and cons of de-cashing. First, currency can become technically obsolete. Banknotes fade and break, and the efforts to remedy the problem with plastic notes are of little help and involve unneeded costs. Transferrable deposits do not have this problem. Second, payments with currency are anonymous, which make them a popular vehicle for abuse, tax avoidance, terrorism financing, and money laundering. Transferrable deposits are personified and generally cannot be used for these purposes. Third, currency is prone to counterfeiting, at times on a large scale. Fourth, currency is often perceived as a means to preserve privacy, i.e., economic operators generally are not interested in the history of the currency of their transaction. Also, the individual right to privacy is usually enshrined in laws and transferrable deposits store each step of the payment history, which can be viewed as a threat to privacy. Transferrable deposits lead to full transparency, at least to the issuing bank, and a complete record of transactions, which, by virtue of the law, can be used by tax and law enforcement authorities.

3.3.2 Macroeconomic Framework

One way to look at the macroeconomic implications of de-cashing is through the prism of the System of National Accounts (SNA). The SNA provides an internationally recognized accounting framework, which allows for the compiling and presenting of macroeconomic data in a consistent manner (UN, EC, OECD, IMF, and World Bank 2008). Economic agents in any economy can be subdivided into five sectors: households, enterprises, financial intermediaries, the government, and the rest of the world; all are linked by accounting identities. In a simplified form, these linkages can be presented as shown in Figure 3.1.

In any economy, there is supply of resources and demand for resources or their use. Supply of resources consists of its own output Y and imports IM. These resources are used for public and private consumption C, investment I, and exports X (1). According to the

Figure 3.1: De-Cashing: The Macroeconomic Framework



Note: The variables potentially most affected by de-cashing are shown in gray.
Source: Author.

expenditure approach, income generated by the output is equal to the sum of its final uses (2). Additional income for the country includes net factor income and net transfers, which can be added to both sides of the identity, but are omitted here to simplify the presentation. Income not consumed equals saving *S*, and the difference between exports and imports equals the current account *CA* in the balance of payments (3). Therefore, ex post, the gap between savings and investment is equivalent to the current account balance (4). In other words, the current account deficit is driven by investment exceeding saving and should be financed from abroad. The current account surplus reflects saving exceeding investment and can be used to finance investment abroad. The saving–investment balance, which is equal to the current account, is the fundamental identity of international macroeconomics.

The outcome of the savings and investment balance depends on the performance of the public and private sectors. On the left-hand side of the savings–investment balance, national saving can be presented as a sum of government saving *Sg* and private saving *Sp*, and national investment as a sum of government investment *Ig* and private investment *Ip* (5). On the right-hand side of the savings–investment balance, the current account itself is part of the balance of payments identity. It says that the current account balance *CA* plus the financial account balance *FA*[5] should equal the change in international reserves *R* of the country (6). In other words, any disequilibrium between savings and investment either in the public or private sector would be reflected in the flows in the financial account or reserves. Assume for simplicity that the private sector always adjusts to the equilibrium, its savings–investment balance is zero, i.e., $Sp - Ip = 0$, and the savings–investment balance of the government sector is the only determinant of the current account.

The savings–investment balance of the public sector broadly reflects the government's budget position. The level of government saving *Sg* depends on the fiscal balance *B*, which is the difference between revenue *Rev* and expenses *Exp*, and is financed –*F* either from external sources *Ext* or domestic sources *Dm* (7). Revenue consists of tax revenue *Tx*, nontax revenue *NTx*, and grants *grnts*. Expenses include only final consumption expenditure by the general government, i.e., usually payments of wages and salaries *W&S*, procurements of goods and services *G&S*, and subsidies *Sb*. In turn, tax revenue consists of domestic taxes *Td* and taxes on international trade and transactions *Ti* (8). Nontax revenue includes fees and charges *Fs* and other revenue *Oth* (9).

The current account is a crucial component of the balance of payments and the external balance. Depending on the balance between domestic savings and investment, the current account can be in deficit or surplus. In the case of a deficit, it is financed by inflows in the financial account *FA* and/or drawing down international reserves *R* (10). This is a budget constraint for the economy, because the deficit can persist only as long as financial inflows are maintained, and the reserve level remains appropriate. In a current account surplus, the country finances the rest of the world by outflows in the financial account and/or accumulates reserves. The current account balance is usually determined mainly by the balance on trade in goods and services $X - Im$. In addition, the net factor income *NF* and net transfers *NT* may be important for the current account in certain countries. The flows in the financial account can be *FDI*, portfolio investment *PI*, and other flows *Oth*, which consist mainly of public and private loans.

The savings–investment balance has an important impact on monetary accounts. Assuming international reserves equal net

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[5] FA refers to "net capital and financial account excluding reserve assets" and NFA refers to "net foreign assets excluding reserve assets".

foreign assets (*NFA*) of the central bank and no changes in the *NFA* of commercial banks, then change in reserves *R* generated by the balance of payments outcome together with the changes in net domestic assets *NDA* lead to changes in broad money *M* (11). Changes in the *NDA* can be driven by net credit to the government *Cg*, credit to the private sector *Cp*, and other items net *OIN*. The monetary sector identity shows the distinction between money of external origin (*NFA*, reserves) and domestic origin (*NDA*, domestic credit). Unless sterilized, any accumulation of international reserves would translate into an increase in the supply of broad money for a given level of domestic credit. Because in equilibrium money supply always equals money demand, rapid accumulation of reserves may lead to a spike in inflation. Conversely, any expansion in domestic credit at a given level of reserves can have similar consequences.

Finally, the savings-investment balance of any country is closely linked to the level of the exchange rate of its currency. The exchange rate level broadly reflects the balance between supply and demand for currency between residents of the domestic economy and the rest of the world. This balance of supply and demand for currency may be an outcome of current account transactions, as exporters sell their foreign currency earnings and importers buy foreign currency to pay for imports; financial account transactions, as residents demand foreign currency to invest abroad and nonresidents need local currency to invest domestically; and transactions with international reserves, as the central bank buys and sells foreign currency to achieve its policy objectives. As a result, flows under all three key accounts of the balance of payments—the current account, the financial account, and the international reserves account—have an impact on the level of the exchange rate (12).

How does de-cashing enter into this simple framework? On a purely macro-accounting level, commitments taken by countries in the process of de-cashing directly affect their savings–investment balance. The impulse may originate in any of the four sectors from the variables shown in red on Figure 3.1. In the real sector, de-cashing would directly influence private consumption and private investment, generally by shifting the means of payments from paper currency to electronic means. In the fiscal sector, the impact of de-cashing would be felt on both the revenue and the expenditure sides. On the revenue side, the level of nontax revenue for governments from seigniorage will be inevitably affected. The impact on the expenditure side will be mainly through reduced and even eliminated currency printing and transaction costs. In the external sector, the impulse should be expected from the savings–investment balance in the private sector, where the interplay between the changes in the two components —investment and savings—

would affect the current account. Finally, in the monetary sector, the impact of de-cashing on the assets side would be from the credit to the private sector, most, if not all of which, will have to be de-cashed. On the liabilities side, the composition between currency and deposits in reserve money would change in favor of the latter.

3.4 Macroeconomic Effect of De-Cashing

3.4.1 Monetary Effects

The initial macroeconomic impulse of de-cashing would originate from a drop in demand for currency. In equilibrium, the central bank stands ready to meet demand for money, be it in the form of currency or transferrable deposits, and stands ready to convert currency into transferrable deposits and vice versa in unlimited amounts. In fact, if demand for currency drops and is offset in full by an increase in demand for transferrable deposits, the impact on money supply will be zero (Figure 3.2). The process of de-cashing would be reflected on the liabilities side of the central bank balance sheet and monetary survey as a simple rebalancing between currency and transferrable deposits.

On the assets side showing the sources of money supply, the net foreign assets will not be affected as this is money of external origin. Some rebalancing is possible between net claims of government and claims of the private sector, depending on their relative demand for currency and deposits. In a most probable scenario of creating incentives for de-cashing, the public sector most likely would reduce its demand for currency more than the private sector, for example, if a decision is taken to pay all public sector salaries by cashless means, i.e., by their transfer to deposits of public employees, and to pay taxes only with cashless means. The private sector may also react to incentives for de-cashing if the authorities introduce a requirement that all payments exceeding a certain amount should be made by cashless means. In any case, the rebalancing in monetary accounts would be purely mechanical with no impact on money supply.

Therefore, the de-cashing incentives should be explicitly included in the demand for currency estimations. Demand for currency is usually modeled in an error correction framework to account for a possible cointegration between currency holdings, gross domestic product (GDP), and interest rates. Indicators of ease of access to currency, such as the number of ATMs, fund transfer terminals, and bank branches per capita, and the ratio of self-employment to total employment in the long-run relationship can be also included. Additional variables to

Figure 3.2: Monetary Effect of De-Cashing

Monetary survey

Assets/Counterparts	Impact
Net foreign assets	0
Central banks	0
Commercial banks	0
Net domestic assets	0
Net claims on government	+/-
Claims on other resident sectors	+/-
Other items net	0

Liabilities	Impact
Broad money	0
Currency outside depository corporations	-
Transferrable deposits	+
Other deposit included in broad money	0
Debt securities included in broad money	0

Monetary base

Assets/Counterparts	Impact
Net foreign assets of the central bank	0
Net domestic assets	0
Net claims on government	+/-
Claims on other depository corporations	+/-
Other items net	0

Liabilities	Impact
Monetary base	0
Currency in circulation	-
Transferrable deposits	+
Other deposits	0
Debt securities issues by central banks	0

Source: Author, based on the Monetary and Financial Statistics Manual (IMF 2016b).

capture the impact of de-cashing on currency demand may include the projected share of salaries paid in cash, an implicit opportunity cost of holding cash, and the number of checking and other transferrable accounts held by economic agents.

De-cashing may improve the transmission mechanism of monetary policy. In principle, the transmission of monetary impulses from the policy rate to inflation may become easier as all rates—money market, interbank, bank deposit, and lending—may react faster to the changes in the policy rate as economic agents would have fewer non-interest bearing assets in the form of saved currency. In particular, the negative interest rate policy becomes a feasible option for monetary policy if savings in physical currency are discouraged and substantially reduced. With de-cashing, most money would be stored in the banking system, and, therefore, would be easily affected by negative rates, which could encourage consumer spending. Moreover, currency has not been an efficient instrument of monetary policy, as in most countries currency is neither the largest part of money supply, nor an efficient mechanism for providing liquidity. The amount of currency in circulation has no impact on inflation, and there are no quantitative limits on banknote issuance in central banks, which also suggests that currency has largely lost its role in monetary policy, in particular in developed countries.

The opposite scenario is also possible, in particular in developing countries with a large share of currency in money, where currency may have an impact on inflation. Even a small negative interest rate would likely result in a sudden jump in demand for cash, both during and after the period of negative interest rates. The supply of cash would increase to meet this demand. In this scenario, negative interest rate policies might be feasible only if cash and prepaid debit cards were eliminated, but even then they would be highly controversial. Also, with negative interest rates, agents could move into other assets for storing value if domestic interest rates are largely negative (think of using other countries' paper currencies, virtual currencies, gold, real estate, etc.).

After de-cashing, the banking system laden with fresh deposits would be able to boost lending. In countries where the depositor base is weak, de-cashing would help increase deposits as economic agents convert their currency holdings into convertible and other types of deposits with the banking system. The availability of deposits should in principle help reduce the lending interest rate and make credit more affordable, therefore increasing borrowing and contributing to growth. Clearly, de-cashing is not the only instrument to lower interest rates. Central banks can lower interest rates whenever they consider it desirable, as long as the zero lower bound is not binding. Even when the zero bound is binding, banks would have excess liquidity. Banks' credit is also constrained by capital requirements and sound lending considerations.

The only useful function of currency, which can be lost with de-cashing, is that demand for cash may help predict financial crises. Such crises usually happen when the public loses confidence in banks and bank money and run into hard cash, erroneously viewed as a safe haven. The strong demand for cash in September 2008 reflected the panic that swept across most developed countries with the visible onset of one of the biggest crises in history. The rise in demand for currency, in particular for high denomination banknotes, was mainly due to an increase in precautionary holdings by people concerned about the liquidity or solvency of financial institutions, and by financial institutions as a contingency. However, it is not entirely clear whether de-cashing would eliminate the ability to see early warning signs. Even in a fully cashless society, people may revert to gold, other commodities, or other (still existing) cash currencies (such as the dollar), demand for which would function as early earning indicators.

Finally, de-cashing may have implications for central bank independence, mainly in emerging economics. It may be argued that de-cashing would lead to a loss of the revenue from seigniorage, one of the important sources of revenue for central banks that allow them to maintain financial independence. However, for most central banks, seigniorage is not a significant revenue stream and, at times, even notional, as all of it is transferred to the general budget. For example, in the euro area, the ECB receives interest only on its 8% share of the total currency issuance, as national central banks' members of the euro system put most currency into circulation. Seigniorage from high denomination banknotes does not exceed 0.1% of GDP in the US, the euro area, Japan, the United Kingdom, and Switzerland (Sands 2016). The ECB earns interest only on its share of the issued currency and at a very low marginal rate (or fixed rate) for the euro system's main refinancing operations. Moreover, most central banks have diversified revenue sources. In addition to the seigniorage, they earn income on their holdings of foreign reserves, which are usually invested in interest-bearing assets, holdings of government securities, issuances of their own securities, revaluation of assets with rising prices, including gold, exchange rate differentials, and other sources. Also, most central bank laws have arrangements for limited profit distribution arrangements with their sovereigns, in particular to safeguard financial independence. Therefore, the examples listed are not necessarily the countries that face significant threats to central bank independence. It is, however, in particular, central banks in numerous emerging markets where seigniorage is key for the central bank's financial independence. Obviously, central banks also bear costs, but their substantial part, such as printing, minting, and retiring banknotes and coins, would be dramatically reduced, if not eliminated, with de-cashing.

3.4.2 Real Effects

De-cashing would have an impact on growth, which may be both positive and negative. The positive impact in the form of higher growth can be expected as de-cashing would reduce transaction costs in the economy estimated at about 2%–2.5% of GDP (Deutsche Bundesbank 2014). Lower costs would mean higher profits, investment, and ultimately growth. This positive impact may be significant as cash transactions are mostly conducted with small denomination bills and are thus the cost of such multiple small transactions may be substantial. Second, de-cashing may reduce the underground and gray economy, and, therefore, increase the GDP captured by official statistics beyond the usual estimates, thus making them explicitly contribute to it. On the other hand, de-cashing may have negative repercussions for private sector growth as a substantial part of private investment (house construction, remodeling, and extensions), especially those financed by remittances, is settled in cash. De-cashing may introduce disruptions in this well-established process. Also, with the elimination of high denomination banknotes, consumers will have to use an increasing number of lower denomination banknotes to settle the same transaction, which will increase costs. Finally, should governments impose de-cashing without the general approval of the population, de-cashing may lead to social tensions, mistrust, walkouts, demonstrations, and, as a result, GDP losses.

At a more granular level, the GDP is produced and spent, and currency is used as a medium of exchange in this process. On the supply side, the GDP can be further decomposed into the value added plus the adjustment of taxes less subsidies on products in the primary sector (mining and agriculture), secondary sector (manufacturing), and tertiary sector (services) (Figure 3.3), and can explicitly show the public and private sectors, both on the supply and demand sides. Arguably, the use of cash is substantially higher in the private sector than in the public sector. Depending on the shares of private and public ownership, the impact may be felt mainly in the tertiary sector, where most services are provided by private agents, and the secondary sector, if the role of the private sector is high in a particular economy. As natural resources are usually in the public sector, the impact of de-cashing on it may be marginal.

On the demand side, de-cashing would affect both private consumption and private investment. While public consumption and

Figure 3.3: Real Effects of De-Cashing

Supply	Impact
GDP (public and private)	+/-
Primary sector	-
Secondary sector	+/-
Tertiary sector	+
Public administration	0

Demand	Impact
GDP (public and private)	+/-
Gross domestic expenditure	+/--
Consumption	+/--
Public	0
Private	+
Gross fixed capital formation	+/-
Public	0
Private	
Change in stocks	
Resource gap	+
Exports of G&NFS	+
Imports of G&NFS	+

GDP = gross domestic product, G&NFS = goods and non-factor services.

Source: Author, based on the System of National Accounts (SNA 2008).

investment are usually noncash transactions, private consumption is strongly influenced by the amount of net disposable income. People generally spend and consume more from their disposable income if they feel financially safe, therefore increasing demand for currency. As consumption spending by the private sector is an important GDP component and is conducted in a significant part in paper currency, de-cashing may have a negative impact on it and somewhat hamper economic growth. Investment, however, should be generally a lesser source for currency demand, in particular in developed countries where it is executed in bank money. Therefore, de-cashing most likely will not significantly affect public consumption and investment, but may create temporary hurdles for private consumption and investment.

3.4.3 Fiscal Effects

De-cashing will have an impact on a country's fiscal balance. As shown above, the fiscal balance is directly linked to the savings–investment balance of the public sector, and, therefore, can have a major impact on external and balance of payments stability. Any changes in government revenue and consumption resulting from de-cashing will translate into changes in the level of government saving, which, for a given level of public investment and an unchanged private sector savings–investment balance, would change the current account. The direction of the shift would largely depend on whether de-cashing would improve the overall fiscal balance or lead to its deterioration. The outcome depends on its relative impact on specific revenue and expenditure lines, primarily those shown in red (Figure 3.4).

In principle, de-cashing should improve tax collection by reducing tax evasion. In Sweden, for example, with de-cashing, the government has benefited from more efficient tax collection, because electronic transactions leave a trail. By contrast, in countries like Greece and Italy, where cash is still heavily used, tax evasion remains a problem. The visibility of tax payments by transfers through banks can serve as a deterrent to tax underreporting and other evasion strategies. Most developed countries and many developing countries have already implemented policies on electronic tax payments and use them as a tax control instrument. However, as these policies require taxpayers to acquire and install electronic payment systems, compliance costs are unavoidable. Recent studies showed that while electronic payments did not appear to influence value-added tax (VAT) collection, the negative effects of cash collection on VAT performance is unambiguous, at least in the countries where electronic cash payments are well-established (Deutsche Bundesbank 2014). Finally, electronic payments may also

Figure 3.4: Fiscal Effects of De-Cashing

Revenue	Impact
Taxes	+
On income, profits, and capital gains	+
On payroll and workforce	+
On property	+
On goods and services	+
General (VAT, sales, turnover)	+
Excise	+
Profit of fiscal monopolies	+
Specific services	+
Use of goods	+
On international trade and transactions	+
Customs and other import duties, o/w	+
Taxes on exports	+
Profit of export and import monopolies	+
Exhange profits and taxes	+
Other duties and charges	+
Social contributions	
Grants	
From foreign governments	+
From international organizations	+
From other government units	
Other revenue	-
Property income (profit transfers)	-
Interest	
Sales of goods and services	
Fines, penalties	

Expenses	Impact
Current expenditure	
Compensation of employees	-
Use of goods & services	-
Subsidies	
To public corporations	-
To private enterprises	-
Interest	+
On external debt	
On domestic debt	
Social benefits	
Other	
Capital expenditure	
Externally financed	-
Domestically financed	-
Fiscal balance (net lending/borrowing)	+/-
Financing (net acquisition of financial assets)	-/+
Domestic	
Bank	
Central bank	
Commercial banks	
Nonbank	
External	
Drawing	+
Repayments	

VAT = value-added tax.

Source: Author, based on the IMF Government Finance Statistics Manual (2001).

lead to new forms of tax evasion and could incentivize barter, facilitated by improved technology, which will hamper tax collection.

The magnitude of possible improvements in tax collection is hard to estimate. Given the scale of cash-based tax evasion, one must assume a fairly modest impact on behavior to generate a substantial increment to tax revenues. For example, tax evasion in the US, called the tax gap, was estimated by the Internal Revenue Service at $458 billion on average in 2008–10 (IRS 2016). The major components of the tax gap are the underreporting of individual income tax ($264 billion) and employment tax ($84 billion). If eliminating $100 bills—to take a simple assumption—meant that 10% of this gap would be collected, the additional tax contribution would be $35 billion a year. In the EU, tax evasion is estimated at €1 trillion a year (European Commission 2017). Using the same illustrative logic, the elimination of large denomination bills of the euro and British pound would help recover €100 billion in tax arrears. In developing countries, additional tax revenue is hard to estimate, given the paucity of analysis on tax compliance gaps in general.

With de-cashing, governments may reduce their interest expenditure due to lower interest payments to central banks. Central banks usually put currency into circulation by purchasing government bonds on the secondary market, meaning the purchase does not increase interest costs to the government. On the contrary, it increases the demand for bonds and thus lowers the interest rate that the government would have to pay. Governments have to pay interest to the central banks on these bonds, which represents their seigniorage and may be substantial. In the US, for example, the fiscal year 2017 seigniorage amounted to 0.46 per dollar issued (US Mint 2017), with such payments amounting to about $70 billion a year. In Sweden, however, seigniorage represents only 1.1% of the central bank's balance sheet (Riksbank 2015). Overall, however, it is not immediately clear that de-cashing would provide savings to the consolidated balance sheet of the public sector (i.e., the Ministry of Finance and the central bank) because of the effects described above. These interest payments are a transfer between the central bank and the Ministry of Finance.

De-cashing may reduce the government's nontax revenue through lower profit on currency issuances. The government purchases the currency from a domestic or foreign mint (or bureau of engraving) and delivers the currency to the central bank. In the central bank's accounts, the nominal (face) value of the currency is recorded as vault cash (currency—domestic), along with a corresponding increase in the central bank's liability (transferrable deposits—in domestic currency) to the central government. Through this transaction, the central government obtains revenue, which is equivalent to the difference between the nominal value of the currency and the cost of its acquisition, distribution, and maintenance. If the nominal value of currency issued declines with de-cashing, so does government revenue from this operation.

Finally, de-cashing may lead to budgetary costs. In most cases, the country would have to introduce deep institutional and legislative reform to initiate and carry over de-cashing. The implementation of many electronic payment procedures is technically complex, and requires extensive training of personnel, procurement of new equipment and technology, redrafting of domestic regulation, and the corresponding institutional changes, including strengthening enforcement. The specific expenditure items that can be affected by the need to finance these implementation costs may include additional staff, procurement of new equipment, and investment in rebuilding an electronic payment infrastructure. Investment can be financed domestically, while some countries may also receive the support of external donors for the adjustment period. In the latter case, the source of financing can be either loans, shown as a financing item in the budget, or grants included in revenue.

Overall, fiscal implications of de-cashing seem ambiguous. The impact on the fiscal balance and, as a result, on the savings–investment balance of the government, would largely depend on the relative impact of revenue and expenditure items affected by de-cashing. On the revenue side, taxes most likely will increase, owing to more rigorous and traceable collection procedures. Nontax revenue most likely would drop, with lower profit transfers from seigniorage by the central bank. On the expenditure side, interest to be paid to the central bank on government bonds would be lower. However, at the same time, additional expenditure, at least for the transition period, can be expected to finance de-cashing. Relatively prolonged transition periods could help smooth out the negative impact, as an increase in tax collection would help offset some losses.

3.4.4 Balance of Payments Effects

The impact on de-cashing on most balance of payment flows most likely will be marginal (Figure 3.5). For small to medium-sized countries, de-cashing is mainly a domestic operation with little direct implications for the rest of the world. The impact on the current account should be expected mainly through the savings-investment balance, which in turn critically depends on the outcome of de-cashing for the public sector. If the fiscal balance improves as tax revenue increases outweigh nontax revenue losses and additional transitional expenditure, the current account will improve. This outcome would mainly reflect stronger exports, as government invests part of its collected taxes, and improves infrastructure, competitiveness, and the business environment. On the other hand, in some countries de-cashing may require additional imports of equipment and technology, which may temporarily worsen the current account.

The balance on the primary and secondary income accounts would be affected mainly through income transfers. If de-cashing is based on the distributed ledger-like technology, such as with Bitcoin, it can dramatically reduce the cost of international transfers, especially remittances intermediated by correspondent banks. Through correspondent banking relationships—agreements between banks to

Figure 3.5: Balance of Payments Effects of De-Cashing

1. Current account	Impact
Goods and services	
Goods	
General merchandise	+/-
Net exports of goods under merchanting	
Nonmonetary gold	
Services	
Manufacturing services	-
Maintenance and repair services	-
Transport	+/-
Travel	+/-
Construction	-
Insurance and pension services	-
Financial services	+/-
Charges for the use of intellectual property	+/-
Telecommunications, computer, and information services	+/-
Other usiness services	-
Personal, cultural, and recreational services	-
Government goods and services	
Primary income	
Compensation of employees	-
Investment income	-
Other primary income	
Secondary income	
General government	
Financial corporations, nonfinancial corporations, households	+
Adjustment for change in pension entitlements	

2. Capital account	Impact
Gross acquisitions/disposals of non-produced nonfinancial assets	
Capital transfers	+
3. Financial account	
Direct investment	+
Portfolio investment	+
Financial derivatives	
Other investment	
Other equity	
Currency and deposits	
Loans	
Insurance, pension, and standardized guarantee schemes	
Trade credit and advances	+/-
Other accounts	
Special Drawing Rights	
4. Reserve assets	
Monetary gold	
Special Drawing Rights	
Reserve position in the IMF	
Other reserve assets	+/-

IMF= International Monetary Fund.

Source: Author, based on the IMF Balance of Payments and International Investment Position Manual. (2006).

provide payment services to each other—banks can access financial services in different jurisdictions and provide cross-border payment services. The costs of sending international remittances, however, are notoriously high, at about 8% of the amount sent. In contrast, the cost with electronic money, such as Bitcoin, is estimated to be about 1% (Goldman Sachs 2014). A blockchain-based remittance system has already emerged in some economies. For instance, in the Philippines and Kenya, blockchain-based intermediaries offer money transfer services via Bitcoin and subsequent conversion back into fiat currency for withdrawal by recipients through either their mobile phones or a bank account (IMF 2016a).

Finally, de-cashing may reduce a very profitable impact on the balance of payments of certain countries from the international circulation of their national currency. While the cost of printing banknotes is minimal, foreign economic agents must provide goods and services at the face value of the banknote to obtain it. Primarily, this flow is important for the US and the euro area. "What is true is that the large holdings of U.S. currency outside the United States—largely in the form of $100 bills, held for obvious reasons—represent, in effect, a roughly $500 billion zero-interest loan to America. That's nice, but even in normal times it's only worth around $20 billion a year, or roughly 0.15 percent of GDP" (Krugman 2013).

3.4.5 Structural Effects

De-cashing may lead to increased financial inclusiveness. By construction, a shift from currency to transferrable deposits would require people to have at least debit accounts with banks. Small businesses that would accept bank money would increase their profits, as most people would have easily accessible and reliable means of payments in the form at least of debit cards and, potentially, tele-payments.

De-cashing should help reduce illegal migration. With less currency in circulation, employers that attract illegal immigration by cash payment would have fewer options to pay for their services off the books.

De-cashing can help improve the environment. Paper money has been the currency of choice for centuries with clearly negative implications for forestry. Now, it is being replaced with polymer notes, which are already in use in over 20 countries. A polymer bill leads to a 32% reduction in global warming potential and a 30% reduction in primary energy demand compared with paper (Wang 2016). However, from the environmental standpoint, transferrable deposits would outperform both paper and polymer currencies, as they need to be neither produced nor disposed.

However, social implications of de-cashing can be substantial. Carrying cash is a human right and is written into constitutions, which therefore have to be changed. Social conventions may also be disrupted as de-cashing may be viewed as a violation of fundamental rights, including freedom of contract and freedom of ownership. While convertible deposits cannot be stolen in a conventional robbery, they can be hacked. There are, obviously, concerns as the cases of electronic fraud have more than doubled in the past decade.

De-cashing would remove a tacit means of social support. In many developing societies, the government implicitly encourages small, unregistered entrepreneurship, which relies entirely on cash transactions with no or little formal accounting. By forgoing tax revenue, the authorities allow small businesses to create informal mechanisms of social self-support, which the government simply cannot afford to finance through formal social payments. At the same time, microfinance most likely will be more difficult as it still relies largely on cash contributions.

Finally, currency substitution can become possible. If there is not enough domestic currency because of the unmeasured pace of de-cashing, foreign currencies or surrogate currencies may start to be used for murky transactions.

3.5 Conclusions and Policy Options

De-cashing by a shift toward transferrable deposits reflects a natural drive towards economic flexibility and growth. It should be seen as a long-term project and does not suggest an immediate move to a cashless society. Although some countries most likely will de-cash in a few years, going completely cashless should be phased in. The de-cashing process could build on the initial and largely uncontested steps, such as the phasing out of large denomination bills, the placement of ceilings on cash transactions, and the reporting of cash moves across the borders. Further steps could include creating economic incentives to reduce the use of cash, simplifying the opening and use of transferrable deposits, and further computerizing the financial system.

Private sector de-cashing seems preferable to public sector de-cashing. The former seems almost entirely benign (e.g., more use of mobile phones to pay for coffee), but still needs policy adaptation. The latter seems more questionable, and people may have valid objections to it. De-cashing of either kind leaves both individuals and states more vulnerable to disruptions, ranging from power outages to hacks to cyberwarfare. In any case, the tempting attempts to impose de-cashing by a decree should be avoided, given the popular personal attachment to cash. A targeted outreach program is needed to alleviate suspicions, in particular that, by de-cashing, the authorities are trying to control all aspects of peoples' lives, including their use of money, or push personal savings into banks. The de-cashing process would acquire more traction if it were based on individual consumer choice and cost-benefit considerations.

The macroeconomic impact of de-cashing would depend on the balance of its costs and benefits, but most likely will still be positive on a net basis. On the side of the benefits, de-cashing should raise recorded GDP growth by reducing transaction costs, creating incentives for the informal economy to join the formal sector, and simplifying transactions, in particular in the private sector, services, and consumption. De-cashing would also expand revenue collection by expanding the taxable base, curbing tax evasion and fraud, and reducing interest payments on government debt. De-cashing should improve the transmission mechanism of monetary policy. With most money having the form of transferrable deposits, central banks would be able to influence liquidity conditions and credit better with their interest rate policy. As de-cashing gives incentives to economies' agents to convert their currency in bank deposits, the deposit base of the banking system will increase, which can help reduce the lending rates and expand credit. In particular, if the negative interest rate policy becomes a mainstream policy option, de-cashing would be critical for its efficiency.

On the external side, de-cashing can improve the current account, mainly through its impact on the savings–investment balance of the government sector and on remittances and other income flows, which should increase with lower transaction costs. Finally, in the structural area, de-cashing can help improve financial inclusiveness with easier digital access to banking services. The labor market would be more orderly, as fewer illegal immigrants would be attracted by cash payments. The central banks will cut their costs with no need to produce and destroy either paper or plastic currency.

On the side of the costs, de-cashing may create temporary frictions in all sectors as the well-established cash procedures have to contract. In the private sector, there may be disruptions, as a substantial part of consumption transactions and private investments, in particular in housing, is made in cash. Also, households and small private businesses may see carrying cash and conducting anonymous transactions as their constitutional right. Their discontent can lead to social tensions, strikes, and, therefore, GDP losses. For the fiscal sector, de-cashing may represent a substantial financial burden, as additional capital and current expenditure will have to be made to procure equipment to manage cashless settlements. Additional spending will be needed for the training of personnel on cashless transactions, although part of these costs would be borne by the private sector. Losses in profit transfers are also possible. In the monetary sector, de-cashing may reduce central bank independence with the lost seigniorage revenue. De-cashing would also deprive central banks of a useful tool in the form of changes in the demand for cash, which has served as a leading indicator of a possible financial crisis. It is not immediately obvious that de-cashing would help improve financial inclusiveness. If the poorest cannot have access to computers or mobile phones, they will lose the most important financial asset that they rely on to save: cash.

In the external sector, some deterioration of the current account may be expected, at least on a temporary basis, as the de-cashing country has to import the massive equipment needed to service cashless transactions and outsource the services (programming, training, etc.) to nonresidents. Finally, in the structural area, substantial groups of the population not yet familiar with digital payments may feel disadvantaged, which could lead to social strain. Also, the tacit form of social protection used in many developing countries in the forms of forgone tax payments would be largely eliminated and need to be replaced with more direct forms of social protections. Finally, if cash is still an important means of payment in a de-cashing country, currency substitution may become an issue, as economic agents would be forced to use other currencies as a means of payment.

Coordinated efforts on de-cashing could help enhance its positive effects and reduce potential costs. At least at the level of major countries and their currencies, the authorities could coordinate their de-cashing efforts. Such coordinated efforts are, in particular, important in the decisions to phase out large denomination bills for all major currencies, to use ceilings and other restrictions on cash transactions, and to introduce the reporting requirements for cash transactions or their taxation. For currency areas, a single de-cashing policy would be clearly preferable to a national one. Finally, consensus between the public and the private sector and outreach on the advantages and modalities of gradual de-cashing should be viewed as key preconditions for its success.

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4

Digital Transformation: Some Implications for Financial and Macroeconomic Stability

Hans Genberg

4.1 Introduction

The increased use of computers, machine learning, robots, and artificial intelligence has been compared with the introduction of the steam engine and electricity as drivers of economic progress. Some scholars have suggested that we are at the beginning of a Second Machine Age (Brynjolfsson and McAfee 2014), where technology-driven changes in market structures based on ideas rather than physical goods will lead to large increases in welfare not measured well by traditional metrics such as gross domestic product (GDP). Others see much less promise in the new technologies (Gordon 2016). According to these views, measured productivity is likely to decrease, leading to slower future economic growth.

Other scholars have debated the future of traditional banking and payment practices. They ask whether digital transformation will mean that financial technology firms, online commerce and payment platforms, or social media platforms will replace traditional banks as providers of financial and payment services.

This chapter does not aspire to pass judgment on these opposing views, but rather to ask what challenges the new technologies might pose for policymakers, particularly those maintaining monetary and financial stability.

In approaching this subject, the chapter will focus on how new digital-based technologies have transformed, and are likely to further transform, financial intermediation (Section 4.2) and payment systems (Section 4.3), and the production and pricing of goods and services (Section 4.4). The chapter ends with some brief reflections on the possible consequences the current coronavirus (COVID-19) pandemic might have for the analysis and conclusions reached.

4.2 Implications for the Banking System and Financial Stability

4.2.1 The Advent of Big Data and Data Analytics

"Big data" and "data analytics" are important drivers of the digital transformation in banking and the financial system more broadly. Although there is no universally agreed definition, "big data" generally refers to very large structured and/or unstructured data sets containing tens of thousands of observations on bank customers, holders of insurance policies, users of online payment platforms, etc. Textual data can also be digitalized and made available for computer-aided analysis of content. Examples include the digitalization of documents containing the latest financial regulations so that these can be incorporated in compliance routines, newspaper articles to aid in the search for indicators of economic uncertainty, and reports by investment banks that may reveal market sentiment providing useful information for regulators.

These sources of information have, of course, existed for a long time, but it is only with the advent of inexpensive storage facilities, huge increases in computing power, and new analytical techniques capable of dealing with very large data sets that the full benefits of big data have been realized.

The analytical techniques that have enabled financial institutions to take advantage of big data are commonly known as "machine learning or "artificial intelligence". Logistic regressions, decision trees, random forests, and neural networks are examples of these techniques, which are sophisticated methods for discovering intricate, often nonlinear, relationships between variables. While the methods rely on advanced computer algorithms to discover patterns in the data, they do not do so without human input. First, the algorithms are conceived by humans, and humans typically decide which variables they will have access to when they search for patterns. But humans may also be involved in the process by which computers learn from the data. For example, in "supervised learning" by the computer, the analyst will tell the computer which variable is to be explained (e.g., the occurrence of a nonperforming loan), and which variables are to be used as possible explanatory factors, but the analysis need not impose a particular functional relationship between them. "Unsupervised learning," on the other hand, refers to a situation where the computer is simply given a data set and is tasked with finding patterns among the variables without being told specifically what to look for. A combination of the two machine learning methods is also possible where the analyst takes the output from the unsupervised learning, imposes some further structure on it, and proceeds to supervise the computer in a follow-up learning step. This method is referred to as "reinforced learning."

It is important to realize that in all three cases the methods typically cannot determine underlying causal structures, and that it is often difficult to explain the underlying reasons for the relationship patterns they identify.

4.2.2 Implications of Digital Finance for Traditional Financial Intermediation

Digitalization, and financial technology (fintech) more generally, have already changed many aspects of financial intermediation, and will continue to do so in the coming years. The changes apply both to the way intermediates operate internally and to the products, services, and experiences offered to customers. This section deals with traditional banks as well as new fintech institutions. The reason for combining the two is that fintech companies themselves are unlikely to pose existential challenges to the traditional banks as the latter will either adopt it themselves or acquire fintech start-ups. The case of BigTech may be different, and the challenges they pose will be taken up in Section 4.3 below.

Several back office and analytical functions have been transformed. Electronic *record keeping and account management* have of course been available for a long time, but it is now possible to use information from movements in accounts when proposing new investment products to customers or granting loans. Banks and other financial firms have introduced so-called "chatbots," which are virtual assistants like Apple's Siri except for financial services, that use natural language-processing technology to interact with customers. While early versions of these chatbots mostly dealt with providing account information, they are increasingly turning to giving advice on financial planning and investments.

Institution-wide *risk management* is another function that can be affected. Effectiveness can be improved by having a more comprehensive and precise view of the quantity and prices of assets and liabilities on the consolidated balance sheet, and algorithms can calculate risk measures and conduct stress tests based on alternative scenarios. The automation of gathering and treatment of the data decreases costs, enables obtaining more timely indications of changes in risk profiles, and allows management to concentrate on analyzing the results and take appropriate decisions rather than on searching for information.

Algorithm-aided *assessment of the creditworthiness* of borrowers can help reduce nonperforming loans. Big data and sophisticated classification algorithms are being used to estimate the probability that a loan will get repaid in full, based on several characteristics of the potential borrower. Credit-scoring techniques have of course already been used to assess creditworthiness, but the new algorithms are typically designed to detect more subtle relationships and are potentially more accurate.

Financial institutions that engage in *asset allocation activities* either on their own account or as a service to clients are using machine learning to aid in the set allocation. Machine learning algorithms can in principle detect correlation patterns between asset classes that are difficult to discern with traditional methods, thereby improving the risk-return profile of the investment portfolio.

Most traditional models employed to *forecast macroeconomic outcomes* use conventional linear regression techniques with varying degrees of complexity. Machine learning may be able to improve the accuracy of such forecasts by allowing for possible nonlinear relationships. A recent publication from the Bank of England, for example, argues that neural network models can beat conventional forecasting models of inflation in the United Kingdom. Private sector financial institutions are heavy users of forecasts both for internal use and in communications with clients, and machine learning is making inroads.

A survey of the use of artificial intelligence in financial services conducted jointly by the Cambridge Centre for Alternative Finance (CCAF) and the World Economic Forum (CCAF and WEF 2020) found that between 70% and 80% of the firms surveyed had already implemented or were in the process of implanting some form of artificial intelligence solution in their business model.[1] Not surprisingly, fintech firms were in general more active users of artificial intelligence, although only by a relatively small margin.

Artificial intelligence had been implemented most in risk management, followed by revenue-generating introductions of new products, customer service, process automation, and client acquisition (Figure 4.1). With business domains, payment processes benefited from artificial intelligence, particularly with respect to automation and risk management, whereas in investment management the generation of

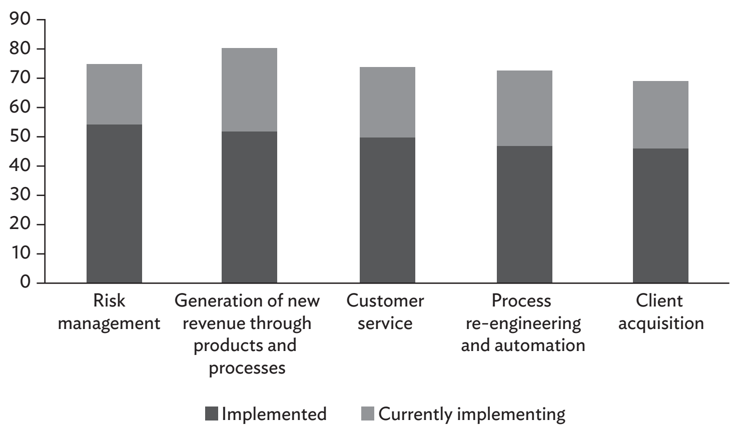
1 The survey obtained responses from 151 firms from 33 countries. Among the respondents, 54% were fintech firms with the remainder being incumbent financial institutions.

new revenue through new products and processes was the dominant incentive.

Another survey by CCAF focusing on the fintech industry in the Association of Southeast Asian Nations (ASEAN) region revealed that a majority of the firms in the industry were focusing on digital lending (32%) or digital payments (26%).[2] In terms of lending, peer-to-peer (P2P) lending to businesses was the dominant activity (52%), followed by P2P lending to consumers. In the payment space, mobile money/wallets/P2P transfers was the dominant segment (67%), followed by remittances and international transfers (65%).

Predictive analytics, e.g., logistic regression and decision trees, based on the availability of big data, were by far the most common techniques used by the ASEAN fintech firms.

Figure 4.1: Implementation of Artificial Intelligence in Fintech and Incumbent Financial Institutions (%)



Source: CCAF and WEF (2020).

2 CCAF, the Asian Development Bank Institute, and FinTechSpace (2019). The survey received data from 173 fintech firms operating in Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam. Data from an additional 35 firms operating in the ASEAN region were also used in the study.

4.2.3 The Challenge from BigTech

The developments just described will change the nature of financial services and how they are provided by incumbent financial institutions and new start-up fintech companies. But by themselves they are not likely to pose an existential threat to the traditional financial services industry. The arrival of new institutions, so-called "BigTech firms," may do so, however.

The term BigTech connotes firms such as Alibaba and Tencent in the People's Republic of China (PRC); Amazon, Google, and Facebook in the United States; Uber in Europe; and Grab in Southeast Asia. These companies did not start as financial services companies, but, taking advantage of their vast networks of customers and the consequent huge amount of data generated by these customers, they have entered into the business. In developed economies, their activities have so far focused mainly on payment services, but in emerging and developing markets they also offer lending, insurance, and asset management products (Financial Stability Board 2019).

BigTech companies are a source of numerous direct benefits for consumers, especially in emerging and developing economies where they have contributed substantially to the financial inclusion of previously unserved segments of the populations. Particularly important has been their engagement with small and medium-sized enterprises (SMEs), which traditional financial institutions have not served adequately. Particularly in lending, BigTech firms can use their wealth of data on payments and receipts of SMEs to assess creditworthiness and hence be in a better position to grant loans.

BigTech companies are also a source of indirect benefits for consumers by providing technology infrastructure to traditional financial institutions, and by encouraging innovation, diversification, and efficiency.

With their size and their extensive customer base and access to customer information, BigTech companies constitute a competitive threat to traditional banks that goes beyond that of fintech start-ups. While incumbent financial service providers can and do replicate many of the innovations of fintech, it is much more difficult to replicate the business model of BigTech because of the advantages the latter can extract from their vast information database on just about all aspects of their customers' behavior.

Hence it does not come as a surprise that incumbent firms view BigTech companies as a major competitive threat (BIS 2019, CCAF and WEF 2020).

4.2.4 Financial Stability Impact and Required Regulatory Response

Liberalization and innovation have traditionally preceded stresses in the financial system. The title of an article published in 1985 by the eminent Latin American economist Carlos Diaz-Alejandro is telling. Describing the experience of some Latin American economies in the late 1970s and early 80s, he titled his article "Good-bye Financial Repression, Hello Financial Crash (Diaz-Alejandro 1985)." This title also describes the chain of events that led to the financial crisis in Scandinavia in 1991–92, and, with some adjustments, to the Asian financial crisis in the late 1980s and the North Atlantic crisis of 2008–2009.

The basic mechanism is as follows. Deregulation and innovation enable expanding credit extension and engaging in new financial ventures without adequate understanding and appreciation of the underlying risks. The extension of credit leads to economic expansion, which makes the increased debt burden of the borrower seem tolerable, and the riskiness of new financial products is not well understood because, by definition, there is no or very little past data to guide decisions. The result is overextended borrowers and over-leveraged lenders; when the tide turns, turmoil ensues.

What does this have to do with digital transformation of finance? There are several possible reasons why financial stability may be at risk. The emergence of new types of financial services institutions is akin to financial liberalization, as some of the activities of these institutions lie outside the perimeter of the regulatory system. Innovations brought by fintech and BigTech include the introduction of products whose risk characteristics are not well known, and which can have systemic stability consequences. For example, rapid growth of P2P lending by fintech firms may in some jurisdictions lead to an increased incidence of nonperforming loans in the absence of a robust regulatory response. Indeed, according to the survey by CCAF on practices in ASEAN economies, several activities of fintech companies are unregulated. In addition, greater competitive pressures, particularly from BigTech firms, may reduce the franchise value of incumbent institutions, inducing increased risk taking on their part.

Machine learning and artificial intelligence may also amplify systemic risk as risk management functions in financial institutions optimize compliance with the existing regulatory framework. If the algorithms lead to solutions that are similar across institutions, the result may be a financial system that is increasingly procyclical when shocks materialize (Danielsson, Macrae, and Uthemann 2017).

Similarly, if several traditional financial service providers rely significantly on a small number of BigTech firms to provide technological solutions to some of their business processes, a type of single-point-of-failure risk may materialize for many of the traditional firms.

Regulators must be vigilant and ready to adapt to the new financial landscape. As some activities of unregulated institutions are indistinguishable from the same activities in regulated institutions, there is a risk of regulatory arbitrage. It is therefore imperative that regulatory frameworks be adjusted to focus on activities rather than on institutions.

4.3 Digital Transformation of the Payment System

Payment systems have evolved and digitalization has been an important contributor. Transfers are now more rapid as real-time gross settlement systems have been introduced in many jurisdictions for wholesale payments and fast payments for retail transactions are becoming more common.

The decreased cost of cross-border transfers has been noted as one of the important potential benefits of using financial technology. This is the case in particular for the cost of remittances. According to World Bank data quoted by The Economist (2019), in 2018 the average costs of sending $200 through banks and fintech firms were 8% and 4%, respectively, with traditional money transfer firms lying in between. These differences lead to huge benefits for countries like the Philippines, where remittances amount to close to 10% of GDP.

Fintech applied to payments has also contributed significantly to financial inclusion, whereby formerly nonbanked individuals and households have not only been able to carry out transactions via mobile phones, but also access simple financial services in the form of placing deposits and receiving loans.

The systemic financial stability risks of the entrance of fintech companies operating in the payment system are modest as long as their operations are limited to transactions, and as long as they do not dominate the overall payment system. If payment innovators use their position to enter credit extension activities this benign situation may change, particularly if they remain unregulated as lenders. As noted above, if they encroach on the credit extension business of traditional intermediaries, the franchise value of the latter may be threatened, leading them to pursue riskier lending to preserve their market share. As with the entrance of BigTech companies in the credit extension business, regulators will need to monitor payment innovators on an activity, rather than an institutional, basis.

While fintech payment companies do not constitute a threat to the business model of banks, another innovation made possible by advances in technology might: cryptocurrencies. The threat is not from the current collection of privately issued cryptocurrencies such as Bitcoin and the like. These should not be considered money in the conventional sense of being units of account, means of payment, and stores of value; rather, they are speculative assets, and, as such, do not encroach significantly on intermediation activities of banks and other financial institutions. The Libra project floated by Facebook could have had an impact on the structure of banking, not principally through its role as a payment vehicle but rather as a means for Facebook to enter the financial services industry providing deposit, lending, and asset management facilities.

Unlike Bitcoin and other similar cryptocurrencies, Libra promised to maintain a stable value relative to a government fiat currency or a basket of such currencies. This constitutes its fatal flaw, because we have learned from countless efforts to fix currency values that success in doing so requires holding inventories of the fiat currency that are at least as large as the outstanding stock of the Libra. Combined with the unreceptive attitude of central banks and regulators towards the project, the threat from Libra to banks is not likely to be significant.

A threat to bank intermediation could, however, come from cryptocurrencies issued by central banks, so-called central bank digital currencies (CBDC). These are digital means of payments guaranteed in value by the central bank in terms of the domestic fiat currency. The central bank can live up to this promise because it is the issuer of the domestic currency. A CBDC can take one of two forms: a token-based form that is issued by the central bank but managed by the banking system, or an account-based form whereby individuals would have accounts with the central bank denominated in the CBDC. It is the second form that could lead to substantial challenges for the private sector intermediation system. Since accounts with the central bank would be less risky than accounts with commercial banks, there is a risk that such a system would lead to disintermediation of the banking system. For this reason, it is likely that the implementation of any CBDC would be a token-based model.

4.4 Macroeconomic Consequences of Digital Transformation

Digital transformation is also taking place in the nonfinancial sectors of the economy. Industrial robots are increasingly used in manufacturing, online commerce has been growing rapidly, globalization of production chains has upended traditional production processes, etc.[3] These changes have important implications for how we should think about economic growth and for the sources and consequences of macroeconomic fluctuations and what the appropriate policy responses should be. The next section discusses each of these issues in turn.

4.4.1 Will Digital Transformation Bring about a New Industrial Revolution?

The conventional way to think about economic growth is in terms of a relationship between the economy's output per capita and inputs such as physical and human capital per capita on the one hand, and a residual that captures the state of the available technology, broadly defined, on the other. Economic growth in this framework can come about through investment in physical and human capital in excess of population growth and technological progress.

In a balanced growth environment where investments are just enough to equip the growing labor force with the existing amount of capital and skills, growth will come about exclusively through technological progress, or "total factor productivity" as it is called in the technical literature. The issue of whether digital transformation will bring about a burst of economic growth then hinges on its effect on this total factor productivity.

Nobel Laureate Robert Solow famously said about the effect of computers on economic growth that "[y]ou can see the computer age everywhere but in the productivity statistics," suggesting that early digitalization did not lead to measurable increases in growth (Solow 1987). Could it be that the effects of more recent developments in robotics, autonomous vehicles, and internet availability will also fail to show up in productivity statistics?

One of the proponents of this view is Robert Gordon, who points to the decline in total factor productivity growth in the United States since 1970 to less than 1% per year, following the historically high growth rate of close to 2% per year during the 50 years from 1920 to 1970 (Figure 4.2). According to Gordon, the strong total factor productivity growth in that period was the consequence of the application of electricity in manufacturing, transport, and communication, the internal combustion engine, and devices such as the telephone and the radio, and

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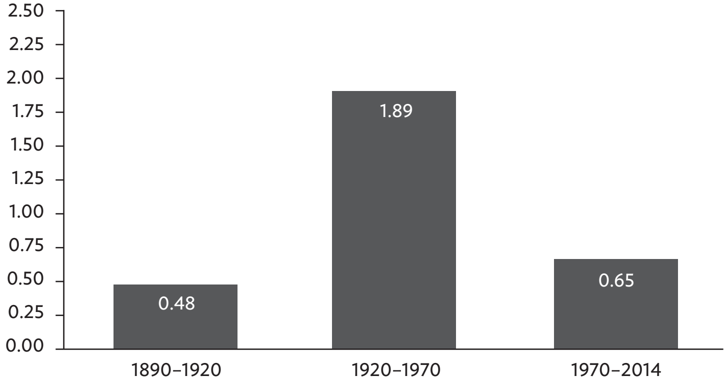
3 The importance of global production chains, and the disruption that ensues when the chains are damaged, is being demonstrated all too clearly as this is being written (March 2020) in the midst of the COVID-19 pandemic.

Figure 4.2: Average Annual Growth Rates of Total Factor Productivity (%)



Source: Gordon (2015).

to the increasing availability of running water and sewage that improved health and longevity.[4]

Gordon's views have not gone unchallenged. According to some authors, digital transformation of the entire economy, not just the financial sector—industrial robots, self-driving cars and trucks, the "internet of things"—driven by artificial intelligence has the potential to increase productivity far beyond what we have seen in the recent past (See, for example, Brynjolfsson and McAfee 2014).

According to this view, several features of the current wave of digital transformation are said to be different from past information communication technology developments and will therefore have a greater effect on productivity and well-being. First, much of the current digital transformation is about the production of ideas rather than the production of goods. Furthermore, ideas are public goods, and because a large proportion of them are shared on the internet, their reach is global and available for anyone to build on and improve. Networks of innovators can be formed, and the shared knowledge and progress will be much more rapid and widespread, spurring additional ideas. Second, many of the internet-based services that have great value (e.g.,

4 For a comprehensive treatment, see Gordon (2016).

online shopping, online translation) are available free of charge and are therefore not measured in GDP and hence in productivity statistics even though they are of great value.

In contrast to these optimistic scenarios, the easy scalability of digital transformations may contain seeds whose effects are less benign. Combined with large setup costs and very low marginal costs of expansion, it is possible that concentration and market dominance will emerge. That in turn could lead to increased inequality and reduced motives for innovation.

I will not attempt to evaluate which of the two views of the future of growth will prevail.[5] Instead, I will briefly discuss what the potential consequences could be for macroeconomic stability and stabilization policy, the principal objective of this chapter.

Stabilization policy is, by definition, concerned with short- to medium-term fluctuations in economic activity around its longer-run potential path. If the longer-run path is uncertain, so will be any measure of the deviation therefrom. If monetary and fiscal policies are calibrated to erroneous measures of economic activity gaps, the resulting policy stance will be inappropriate.

A related issue concerns modeling, and particularly a standard modeling of inflation. The conventional approach is to relate inflation pressures to some measure of slack in the economy, usually measured by an output gap measure. Could it be that difficulties encountered in explaining inflation are due to difficulties in measuring the relevant output gap?[6] More research on these issues is warranted.

4.4.2 Global Value Chains, the Phillips Curve, and Monetary Policy

This is being written as the COVID-19 pandemic is ravaging the globe. The economic fallout of the pandemic and the measures taken in attempts to contain it have brought home how immensely interwoven a country's different economic regions and sectors are. A manufacturing firm in one region has to curtail its operations because it cannot obtain the required parts produced by another firm in another region. As a consequence, the firm is unable to ship its products that are crucial for

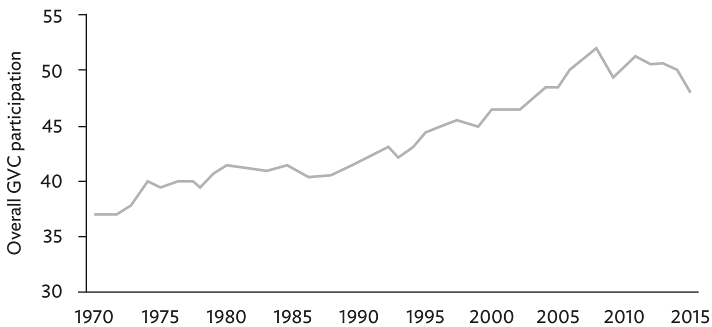
5 Making any long-term economic predictions is notoriously difficult, but it is perhaps particularly hazardous when it involves new technologies. Many embarrassing quotes can be mentioned, but one of the classics is attributed to Ken Olsen, founder of Digital Equipment Corporation, who in 1977 allegedly opined that "[t]here is no reason anyone would want a computer in their home."

6 Remember that one of the consequences of digital transformations in the economy is that GDP is a flawed measure of economic activity.

the assembly of the final product, which is carried out in yet another region by yet another firm.

Replace "regions" in this example with "countries" in the global economy and we have a description of global value chains (GVCs). The importance of these GVCs has increased over time as digitalization has facilitated fragmentation and outsourcing of production to take advantage of different comparative advantages and economies of scale. As illustrated in Figure 4.3, the importance of GVCs increased steadily during the period from 1970 to the global financial crisis, after which it declined somewhat.

Figure 4.3: The Evolution of Global Value Chains (%)



GVC = global value chain.

Note: The chart measures "GVC participation," which is defined as the share of world exports that flow through at least two borders.

Source: World Bank (2020).

The implications of production chains, and GVCs in particular, are that they tie regions and economies more closely together. A dislocation in supply in one part of the chain, a supply shock, will propagate throughout the system, decreasing output in the system as a whole, be it the entire domestic economy in the case of domestic supply chains or the world as a whole in the case of GVCs.

Likewise, an increase in demand for the final output will propagate throughout the production system as the demand for intermediate inputs will increase.

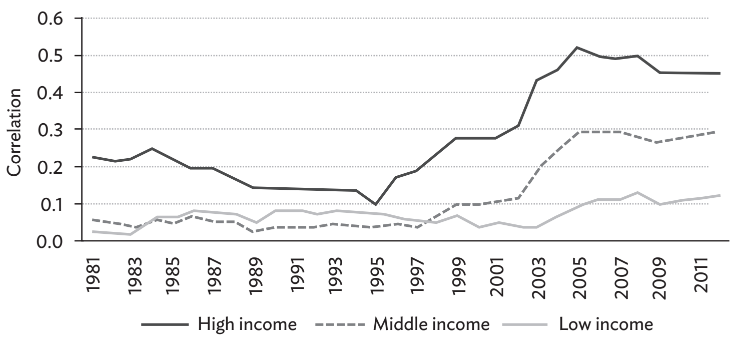
Price developments will also become more global, as the price of the final output will depend not only on the cost of production locally but on the additions throughout the value chain. Inflation rates will become more closely linked across economies.

Data on linkages across economies are consistent with these predictions. Figures 4.4 and 4.5 show the correlations of business cycles and inflation rates, respectively, across countries. For high-income countries in particular, the increase in these correlations is similar to the increase in GVC participation shown in Figure 4.3.

Statistical work presented in the World Bank's 2012 World Development report lends some formal support to the visual impressions in the graphs. Country pairs that have greater trade connectedness also have higher correlations of business cycles and inflation (World Bank 2020, Chapter 4).

What are the implications for macroeconomic stability and stabilization policies? The most obvious is that greater connectedness means that policy spillovers will be stronger, making some form of policy consultation between country authorities more desirable. To some extent, this is already taking place in fora such as the Group of 20, the Bank for International Settlements, and the International Monetary Fund. While formal policy coordination may not be achievable because authorities in every country are accountable to their own constituents, some tacit agreement to proscribe polices that directly harm others, so-called "beggar-thy-neighbor policies," would be desirable.

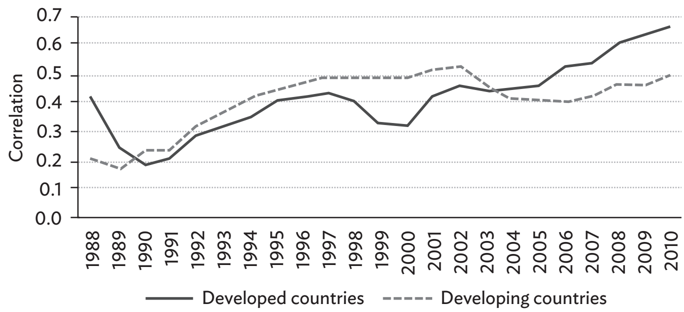
Figure 4.4: Correlation between Business Cycles



Note: Each year represents the midpoint of a 10-year moving window. Each line represents the average of all detrended country-pair gross domestic product correlations, taken over all country pairs containing at least one country in the income group considered (high, middle, and low).

Source: World Bank (2020).

Figure 4.5: Correlation of CPI Inflation Rates



CPI = consumer price index.

Note: For each country, the correlation is measured between domestic and world inflation. An average is then taken across two income groups separately. Each year represents the midpoint of a 15-year rolling window.

Source: World Bank (2020).

At the national level, the increased importance of GVCs appears to have changed inflation dynamics. A 2017 study by Auer, Borio, and Filardo at the Bank for International Settlements indicates that, as GVCs have increased in importance, the output gap in domestic inflation has decreased, and the role of a measure of a global output gap increased. There are also studies suggesting that the Phillips curve has become flatter, i.e., that the coefficient on domestic economic slack (or overheating) in an estimated inflation equation has become smaller (See, for example, Carney 2017). If this last finding is indeed a feature of the new economic structure central banks are facing, it begs the question as to how they can hope to implement inflation-targeting strategies successfully.

4.5 Reflections on the Possible Implications of the Coronavirus Pandemic

As noted, this is being written in the midst of the 2020 COVID-19 pandemic that has created unimaginable human suffering and great economic upheaval. As it unfolds, it is hard to imagine that the world will return to what it was only half a year ago. In this final section I will look at only a small corner of this very broad and important question. Specifically, I will make two brief remarks on how the analysis and conclusions in this chapter could be affected by this momentous experience.

A salient feature of the digital transformation of finance is that artificial intelligence is challenging financial intermediation and payment services that are based on personal contacts. The social distancing that has been mandated or highly recommended during the pandemic increases the competitive advantage of the virtual business model. Entities that have a broad access to potential customers, either through their social media presence or their internet-based commerce engagement, will be particularly strongly positioned to expand in this environment. These are the BigTech firms.

I have already suggested that, because of their ability to take advantage of scale, there is a risk of greater concentration in the financial intermediation industry, and hence a greater risk of monopoly pricing, cybersecurity challenges, and too-big-to-fail problems. Regulatory authorities must be vigilant and make sure that the financial services activities of these firms are appropriately regulated.

The discussion on the macroeconomic stability effects of digital transformation focused primarily on the consequences of increased interconnectedness brought about by production chains, both regional and global. Some of the economic havoc brought about by the COVID-19 pandemic is the result of this interconnectedness. The business case for some fragmentation of production processes will certainly remain, but one cannot rule out that there will be some retrenchment. This may give back some of the effectiveness of domestic economic policies lost to global influences, but it would also reduce some of the benefits from trade, which would be particularly painful for small trade-dependent developing and emerging economies.

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5

Fintech Development in the People's Republic of China and Its Macroeconomic Implications

Yiping Huang

5.1 Introduction

The People's Republic of China (PRC) successfully maintained macroeconomic stability during much of the reform period. Until recently, the PRC's gross domestic product (GDP) growth stayed within a relatively narrow band, while inflationary pressure remained very modest. Stable macroeconomic conditions are often regarded as one of the key factors contributing to the PRC's economic miracle (Dollar, Huang, and Yao 2020). However, over the last few years, the situation has started to change. For instance, GDP growth decreased steadily from 10.6% in 2010 to 6.1% in 2019. Financial risks also emerged in various parts of the economy. In this chapter, we take a close look at the latest development of financial technology (fintech) in the PRC and draw implications for its macroeconomic stability.

Fintech is currently revolutionizing the world's financial landscape at an extraordinary pace (Gomber et al. 2018; Goldstein, Jiang, and Karolyi 2019). This transformation is even more profound in the PRC (Chen 2016; Xiao et al. 2017; Huang and Huang 2018). Each of the two leading PRC mobile payment service providers, Alipay and WeChat Pay, has around 1 billion active users. Many of these users organize their daily lives around payment ecosystems, from making doctor's appointments to purchasing air tickets, and from paying electricity bills to investing in financial products. Each of the three main online banks, WeBank, MyBank, and XWBank, with between 1,000 and 2,000 staff, extends around 10 million loans annually for individuals and/or small and medium-sized enterprises (SMEs). Fintech development in the

PRC has attracted widespread international attention (see, for instance, Frost et al. 2019; Klein 2019).

In many ways, the PRC's fintech sector looks different from those in the developed world. While in North America and Western Europe much attention is placed on cryptocurrencies and cross-border payment, in the PRC, most of the headline news cover mobile payment and online lending. The PRC's fintech landscape is dominated by a small number of unicorn players such as Ant, Tencent, Baidu, and JD Digits.[1] Unlike many of their developed country counterparts, most PRC fintech companies directly offer financial services by utilizing digital technology, i.e., big platforms linking large numbers of mobile terminals, cloud computing, and big data analysis. This often generates productive results but, at times, also causes serious problems, such as privacy invasion. Perhaps the most striking feature of the PRC's fintech industry is its "inclusion"—it improves access to financial services by SMEs and low-income households on scales never seen before in human history (Huang and Huang 2018; Chong et al. 2019).

The PRC's fintech sector also evolved dramatically over time. It started in December 2004 when Alipay first came online, although the real boom did not begin until June 2013, when Ant Financial successfully launched its online money market fund Yu'ebao. From 2014, the Government Work Report, which is delivered by the Premier at the National People's Congress at the beginning of the year, has mentioned "internet finance" (the PRC term for fintech) almost every year, but the tune gradually shifted from appraising innovation to warning of risks. The PRC once developed the world's largest online peer-to-peer (P2P) lending industry, with more than 6,000 platforms cumulatively. After the government started to introduce proper regulation from late 2015, however, the industry gradually collapsed (Wang, Shen, and Huang 2016). One failed P2P, E'zubao, involved almost 1 million online investors. It became a source of social tension as well as financial stress.

While the PRC's fintech sector has achieved unprecedented success in improving financial services, it has also created serious financial risks and social problems. The sector as a whole is still in its early stage of development. Many of the business models are not yet well developed.

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1 Ant Group is affiliated with the e-commerce giant Alibaba, owns Alipay, and sponsors MyBank. While Tencent started business in online games, it is probably most widely known for its social media service WeChat, on which it also built WeChat Pay and sponsored WeBank. Baidu specializes in search engines in PRC texts, owns a financial arm, Duxiaoman, and also formed a joint venture bank, Baixin Bank, with Citic Bank. JD Digits, which was previously known as JD Financial, is affiliated with the e-commerce giant JD and owns numerous financial licenses.

Some newly invented risk control approaches, such as big data-based credit-scoring models, still need to be tested through full financial cycles. The authorities are yet to bring the sector under full coverage of financial regulation and to formulate new methods of regulation in order to balance innovation and stability. All these changes will likely have important implications for macroeconomic stability in the PRC.

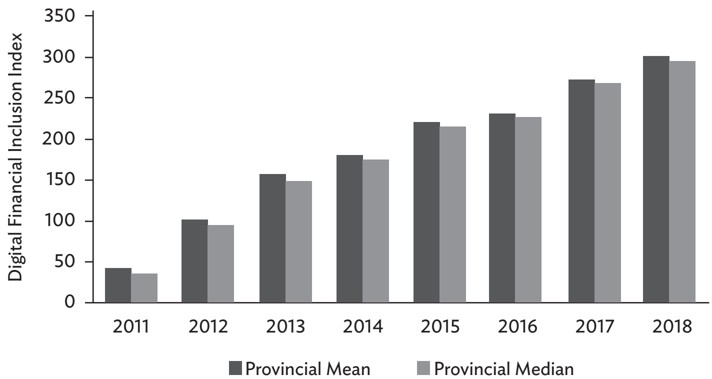
The remainder of the chapter is structured as follows. In section 5.2, we take stock of the recent fintech development in the PRC, with special attention on the development of mobile payment services and data-based online bank lending. In section 5.3, we document the key financial risks in the fintech sector, by focusing on the P2P lending industry as a case study, and draw some implications for financial regulation. In section 5.4, we briefly introduce the People's Bank of China's (PBC's) digital currency/electronic payment (DC/EP) system—its design, key features, and likely impact on the fintech sector and the broad financial industry. In section 5.5, we discuss the likely implications of fintech development for macroeconomic stability, followed by some concluding remarks in the final section.

5.2 Recent Fintech Development

The PRC's first online payment transaction took place on 18 October 2003. A university student in Xi'an bought a second-hand Fujifilm camera for CNY750, on Alibaba's newly established e-commerce platform T-Mall, from a PRC student studying in Yokohama, Japan. But it was difficult to complete the transaction because of a lack of trust between the buyer and the seller. In the end, Alibaba had to provide a guarantee for the transaction: the buyer would first send money to Alibaba, then Alibaba would advise the seller to mail the camera to the buyer, and once the buyer had confirmed receipt of the camera, Alibaba would wire the money to the seller. Even with this guarantee, Alibaba's customer officer still took hours to convince the buyer to proceed with the transaction. This was the beginning of the PRC's fintech development, which confirms that most fintech products are created to satisfy real demand.

Today, the PRC is a global leader in many fintech businesses. According to the 2018 edition of "Fintech100," PRC companies occupied three of the top five places, with Ant Financial, JD Finance, and Baidu in first, second, and fourth place, respectively (H2 Ventures and KPMG 2018). To proffer a bird's-eye view of fintech development in the PRC, we first introduce the Peking University Digital Financial Inclusion Index of China, which quantifies annually the PRC's fintech development,

Figure 5.1: Provincial Means and Medians of Digital Financial Inclusion Index, 2011–2018



Source: Guo et al. (2020).

disaggregated at provincial, municipal, and county levels, as well as for different businesses including mobile payment, online lending, digital insurance, online investment, and other digital financial services (Guo et al. 2020).[2]

The index reveals at least two important characteristics. One is extraordinary growth. The median of provincial indices was 33.6 in 2011, and rose to 294.3 in 2018, implying an average growth of 36.4% per annum (Figure 5.1). As a comparison, the newly increased total social finance of the formal financial sector rose from CNY12.8 trillion to CNY19.3 trillion during the same period, recording an average growth rate of 6%.

The second characteristic is a clear trend of convergence. The highest-to-lowest provincial index ratio dropped from 50.4 in 2011 to 1.4 in 2018, revealing dramatic narrowing of provincial gaps. Data at the municipal level also show that the inland regions caught up with the east coast region rapidly between 2011 and 2018, exhibiting an important quality of inclusion (Guo et al. 2020).

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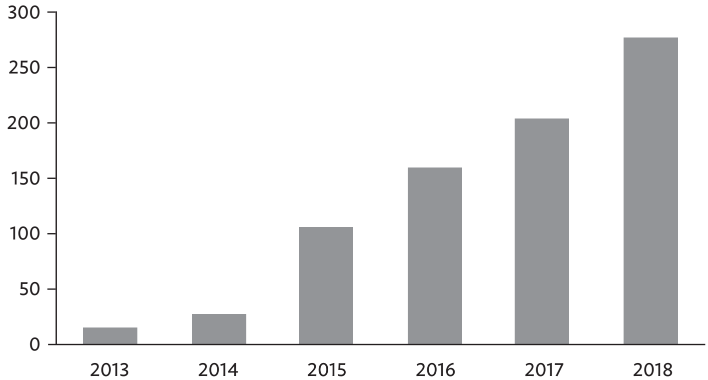
2 The Peking University Digital Financial Inclusion Index of China was developed by Peking University's Institute of Digital Finance, in collaboration with Ant Financial. https://en.idf.pku.edu.cn/docs/20190610145822397835.pdf

Figure 5.2: Transaction Value of Mobile Payment in the PRC, 2013–2018 (CNY trillion)



PRC = People's Republic of China.
Source: CEIC database, People's Bank of China.

In 1935, a PRC economic geographer, Hu Huanyong, drew a line on the map of the PRC from Heihe in Heilongjiang to Tengchong in Yunnan, which later became known as the "Hu Huanyong Line" (Hu 1935). On the right side of this line, about 46% of the total land area supported 96% of the population. Western PRC lags in economic development, even today. However, recently, with the help of technology and innovation, fintech crossed the Hu Huanyong Line for the first time and moved rapidly into many regions in the western part of the country.

At the disaggregated level, fintech development has been more successful in mobile payment, online lending, digital insurance, and online investment funds. Due to concerns about money laundering and financial instability, the authorities banned trading in cryptocurrencies and initial currency offerings. Currently, however, the People's Bank of China (PBC) is actively exploring issuance of its own version of sovereign digital currency: DC/EP.

Mobile payment is the most prominent fintech business in the PRC, and started as a means to support e-commerce. It benefited from a rapid increase in the penetration rate of smartphones, which makes it possible to use mobile payment services anywhere, any time. The success of Ant Financial's money market fund Yu'ebao, which was launched in June

2013, significantly boosted the society's awareness of, and enthusiasm about, fintech, including mobile payment. The distribution of red (cash) envelopes on WeChat Pay during the PRC New Year holiday in 2014 helped attract hundreds of millions of new users. The adoption of the Quick Response code, starting from 2017, made it possible for any businesses, formal or informal, to use the mobile payment service by printing out the code on a piece of paper.

The last few years witnessed rapid expansion of the PRC's mobile payment business, in terms of users and transactions. The number of active users of Alipay increased from a little over 100 million in 2013 to 900 million in 2018, while that of WeChat Pay grew from about 350 million to 1.1 billion during the same period. The total transaction value jumped from CNY14.5 trillion in 2013 to CNY277.4 trillion in 2018, recording an annual growth rate of 80% (Figure 5.2). The share of mobile payment in total noncash payment value rose from less than 1% to 7.4% during the same period, while the share of mobile payment in the total number of noncash payment transactions increased from 3.3% to 27.3%.

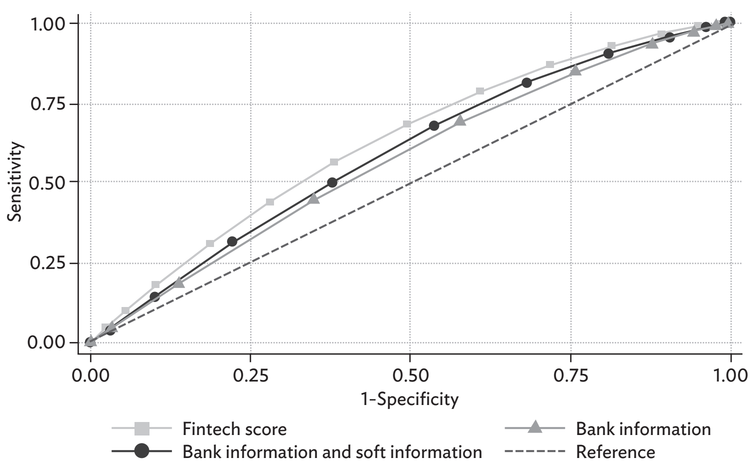
Perhaps the most impressive development concerning mobile payment is the ecosystems built around it. Today, users can organize their daily lives around the payment app. These ecosystems not only make people's lives easier, but also bring about significant changes to the broader financial sector and the economy. Facilitated by mobile payment, e-commerce now accounts for more than 20% of total retail sales, with major consequences for offline supermarkets and department stores. Commercial banks also started to reduce the number of branches and lay off employees.

Another prominent fintech business is online lending. Here, there is a tale of two online lending models—one refers to the P2P lending platforms and the other points to the new online banks. In general, the former largely failed, while the latter is functioning well so far. These two types of institutions are distinguishable in several ways. While the online banks are licensed from the beginning, most of the P2Ps are not properly regulated. According to the current regulation, the banks can engage in credit intermediation, while a P2P can only serve as an information intermediary. The most important distinction between the two, however, lies in their abilities to assess and control financial risks. Most of the P2Ps do not have the necessary means of controlling either the adverse selection problem or the moral hazard problem.

The online banks, WeBank, MyBank, and XWBank, all created their own credit-scoring models based on machine learning and big data analyses (Gambacorta et al. 2019). They provide loans to SMEs and low-income households, which often lack historical data, fixed assets, and government guarantees. In 2017, MyBank had a total of 377 employees but extended 5 million SME loans. WeBank was built on social media data, MyBank started with e-commerce information, and XWBank established an open banking system to connect with other existing platforms. For instance, WeBank assesses creditworthiness by looking at one's work office environment, residential property quality, close social media friends, and other digital footprints. In a similar way, MyBank invented the so-called "310 model"—it takes the customer 3 minutes to apply, the approved loan amount is in the borrower's account within 1 second, and there is no human interference in this whole process. Existing evidence suggests that fintech credit-scoring models based on big data and the machine learning method outperform the traditional bank approaches, as illustrated by a higher receiving operating characteristic curve for the fintech credit model than others (Figure 5.3).

Other prominent fintech businesses include digital insurance and online investment. During the last few years, several financial institutions and fintech companies have tried to develop a robo-advisor service for individual investment and crowdfunding but they have made very limited progress so far.

Figure 5.3: Receiver Operating Characteristics Curve for Credit Scoring Models



Source: Gambacorta et al. (2019).

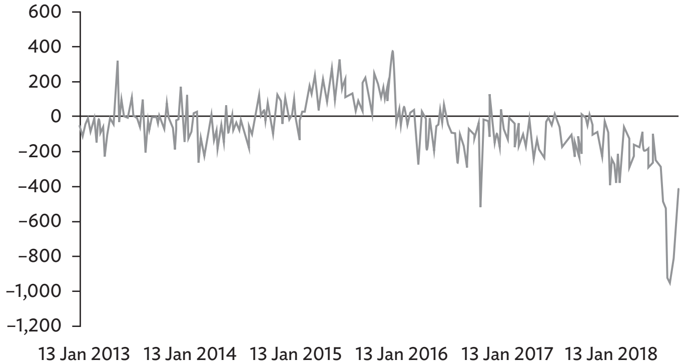
5.3 Evolving Financial Risks

In retrospect, three main factors probably contributed to the unusual success of the PRC's recent fintech development. The first factor was a supply shortage in the traditional financial industry. After 40 years of economic reform, the PRC has already built a gigantic financial industry; nonetheless, some economic entities, especially SMEs and low-income households, are not well serviced financially. For instance, only about 20% of PRC SMEs have ever borrowed from the banks, compared to 50% in the United Kingdom (UK). Therefore, the new fintech products have often been enthusiastically embraced by the market. The second factor is the rapid development of digital technology, particularly the BigTech platforms, cloud computing, and big data analyses. By connecting to hundreds of millions of users and reducing information asymmetry, fintech business models mitigate two important problems in financial transaction, i.e., adverse selection and moral hazard problems. A further factor is tolerant financial regulation. Seeing the potential benefits of fintech products in filling gaps in the markets, the regulators did not go out to end these practices abruptly. This provided the window for fintech companies to experiment with their innovation.

This last factor was likely also behind the very volatile sentiment in the fintech industry (Figure 5.4). During much of the past decade or so, the fintech industry has been largely unregulated. For instance, Alipay first came online in December 2004, but it did not obtain an official payment license from the central bank until May 2011. Again, the first P2P, Paipaidai (PPD), was established in June 2007. In the following years, thousands of other platforms were created. The authorities adopted the first temporary regulation of P2Ps in August 2016. For many years, the fintech players were left to do almost whatever they wanted. Such a regulatory environment led to risky business practices and even Ponzi schemes.

The discussion here focuses on the P2P sector as a case study, which shows that its development trajectory was actually a result of dynamic interactions among real economic demand, credit culture, and the regulatory environment. Like its counterparts in the United States (US) and the UK, PPD was initially set up as an information intermediary. This means that the platform did not provide any guarantee or pool the funds. Lenders and borrowers can transact directly on PPD's system, which sounded like a revolution, as most of the borrowers would not be able to obtain loans from the banks and the lenders can now receive higher returns. Since the interest rates were not regulated by the central bank, such transactions could also be viewed as a de facto method of interest rate liberalization. There is only one small problem with such

Figure 5.4: Peking University Fintech Sentiment Index



Note: The sentiment was measured by both positive and negative subindices, using 18 million news articles during the period covered. The measure plotted in this figure is the net sentiment.

Sources: Institute of Digital Finance, Peking University; Wang and Huang (2018).

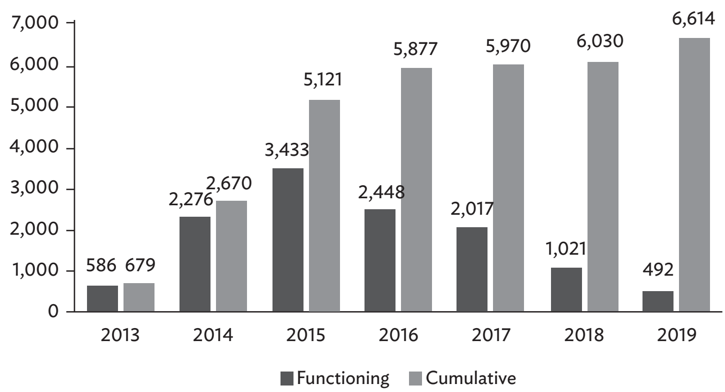
a seemingly wonderful financial innovation: How to control financial risks? The borrowers and the lenders never met before. The platforms could neither access the central bank's credit-scoring system nor engage in risk intermediation, making it impossible for the lenders to evaluate and control adverse selection and moral hazard problems (Wang, Shen, and Huang 2016).

In order to continue the business, P2P operators were forced to change their practices, by pooling the funds and providing guarantees. These activities literally turned the P2P platforms into de facto banks, however, they were not regulated as banks, as they are not subject to the usual capital adequacy and reserve requirement regulations. These made the P2P platforms excessively vulnerable for several reasons. First, because they are not properly regulated, public sentiment toward the platforms was very volatile. Any bad news could result in runs on the platforms. Second, the platforms often did not have much capacity to withstand losses of funds because they did not have the capital or liquidity buffers. Third, most platforms did not have effective ways to collect debts from the borrowers. If a borrower decided not to repay the debt, the costs for the platform to recover the debt would be very high. Zhang and Huang (2018) even discovered what they described as a "reversal run" on the platform. By looking at individual borrowers' data, they found that "low credit score" borrowers were more likely to borrow when the platform appeared to be vulnerable, in the hope that nobody would collect the debt from them if the platform collapsed.

It is, therefore, not difficult to imagine, when the temporary regulation requiring the P2Ps to only function as information intermediaries was announced in 2016, that most of the platforms had to find ways to exit from the industry. The collapse of P2Ps was unfortunate. But the total outstanding loan amount in the peak year, 2017, was CNY1.2 trillion, which was only about 1% of the total outstanding loans by commercial banks. However, the social impact was much greater, as the sector involved a large number of investors. Most of these investors did not have the ability to both understand and accept investment risks. In a way, the collapse of P2Ps in many PRC cities is a bigger concern for social stability than for financial stability.

This suggests that, in the current PRC credit environment, P2P is probably not a viable business model. This conclusion could change if the platforms could effectively reduce information asymmetry by either accessing the central bank's credit data or independently analyzing credit risks. This implies that probably only a small number of platforms can exist in the PRC market. However, because of the absence of regulation, the number of "cumulative" platforms reached more than 6,000 (Figure 5.5). After 2016, the number of "functioning" platforms declined

Figure 5.5: Total Number of P2P Platforms in the PRC, Functioning vs. Cumulative



P2P = peer-to-peer, PRC = People's Republic of China.

Source: WDZJ.com (accessed 24 September 2020).

sharply. In 2019, it fell to 492. But even this number is not sustainable, as most of them still do not satisfy the regulatory requirements.

The experiences of P2Ps and other fintech businesses during the past decade or so offer some important implications for regulation. Currently, the PRC financial regulatory framework consists of four core institutions: the central bank, the banking and insurance regulator, the security regulator, and the local financial regulation bureaus. Each regulator is responsible for regulating a set of financial institutions, coordinated by the State Council Financial Stability and Development Commission. This system is incompatible with the current financial practice in the PRC, especially the fintech businesses. In fact, there are several lessons to be learned from the experiences of fintech development in terms of financial regulation.

The first lesson is that all financial transactions need to be regulated. The industry-segregated approach to regulation often leaves out many financial activities that do not fall into the traditional categories of financial institutions. Shadow banking and fintech were very important new financial activities in the PRC, but were unregulated or underregulated. Financial activities need to be closely regulated because financial risks often change quickly, with economy-wide amplifying consequences. Given the reasons already discussed, most of the P2Ps should not have existed. This probably requires the regulators to change their institution-focused approach to an institution- and function-focused approach. Anybody who wants to engage in financial services should have the necessary qualities and apply for a license.

The second lesson is that a new regulatory framework needs to be devised to adapt to a de facto universal banking business model. All of the leading fintech players in the PRC, i.e., Ant Financial, JD Financial, Baidu, and Tencent, all own multiple financial licenses. This does not necessarily mean that the PRC should combine all the financial regulators. For instance, the US adopted a segregated regulatory systems while the UK adopted the twin-peak framework. Both the UK and the US are able to monitor and regulate cross-industry fund flows and risk transmission. In the case of the PRC, one urgent task is to improve the coordination of regulatory policies.

The third lesson is that the regulators also need to use policy tools to monitor and regulate financial risks. With fintech, especially BigTech platforms, the speed and breadth of risk spreading is unprecedented. Routine reports by financial institutions, or on-site/off-site inspections, are not sufficient to grasp the problems. Regulators also need to apply digital technologies to improve their regulatory capability. Regulatory technology should be capable of benefiting regulators in many ways (Sheridan 2017). Zhu and Zhou (2016) revealed that digital technologies such as blockchain help solve the problems of regulatory compliance and security of fund management by developing a distributed voting system for crowdfunders. Beijing's local financial regulatory bureau also created a "smoke index," which monitors the risks of P2Ps in real time.

The final lesson is that regulators should try to balance innovation and stability. Good innovations can bring huge benefits, while bad innovations can cause immense damage. But it is not always crystal clear whether an innovation proposal is good or bad. One of the practices adopted by regulators in other countries is the so-called "regulatory sandbox", which is an experimentation space that allows a firm to make its advice platform available to a limited number of financial consumers. By reducing time and cost, as well as enabling greater access to finance for innovators, it helps to deliver more effective competition in the interests of consumers (FCA 2015). To engage with the fast-paced developments in the fintech industry, it is necessary to rationally evaluate the costs and benefits of market innovations by adopting a regulatory sandbox regime in the PRC. In this way, PRC regulators will have a more informed context in which to navigate their regulatory priorities and build a regulatory environment where such new fintech business models will thrive in appropriate approaches.

5.4 Digital Currency/Electronic Payments

While the authorities banned trading of cryptocurrencies and initial currency offerings due to concerns about money laundering and financial instability, the PBC began to study central bank digital currency from as early as 2014. In 2017, it established its own Institute of Digital Currency, and, in late 2019, senior PBC officials disclosed that the central bank had completed top-level design, standard setting, function development, and operational testing of the digital currency and had started implementing trials in certain areas. In fact, the digital currency could be rolled out in the perceivable future (Fan 2019).

The PBC's digital currency, DC/EP, is a loosely coupled hybrid of digital currency and electronic payment, issued by the central bank, operated and exchanged by authorized operators. The key features of DC/EP may be summarized as follows. First, DC/EP is a legal tender, i.e., a digital version of the yuan, and substitutes only for M0. A legal tender is different from electronic cash offered by commercial banks and mobile payment providers. It is almost impossible for DC/EP to default, but commercial banks and mobile payment providers could, potentially. The fact that DC/EP is a substitute only for M0, but not for M1 or M2, implies that it would not become a means of credit. For now, the PBC would not pay any interest to DC/EP. But it can be conveniently used in retail transaction and daily payment.

Second, DC/EP will be operated through a two-tier system, and the PBC will not directly interact with the public. Like any other sovereign currency, DC/EP is the liability of the central bank. It functions through a two-tier system, in which the central bank creates and issues the digital currency to the authorized institutional operators, and then the general public exchange cash for digital currency from the authorized financial institutions (Figure 5.6). The fact that the central bank does not directly interact with the public helps avoid competition with existing financial institutions, which otherwise could lead to financial disintermediation. DC/EP is 100% reserved, meaning that authorized financial operators must deposit one-to-one reserves with the central bank. The operators can then issue DC/EP to the general public in the same way they issue paper notes. The central bank will likely also set a ceiling for the amount of transaction and account balance. The purpose of this is to avoid the possibility that the public exchanges all their deposits into digital currency, and, therefore, to prevent the potential risk of a bank run. It also ensures limited anonymity in payment transactions. More importantly, the authorized institutional operators should have the necessary information about the owners of these digital wallets.

Figure 5.6: Illustration of the Two-Tier System of DC/EP

DC/EP = digital currency/electronic payment.

Source: People's Bank of China.

Third, DC/EP is a loosely coupled and value-based account, i.e., it is token-based. The value transfer can be achieved without an account. In comparison, credit cards, Alipay, and WeChat Pay are account-based and require linking to bank accounts. But DC/EP is a stand-alone set of passcodes, like cash. P2P payment can take place without linking to the internet.

So why does the PBC create a DC/EP but ban the trading of cryptocurrencies such as Bitcoin and Ethereum? Cryptocurrencies have two distinctive features: the value of anonymity and a lack of intrinsic value. They are neither precious metals nor sovereign currencies guaranteed by the states. So, they do not have all three key functions of money: means of payment, unit of accounting, and vehicle of investment. This is why cryptocurrencies are often regarded as digital assets, not digital currencies. The anonymity creates concerns for policy makers, especially in countries where management of cross-border capital flows is common and corruption is widespread. These are the key reasons why it is hard for the PRC regulators to tolerate onshore active trading of cryptocurrencies.

There are many reasons why the PBC made so much effort to roll out DC/EP. One possible reason is to promote financial inclusion—one does not require a bank account to have a digital currency account and enjoy basic financial services. The loosely coupled digital currency and payment account make it possible for those previously underserved by the financial system. With the support of the DC/EP system, foreigners could have a digital wallet without a bank account in the PRC and enjoy the convenience of mobile payment. This could seriously reduce the burdens of anti-money laundering and certificates in finance and technology processes. In a way, this is an important step forward from the current mobile payment system, which still requires linking to a bank account to be operable.

Clearly DC/EP is only the first step of the PBC's digital currency ambition, although nobody knows when the central bank will take further steps, such as paying interest on the digital currency. For now, since it only substitutes for M0, it might have limited impact on the PRC's macroeconomy. At the end of December 2019, the PRC's M0 was CNY7.72 trillion, which was only about 3.9% of the broad money supply M2, CNY198.65 trillion. Therefore, even if DC/EP completely replaces M0, it still does not constitute a significant part of the country's financial operation.

However, DC/EP could potentially have a very significant impact on the fintech sector. Most of the PRC's fintech businesses are built around its mobile payment system. Mobile payment facilitated the boom of e-commerce, which created the initial business area for digital insurance for the delivery and return of goods. It also opened the opportunities for online investment and online lending. In fact, almost the entire fintech ecosystem is built on the mobile payment facility.

The mobile payment system offers two unique features: connectivity and data. The mobile payment platforms attract hundreds of millions of users and thus substantially reduce the costs of acquiring customers. More importantly, transactions with payment and other services leave a gigantic digital footprints on those platforms. Equipped with extraordinary analytical capabilities, the mobile payment platforms are then able to provide a wide range of financial services, such as digital insurance and online lending. Without the mobile payment services, the PRC's fintech industry would probably be much more modest in terms of scale and complexity.

To be fair, policy makers have legitimate concerns about this business model. Since the fintech business is concentrated in a small number of unicorn players, any risks that occur to them could be systemic risks. At the same time, abuse of data by big fintech platforms, such as invasion of individual privacy, is also quite common.

It is too early to be sure about the exact impact of DC/EP on the fintech industry. But now that the public has an alternative to mobile payment that can also carry out payment transactions but does not leave a digital footprint with a private company, it is possible that many will substitute mobile payment accounts with DC/EP. If this happens, then the consequences for the fintech industry could be game changing.

5.5 Implications for Macroeconomic Stability

How does this exciting fintech development affect the PRC's macroeconomic stability? Our assessment so far arrives at the following three takeaways:

- The fintech space is still rapidly changing, and thus the shape of the industry and its macroeconomic implications could evolve in the coming years.
- In many ways, the use of digital technology, especially fintech, could improve macroeconomic stability by reducing the short-term volatility of economic activities and prices.
- It could also give rise to new risks and magnify existing risks, especially if regulation does not keep pace with innovation.

The PRC's fintech industry is probably entering a new phase of development. In the past, many tech companies engaged directly in financial services, partly because there was no strict requirement for a license then. This could change as financial regulation tightens. A clearer division of labor could emerge between tech and financial players, with financial institutions focusing on providing financial products, and tech companies specializing in offering technological solutions. Even Jack Ma, founder of Ant Financial, said that the unicorn fintech player aims to become a techfin institution, concentrating only on the tech part of financial transactions. One likely scenario is that traditional financial institutions could become the main providers of financial services. But many small tech companies might emerge to provide specialized tech services to these financial institutions. The unicorn tech companies, such as Ant Financial, Tencent, Baidu, and JD Digits, could become platforms for financial products, just like Taobao for goods. While the form of the fintech industry could change, the essence of using digital technology to improve financial transaction should not.

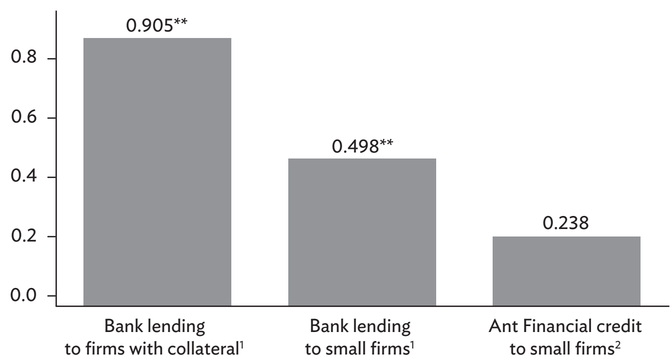
One potential wild card that could substantially transform the PRC's fintech landscape is the PBC's DC/EP, alongside tighter regulation. If, as some suggest, DC/EP offers a more attractive alternative to the current mobile payment service, because it does not depend on bank accounts and maintains a certain degree of anonymity, then it is quite possible that it could serve as a negative shock to mobile payment businesses and, more fundamentally, undermine unicorn BigTech companies' function of accumulating and analyzing digital footprints. Since connectivity and data are the backbones of the existing fintech businesses, DC/EP could potentially weaken BigTech companies' position in the fintech space. Furthermore, if the PBC decides to grant more functions to its digital currency, such as making it interest-bearing and a means of credit, then even the traditional financial institutions, including commercial banks, could experience a major "earthquake." This, however, will probably not happen in the perceivable future.

There is preliminary but important evidence confirming that fintech could actually improve macroeconomic stability. The first piece of evidence shows rapid convergence of regional fintech development—the lagging regions developed at faster paces than the leading regions between 2013 and 2018. More importantly, tentative analysis of the regional growth pattern shows that, while, in general, growth is still diverging in the PRC, the fintech variable facilitates growth convergence across regions. If this effect can be confirmed, then fintech development is definitely helpful for improving macroeconomic stability, since regional economic development could become even greater as a result of the spreading of fintech businesses.

The second piece of evidence relates to unsecured loans provided by several online banks, using data instead of collateral in risk assessment. In fact, this method can also be applied by traditional commercial banks. As discussed earlier, the fintech credit-scoring models, based on big data and the machine-learning approach, often perform better than the traditional bank models, especially for SME loans. Such unsecured loans have the additional benefit of delinking credit decisions from asset prices. The elasticity of collateralized bank loans with respect to housing prices is 0.91, that of banks' SME loans is 0.50, while that of MyBank's unsecured SME loans is insignificant (Figure 5.7). This breakdown of connection between loan growth and housing prices takes out the so-called "financial accelerator," which was often behind financial crises through the formation of a vicious cycle among asset price, credit policy, and real economic activities. Therefore, the data-based credit-scoring models should improve financial and macroeconomic stability.

The third piece of evidence can be observed from the current PRC economy suffering the devastating novel coronavirus (COVID-19)—the fintech-supported new economy serves as a macroeconomic stabilizing force. Like the severe acute respiratory syndrome that haunted the PRC in early 2003, COVID-19 is infectious and deadly, restricts people's mobility, and reduces consumption demand, especially for restaurants, shopping, and other tourism activities. Compared with 2003, what is different this time is the greater role of the new economy. Online shopping already accounts for more than 20% of all retail sales. A tentative look at Alipay's data confirms that, during the PRC New Year holiday this year,

Figure 5.7: Elasticity of Bank Credit with Respect to Housing Prices in the PRC

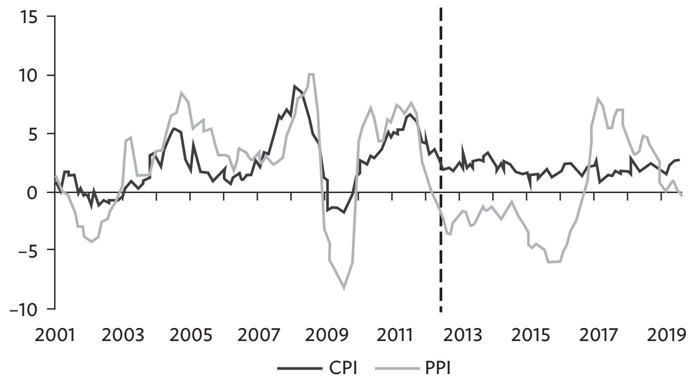


PRC = People's Republic of China.

Note: [1] Data from traditional banks and [2] Data from MyBank.

Source: Gambacorta et al. (2019).

Figure 5.8: Consumer Price Index and Producer Price Index in the PRC, 2001–2019 (%)



CPI = consumer price index, PPI = producer price index, PRC = People's Republic of China.

Source: National Bureau of Statistics of China. http://www.stats.gov.cn/enGliSH/ (accessed 24 September 2020).

which coincided with the heightened COVID-19 warning, transactions with offline vendors declined by almost 10%, while transactions with online vendors were up by 10%. Clearly, the new economic activities help mitigate negative shocks such as disease. More generally, there are also tentative research findings confirming that the mobile payment service helps to improve risk sharing among households (Wang et al. 2019).

The final piece of evidence is still only a hypothesis, which needs to be verified by rigorous analysis. Figure 5.8 plots both the consumer price index (CPI) and the producer price index for the period 2001–2019, finding a structural break in 2013 for the former, but not the latter. One possible explanation is growing e-commerce. One might recall from earlier discussions that Alipay was initially created to facilitate online transactions on Alibaba's e-commerce platform Taobao. The real fintech boom, however, did not happen until June 2013 when Yu'ebao came online. This also led to an extraordinary expansion of e-commerce. The growing e-commerce helped integrate different regional markets and significantly reduced price volatility.

But clearly, fintech would also pose new risks to macroeconomic stability. Any financial innovation, including fintech, could magnify or even create financial risks, as well as improving financial efficiency. The most striking example is the derivative product, which was initially created to manage exchange rate volatility after the breakdown of the Bretton Woods system. However, it caused the subprime crisis. Similarly, fintech businesses should help to improve both financial inclusion and financial efficiency, but it could also generate new financial risks. For instance, the PBC has issued a total of more than 200 payment licenses in recent years. With the exception of a couple of the largest players, most of the license holders suffer from financial problems. Fortunately, the sizes of these institutions' businesses are small. With the help of digital technology, fintech businesses adjust very rapidly. This presents a serious challenge to the existing regulatory system, which normally requires the financial institutions to disclose information periodically. Without also applying digital technology in regulation, it is hard to monitor and control fintech risks. In addition, the BigTech firms sometimes result in greater concentration of market shares, and are able to further concentrate market power. They have the potential to give rise to new financial systemic risks (Frost et al. 2019).

5.6 Concluding Remarks

While it is too early to make any accurate assessment at the moment, it is quite clear that fintech is rapidly changing the financial industry, with important implications for macroeconomic stability. Therefore, we need to monitor and study this new development very closely. Analyses suggest that while fintech could provide some stabilizing forces, it could potentially also become a major threat to macroeconomic stability. In order to maximize the benefits, while keeping the risks under control, we make the following policy recommendations:

First, the regulators need to develop new techniques such as a "sandbox" in order to balance fintech innovation and financial stability. All financial transactions need to be regulated and all financial service providers need to obtain proper licenses. The experiences of the unregulated P2Ps should not happen again. Following the practices in the UK, Singapore, and many other countries, the PBC also started a practice similar to sandbox. Under this new scheme, regulators first call for proposals of new fintech businesses. If they meet certain criteria, such as strengthening financial access, improving financial efficiency, and managing financial risks, then the proposals may be tested under the regulators' close watch. If the experiment turns out to be successful, then the business could be formally licensed.

Second, the regulatory framework needs to apply digital technology, i.e., regulatory technology, in regulating fintech and other financial businesses. The fintech businesses, in particular, have the typical features of large numbers of customers and very rapid transmission of risks. The traditional regulatory approach, however, would not win the race with financial risks, either in terms of breadth or speed. Using big data analytical tools, the regulators should be able to monitor real-time data and detect any irregular symptoms.

Third, the macroprudential policies also need to be upgraded to incorporate the new features of fintech. For instance, simply judged by asset size, some of the key fintech players such as Ant Financial and Tencent might not qualify as "systemically important institutions." But these two players are behind almost all new economic activities. If there is a collapse of the mobile payment system, or simply a power blackout, a large part of the economy will become dysfunctional, with serious macroeconomic and financial implications.

Finally, the central bank will have to consider these new fintech features when making monetary policy. Although the full implications still need to be studied and appreciated, we found that data-based online bank lending responds to monetary policy more aggressively than collateral-based traditional bank loans. Likewise, we also found that the CPI become a lot more stable during the age of fintech and the new economy. This would have serious implications for monetary policy making, especially with an explicit or implicit inflation targeting scheme. If the CPI becomes more stable because of technology, then there is the question of whether monetary policy expansion might lead to the accumulation of financial risks, such as the subprime risks in the early 2000s in the US.

The bottom line is that the PBC, financial regulators, and academics should follow the development of the fintech industry and understand its implications for macroeconomic stability.

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6

A Multivariate Bayesian Vector Autoregression Analysis of Digital Payment Systems and Economic Growth in India

Debasis Rooj and Reshmi Sengupta

6.1 Introduction

A well-developed financial sector is an essential ingredient for the long-run economic growth of a country (Schumpeter 1911). In recent times, the world has witnessed a rapid increase in technological innovation, including that in the financial sector. Rapid advances in financial technology, commonly referred to as fintech, are transforming the economic and financial landscape of the world economy (IMF 2018). Financial technologies are offering a wide range of services across the world. While different definitions of fintech are possible and are in use internationally, it can be categorized either in the form of a new product or a new process for supplying an already existing product, or in terms of market arrangements (Lewis and Mizen 2000). One such example of financial innovation is the digitalization of means of payment.

One of the primary functions of the financial sector is to provide efficient and fast modes of payments. By reducing transaction costs, the payment system can facilitate trading and thus allow for greater specialization in economic activities by economic agents (Bech and Hobijn 2007). Moreover, emerging market economies such as India, have less developed financial sectors than developed economies. Further regarding India, a large section of its population is also financially excluded due to a lack of knowledge and awareness about financial institutions. Although a large section of the population does not have access to banking and other financial services or to formal credit facilities, it does have widespread access to mobile phones and mobile data. In such a scenario, India can bring in infrastructural innovations and digitalization, which have enormous potential in terms of making the financial sector inclusive.

In recent years, the Government of India has made a push to bring a broad ambit of its economy under the digital umbrella. The objective is to provide an inclusive, leakage-free delivery of services to a vast majority of its population. One such mechanism is digital transactions, and Indian banks are being encouraged to make various electronic payment modes available to their customers.

The central bank of a country is responsible for providing the medium of payment to settle small-value cash transactions, as well as supporting an interbank system that settles large-value transactions and time-critical payments (Bech and Hobijn 2007). Moreover, the central bank also uses the interbank payment system to implement monetary policies. The system also serves as the platform for the interbank money market.

Payment and settlement systems are the backbone of any economy (RBI 2019). Over the last decade, India has witnessed a significant development in the use of modern technology in financial services. In India, the Reserve Bank of India (RBI) is the sole custodian of the payment system. The RBI has endeavored to ensure that India has one of the most state-of-the-art payment and settlement systems in the world.

One such payment and settlement system introduced in 2004 is real-time gross settlement (RTGS), an internet-based funds transfer system where there is a continuous and real-time settlement on an individual transaction basis (without netting). "Real time" refers to the processing of instructions at the time they are received, and "gross settlement" means that the settlement of funds transfer instructions occurs individually. The RTGS system primarily deals with large-value transactions with the objective of providing not only a safe and secure but also an efficient, fast, and affordable payment system to boost the economic activity in the country. This transaction system requires a minimum transfer value of INR200,000 (approximately $3,000) with no upper limit. RTGS payments are final and are not revocable by the paying bank. An RTGS system reduces settlement risk, as payments are settled individually and irrevocably on a gross basis in real time.[1]

The database on the payment system from the RBI shows that electronic transactions in the total volume of retail payments increased to 95.4% in 2018–19 from 92.6% in the previous financial year. In 2018–19, RTGS transactions constituted less than 0.40% of the total volume of payments but were close to 46% of the transactions in terms of value.

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1 More details on the Indian RTGS can be found at https://m.rbi.org.in/Scripts/FAQView.aspx?Id=65

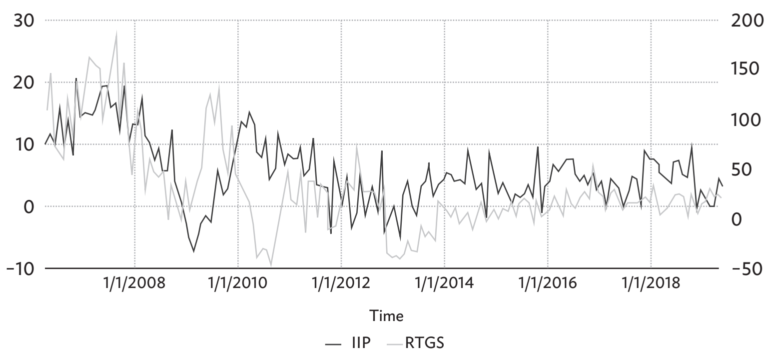
While the volume of RTGS increased by close to 10% in 2018–19 from 2017–18, the value increased by close to 17% during the same period.

The RBI plans the ratio of digital payment transaction turnover to nominal gross domestic product (GDP) to increase from 10.37 in 2019 to 12.29 in 2020 and consequently to 14.80 in 2021. To facilitate this process, on 6 June 2019, the RBI decided to withdraw the charges levied upon the transaction processes using RTGS and National Electronic Funds Transfer systems. The RBI also directed the banks to pass these benefits to their customers. Some commercial banks have already implemented this policy.

Using data on the indicators of the payment system, as well as on economic growth, we observe that the value and the volume of RTGS are steadily growing in India. A visual analysis (Figure 6.1) shows a close linkage between the value of RTGS and economic growth, measured by the index of industrial production in India. A similar trend is observed between the volume of RTGS and economic growth (Figure 6.2).

Motivated by these observations, we attempt to understand the dynamic relationship between the use of financial technology and economic activity in India. We use RTGS as a proxy for the payment system and the index of industrial production (IIP) as a measure of economic activity.

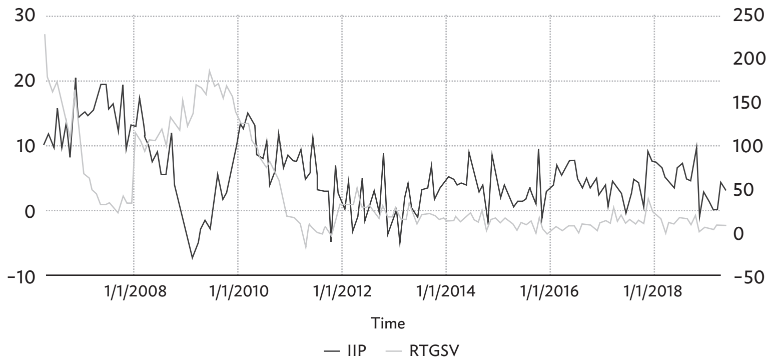
Figure 6.1: The Dynamics of the Value of Real-Time Gross Settlement, and the Index of Industrial Production



Note: RTGS represents the growth rate of the value of real-time gross settlement (right-hand vertical axis); IIP represents the growth rate of the index of industrial production (left-hand vertical axis). The observations are percentage changes, year on year (monthly). The sample period is from 2005 M4 to 2019 M5.

Source: Authors' calculations.

Figure 6.2: The Dynamics of the Volume of Real-Time Gross Settlement, and the Index of Industrial Production



Note: RTGSV represents the growth rate of the volume of real-time gross settlement; IIP represents the growth rate of the index of industrial production. The observations are percentage changes, year on year (monthly). The sample period is from 2005 M4 to 2019 M5.

Source: Authors' calculations.

We use a Bayesian vector autoregression (BVAR) methodology that simultaneously addresses the problem of model misspecification and the "curse of dimensionality." We corroborate our findings through several sensitivity analyses. In this chapter, we provide a detailed understanding of the empirical linkage between the development of a digital payment system and economic growth, thereby providing a strong basis for policy recommendations to promote the digital economy.

The rest of the chapter is organized as follows. Section 6.2 briefly discusses the relevant literature. The data sets used for the study are discussed in Section 6.3. In Section 6.4, we describe the empirical methodology, and in Section 6.5, the empirical results are presented. Finally, in Section 6.6, we conclude.

6.2 Related Literature

Information technology plays a vital role in driving economic activity. Jorgenson and Stiroh (1999) suggest that information technology could be a substitute for capital and labor inputs, given its high contribution to the growth of total output in the United States (US). They show that although computers contributed virtually nothing to US economic growth before 1973, from 1990 to 1996, they contributed close to

16% of US output growth. Dedrick, Gurbaxani, and Kraemer (2003) and Jorgenson and Vu (2007) provide further evidence of the role of information technology on economic growth.

The role of information technology in the financial and banking sector is also widely accepted (Berentsen 1998; Nsouli and Fullenkamp 2014; Goodhart and Sims 2000). However, the quantitative literature on the dynamics of the payment system and the economy is limited.

Yilmazkuday (2011), using vector autoregression (VAR), examines the linkage between the use of credit cards and monetary policy in Turkey, finding that credit card use has an increasing effect on inflation rates over time. He suggests that there is an increasing need to consider the credit channel of monetary policy transmission through credit cards.

Geanakoplos and Dubey (2010) argue that the introduction and widespread use of credit cards not only increases trading efficiency but also increases the velocity of money, which in turn causes inflation in the absence of monetary intervention. They also point out that price increases might worsen when there is any default on the part of the credit card holders. Tule and Oduh (2017) demonstrate that the increase in financial innovation has gradually dampened the effectiveness of the money multiplier. Milbourne (1986) argues that financial innovation complicates the task of monetary policy by shifting the monetary aggregates, making it difficult to understand the behavior of interest rates and using the asset demand function as the basis for the conduct of monetary policy.

Bech and Hobijn (2007) examine the diffusion of RTGS technology across the world's 174 central banks, finding that the probability of its adoption in a given year increases significantly with the per capita GDP of an economy. Moreover, they also show that countries with a lower relative price of capital and countries whose major trading partners have already adopted RTGS are also more likely to adopt it themselves. These determinants are similar to those that seem to drive the cross-country adoption patterns of other technologies.

Lee and Yip (2008) argue that higher RTSG turnover correlates with faster growth and is a good indicator of the overall performance of the economy.

However, to the best of our knowledge, no study so far has focused on empirically analyzing the impact of such payment systems on the economic growth in India. Given the increasing adoption of modern technology in the financial sector across the globe, it is essential to empirically analyze the role of RTGS in enhancing economic growth and vice versa, especially since it is widely used in almost all parts of the world (Bech, Shimizu, and Wong 2017). In the case of India, this is the prime form of electronic transaction.

To the best of our knowledge, this is also the first study to examine the dynamic linkages between RTGS and economic growth using a multivariate framework and the BVAR methodology that simultaneously addresses the problem of model misspecification and the "curse of dimensionality." We corroborate our findings using several sensitivity analyses.

The findings from our empirical analysis show a positive and significant relationship between RTGS and economic growth in India. We demonstrate the existence of bidirectional causality between RTGS and IIP, where one affects the other. Our variance decomposition analysis also shows that both RTGS and IIP explain a considerable variation in each other's fluctuations. We also find that RTGS increases the general price level in the economy; however, we do not find any direct evidence on the effect of monetary policy on RTGS in India. Our study provides evidence-based policy implications highlighting the importance of digitalization in facilitating economic growth in India.

6.3 Data and Variable Selection

The objective of this chapter is to examine the dynamic relationship between RTGS and economic growth. This translates into considering variables that capture financial transactions, economic activity, monetary policy, and a price index. The data on RTGS are available for both the value and the volume (number of transactions) of the transactions. We use the value of transactions in our baseline model and the volume while conducting the sensitivity analyses.

For economic activities, we use the data on the IIP as a proxy for economic growth. The IIP data series is available from the Central Statistics Office, Government of India. The monetary policy is represented by the yield on the 91-day T-Bill (INT). We include the consumer price index (CPI) as a measure of price in our analysis. Finally, we use M1 as a measure of the money supply in our analysis. All the variables mentioned above are available from the RBI website.

We use a sample period of 170 months from 2005-M4 to 2019-M5. All the relevant variables are seasonally adjusted using the X-13ARIMA-SEATS seasonal adjustment program by the United States' Census Bureau.[2]

[2] Hamilton (1994) argues that the Minnesota prior is not very suitable for seasonal data.

6.4 Empirical Methodology

6.4.1 BVAR

Empirical macroeconomics literature often employs a VAR model to examine the linear causal relationship between the time series variables and also to forecast their evolution (Sims 1972, 1980). The VAR model in this study is a simple dynamic simultaneous equations system with endogenous variables that allows us to examine the dynamic link between RTGS and IIP alongside capturing the feedback mechanism that exists among the other controls, CPI, INT, and the money supply.

Consider the following VAR(p) model:

$$Y_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + CX_t + \in_t \text{ where t = 1, 2, ..., T} \quad (1)$$

where $Y_t = \left(y_{1,t}, y_{2,t} \cdots y_{n,t}\right)'$ is an n-dimensional vector of endogenous variables; X_t represents a vector of m exogenous regressors, including a constant; A_p are n×n matrices of coefficients; C are is n×m coefficient matrices of the exogenous regressors; and $\in_t$ is an n-dimensional Gaussian white noise with covariance matrix, $X_t \;\; E(\in_t \in_t') = \Omega$. T is the size of the sample used for the regression. For n and p of modest size, the number of estimated coefficients becomes quite large leading to the problem of the "curse of dimensionality."[3] BVAR models can resolve this problem by shrinking these coefficients toward some prior belief.

The primary advantage of using Bayesian analysis is its ability to combine prior information with the likelihood function as derived from the sample. This helps in obtaining the posterior distribution for any parameter and deals with the over-parameterization problem (the "curse of dimensionality") by imposing prior beliefs on the parameters. However, posterior results must be confronted with prior beliefs, and hence prior distributions must be chosen carefully to avoid any misspecifications, which may affect the posterior results. Therefore, we follow Litterman (1986) in defining the BVAR prior specifications with some modifications as proposed by Kadiyala and Karlsson (1997) and Sims and Zha (1998) to improve the model outcomes.

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[3] The structure of the VAR implies that there are k = np + m coefficients to estimate for each equation, leaving a total of q = nk = n(np + m) coefficients to estimate for the full VAR model.

Following Koop and Korobilis (2010) and Dieppe and Legrand (2016), equation (1) can be rewritten as

$$Y = \mathrm{XB} + \varepsilon \tag{2}$$

where

$$Y = \begin{bmatrix} y_1' \\ y_2' \\ \cdots \\ y_T' \end{bmatrix},\ X = \begin{bmatrix} y_0' & y_{-1}' & \cdots & y_{(1-p)}' & x_1' \\ y_1' & y_0' & \cdots & y_{(2-p)}' & x_2' \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ y_{(T-1)}' & y_{(T-2)}' & \cdots & y_{(T-p)}' & x_T' \end{bmatrix},\ B = \begin{bmatrix} A_1' \\ A_2' \\ \cdots \\ A_p' \\ C \end{bmatrix},\ \varepsilon = \begin{bmatrix} \varepsilon_1' \\ \varepsilon_2' \\ \cdots \\ \varepsilon_T' \end{bmatrix} \tag{3}$$

with $y = vec(Y)$, $\bar{X} = I_n \otimes X$, $\beta = vec(B)$, and $Y = \mathrm{XB} + \varepsilon$

$$e: \ N(0, \bar{\mathrm{S}}),\ \bar{\mathrm{S}} = \mathrm{S}\ \text{Ä}\ I_T \tag{4}$$

The likelihood function $f(y|b,\bar{\mathrm{S}})$ can then be written as

$$f(y|b,\bar{\mathrm{S}}) \propto \exp[-\frac{1}{2}(y - \bar{X}b)¢\bar{\mathrm{S}}^{-1}(y - \bar{X}b] \tag{5}$$

Now, for the prior distribution of β, it is assumed that β follows a multivariate normal distribution with mean β_0 and covariance matrix Ω_0: with $p(b)$: $N(b_0,\mathrm{W}_0)$.

We follow Litterman (1986) to identify β_0 and Ω_0. In a VAR setup, the explanatory variable in any equation can take several lag structures, such as the dependent variable's own lag and those of the other dependent variables and the exogenous or the deterministic variables, including the constant.

In the Minnesota prior, most or all of the coefficients of the parameters are set to zero, thereby ensuring shrinkage of the VAR coefficients toward zero and lessening the risk of overfitting. As most observed macroeconomic variables seem to be characterized by a unit root, our prior belief is that each endogenous variable as included in the model presents a unit root in its first own lag and coefficients equal to zero for further lags and cross-variable lags. Moreover, in the absence of any prior belief about exogenous variables, the most reasonable strategy is to assume that they are neutral with respect to the endogenous variables, and hence their coefficients are equal to zero. All these elements thus translate into β_0 being a vector of zeros, except for the entries concerning the first own lag of each endogenous variable, which are given a value of 1 each.

For the variance-covariance matrix, Ω_0, it is assumed that no covariance exists among the elements in β, which implies that Ω_0 is diagonal.

Moreover, Litterman (1986) argues that the further the lag, the more confident one should be that coefficients linked to it have a value of zero. Therefore, the variance of the coefficients linked to a lag should be smaller than the initial lags the further it is from them. Also, the confidence is expected to be greater for the coefficients that relate variables to their past values. Finally, as little is known about the exogenous variables in the model, we assume that their variance is large. Thus, according to Litterman (1986), Minnesota priors are imposed by setting the following moments for the prior distribution of the coefficients:

For parameters in β that relate the endogenous variables to their own lags, the variance is given by

$$\sigma_{a_{ii}}^2 = \left(\frac{\lambda_1}{l_3^{\lambda}}\right)^2 \quad (6)$$

where λ_1 is an overall tightness parameter, l is the lag considered by the coefficient, and λ_3 is a scaling coefficient controlling the speed at which coefficients for lags greater than 1 converge to 0 with greater certainty.

For parameters related to cross-variable lag coefficients, the variance is given by:

$$\sigma_{a_{ij}}^2 = \left(\frac{\sigma_i^2}{\sigma_j^2}\right)\left(\frac{\lambda_1\lambda_2}{l_3^{\lambda}}\right)^2 \quad (7)$$

where σ_i^2 and σ_j^2 denote the ordinary least squares residual variance of the autoregressive models estimated for variables i and j, and λ_2 represents a cross-variable specific variance parameter.

For exogenous variables, including constant terms, the variance is given by:

$$\sigma_{c_i}^2 = \sigma_i^2(\lambda_1\lambda_4)^2 \quad (8)$$

where σ_i^2 is again the ordinary least squares residual variance of an autoregressive model previously estimated for variable i, and λ_4 is a large (potentially infinite) variance parameter. Several combinations are possible for λ_1, λ_2, λ_3, and λ_4. Following the standard literature practice, for example in Sims and Zha (1998) and Giannone et al. (2014), we choose $\lambda_1 = 0.2$, $\lambda_2 = 0.5$, $\lambda_3 = 1$, and $\lambda_4 = 100$.

6.4.2 Identification of the Structural Shocks in the BVAR Model

Following Bańbura, Giannone, and Lenza (2015), we identify several shocks using a simple recursive ordering, commonly known as the Cholesky decomposition of the error covariance matrix. In other words, as indicated by Forni and Gambetti (2016) and Erten (2013), this implies that the independent standard normal shocks can be identified based on the estimated reduced-form shocks, and also the ordering of the variables in equation 1. Thus, the initial ordering is as follows: IIP, CPI, INT, money supply, RTGS. The initial ordering of the variables in the model determines the sequence of the structural shocks and their effect on the other endogenous variables. We place the variables in order of output, prices, and monetary policy instruments. This ordering assumes that the RBI sees current output and prices when it sets the policy instrument, but that output and prices only respond to a policy shock with one lag. RTGS is ordered last, implying that the financial sector variable responds to a policy shock with no lag. This ordering mostly follows the monetary policy literature (Christiano, Eichenbaum, and Evans 1996, 2005; Thorbecke 1997), which places the VAR variables in the following order: macroeconomic, monetary policy, and financial. In our sensitivity analysis, we place RTGS before other variables and examine the implications of such identification for the other variables of our model.

All the variables in our model enter in log levels. Sims, Stock, and Watson (1990) argue that as the Bayesian approach is entirely based on the likelihood function, the associated inference does not need to take special account of non-stationarity. The likelihood function has the same Gaussian shape regardless of the presence of non-stationarity.

Moreover, estimation of a VAR model in levels will produce consistent estimates of impulse responses and is robust to cointegration of an unknown order (Barsky and Sims 2011). Hamilton (1994) also indicates that when there is uncertainty regarding the nature of the common trends in the data, estimating a VAR in levels is a "conservative" approach. Brooks (2014) also favors using VAR in levels, when the objective is to purely examine the dynamic relationship among the variables and not to merely estimate the parameters of a model, as opposed to differencing where we may lose important information as embedded in a series. Given this, all the variables (except for interest rate, which is levels) have been specified in log levels (Fujiwara 2006).

In macroeconomics literature, a common practice is to use a log transformation of the variables. According to Ehrlich (1977) and Layson (1983), a log transformation helps in providing better empirical results than a linear specification. Moreover, the coefficient estimates can be interpreted in terms of elasticities (i.e., a percentage change in one variable due to a percentage change in the other variable).

We include one lag of each endogenous variable and a constant term. This choice of lag structure is selected by deviance information criteria (DIC) that measure the goodness of fit and complexity of fitted Bayesian models to optimize the behavior of the residual error terms (Spiegelhalter, Best, and Carlin 2002; Saldías 2017).[4] The stability of the VAR model is important as the impact of the shocks is calculable and finite only when it is stable. The stability condition requires all the eigenvalues to be less than unity, i.e., no root lies outside the unit circle (Patterson 2000). Our estimated VAR model satisfies the stability condition. We present the impulse responses based on 15,000 Markov Chain Monte Carlo draws after discarding the first 10,000 draws as burn-in.[5]

6.5 Results

6.5.1 Impulse Response Analysis

In this section, we present the impulse responses from our baseline BVAR, as presented in Section 6.4.2. We present the impulse responses to all the shocks in Figure 6.3. The continuous solid line depicts the median posterior response, and the shaded area represents a 68% confidence interval. We follow Sims and Zha (1999) for the 68% interval band.[6] The horizontal axis shows the time period or the horizon after the initial shock, while the vertical lines in impulse responses show the magnitude of the response to the shocks.

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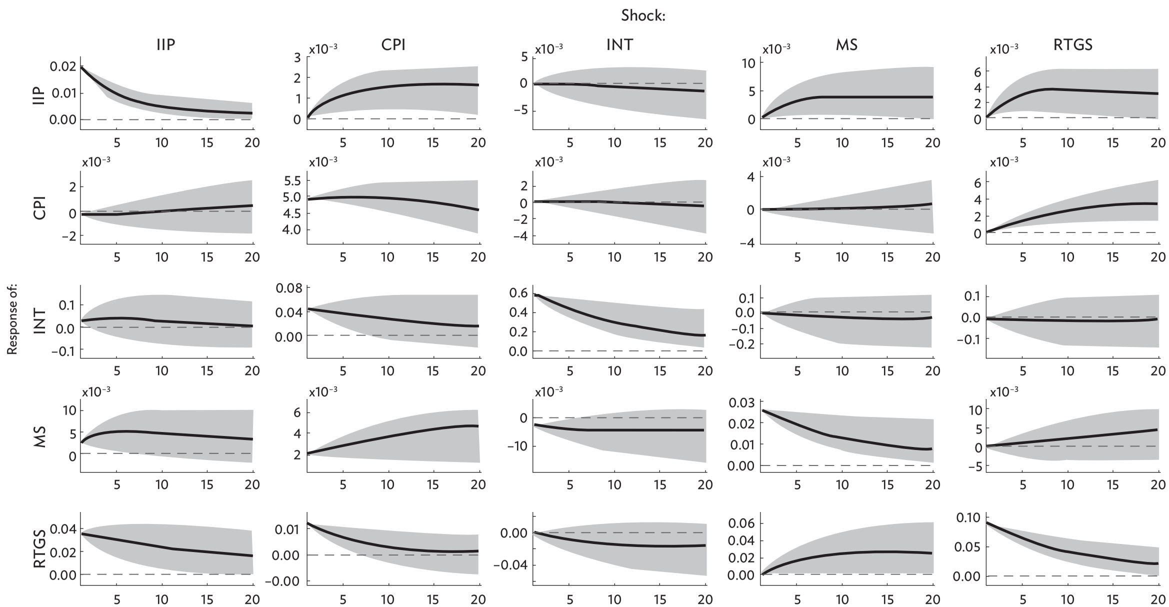
4 The DIC value for our baseline model is –2,919.39. We provide an alternate model using classical Akaike information criterion (AIC) lag selection criteria in our robustness analysis.

5 BVAR estimation is carried out by using the BEAR toolbox (Dieppe and Legrand 2016).

6 Sims and Zha (1999) argue that the conventional frequentist error bands can be misleading because they mix information about parameter location with information about model fit. They propose likelihood-based bands and suggest using 68% interval bands to provide a more precise estimate of the true coverage probability.

Figure 6.3: Impulse Responses – Baseline Bayesian VAR



VAR = vector autoregression.

Note: Each column represents a shock; rows show the impulse responses due to shocks in the rows. The shocks are represented as follows: IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply, RTGS is the value of real-time gross settlement. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, IIP, CPI, INT, MS, RTGS. The shocks are identified using the Cholesky decomposition. The solid black line is the median posterior response, and the shaded area represents 68% confidence interval.

Source: Authors' calculations.

We present the impulse responses for a one-standard-deviation shock on IIP in the first column of Figure 6.3. A one-standard-deviation shock leads to a close to 2% increase in IIP. This shock is persistent and remains significant almost for the entire horizon of nearly 20 months. The impact of IIP on RTGS is also positive and significant. The effect is maximum immediately on impact and declines slowly over the time horizon. On impact, the value of RTGS increases by close to 4%. This is a significant impact of economic growth on the high-value transfer of money using RTGS. We find that IIP also increases money supply, but the effect becomes insignificant after 6 months. Interestingly, we find no significant impact of IIP on CPI.

Next, we examine the impact of RTGS on the other variables of our model. In the fifth column of Figure 6.3, we show the impulse responses for a one-standard-deviation shock on RTGS. A one-standard-deviation shock increases RTGS by close to 10%. The impact of RTG on IIP is positive and significant. This impact reaches its peak at around the seventh month with an increase in IIP of 0.4% at the peak. The effect remains significant for the entire horizon. We also find that an increase in RTGS also increases CPI; the effect is persistent and remains significant for the entire horizon.

The inflationary impact of RTGS on CPI is akin to the inflationary impact of credit cards in Turkey (Yilmazkuday 2011). In our analysis, we control for the money supply. Hence, the finding indicates that an increase in RTGS not only increases the value of output but also impacts prices through an increase in the velocity of money.

Thus, our multivariate BVAR analysis suggests the existence of bidirectional causality between IIP and RTGS.

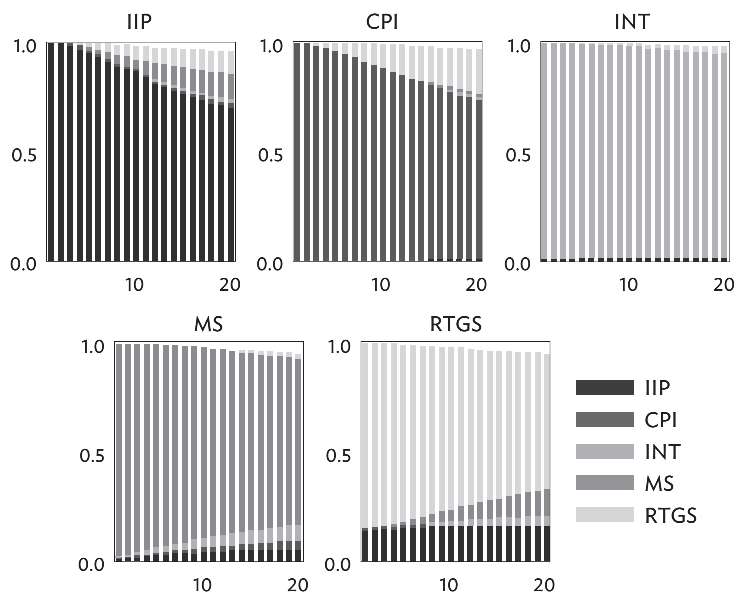
6.5.2 Forecast Error Variance Decomposition

In this section, we discuss the contribution of IIP and RTG shocks, respectively, in explaining each other's variations. We use forecast error variance decomposition (FEVD) to show the significance of each of the identified shocks in fluctuations of the variables. The FEVDs presented in Figure 6.4 show that RTGS contributes close to 10% of the fluctuations in IIP in the long run. Similarly, IIP is responsible for explaining almost 16% of the fluctuations in RTGS. Combined with the impulse responses, FEVDs also support the close link between RTGS and IIP in India. These findings suggest that high-value online transactions and economic growth are closely interlinked. RTGS also contributes to approximately 20% of the variations in the CPI.

6.5.3 Historical Decomposition

The historical decompositions are presented in Figure 6.5. Similar to impulse response and FEVD, they also emphasize the impact of RTGS on IIP and CPI. The roles have clearly been stronger during the post-2012 period with the growth of the RTGS activity. The impacts have been less in the recent past given that other forms of digital payments are also growing.

Figure 6.4: Forecast Error Variance Decomposition – Baseline Bayesian VAR

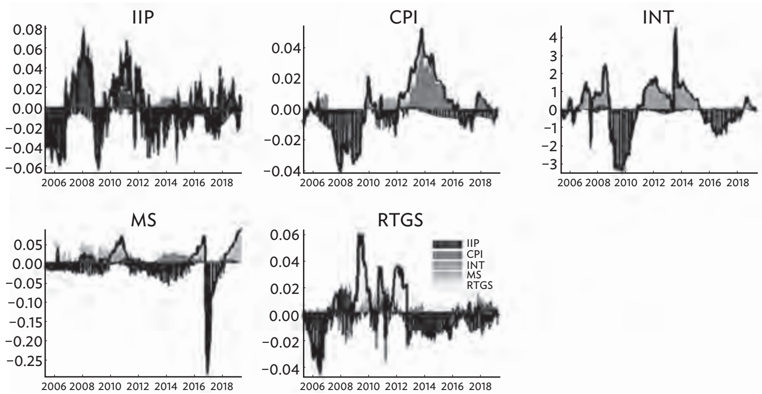


VAR = vector autoregression.

Note: The FEVD is based on median target IRFs as suggested by Fry and Pagan (2011). The shocks are represented as follows: IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply, RTGS is the value of real-time gross settlement. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, IIP, CPI, INT, MS, RTGS.

Source: Authors' calculations.

Figure 6.5: Historical Decomposition – Baseline Bayesian VAR



VAR = vector autoregression.

Note: Shock contributions are expressed in the deviation from the unconditional model forecast. The shocks are represented as follows: IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply, RTGS is the value of real-time gross settlement. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, IIP, CPI, INT, MS, RTGS.

Source: Authors' calculations.

6.5.4 Sensitivity Analysis

In this section, we examine the sensitivity of our empirical results to several changes in the basic setup of our model. We primarily examine the robustness of our model by (i) using the volume of RTGS as a measure of the usage of a digital payment system; (ii) ordering RTGS before the other variables for identification of the shocks; (iii) using the Akaike information criterion (AIC) as an alternative lag selection criterion; (iv) including an exogenous variable capturing the change in monetary policy stance in India (inflation-targeting regime); (v) using an alternative measure of the digital payment system; and (vi) using interpolated real GDP as a measure of economic activity. In each case, the model is identified through the Cholesky ordering as discussed for our baseline model. We evaluate these changes by comparing the impulse responses with our baseline model.

Using Volume of RTGS as a Measure of Usage of Payment System

In this specification, we use the volume of RTGS (RTGSV) as a measure of the payment system in our analysis. RTGSV represents the number of monthly RTGS transactions. The ordering of the variables is the same as in the baseline model, with RTSGV coming after IIP, CPI, INT, and real money supply. The impulse responses are presented in Figure 6.6. We find that the impact of the impulse responses is not as strong as the value of such transactions, indicating that the value of RTGS is a better measure of the payment system than the volume to capture the dynamic linkage between RTGS and economic activity.

Ordering RTGS before the Other Variables in Our Model

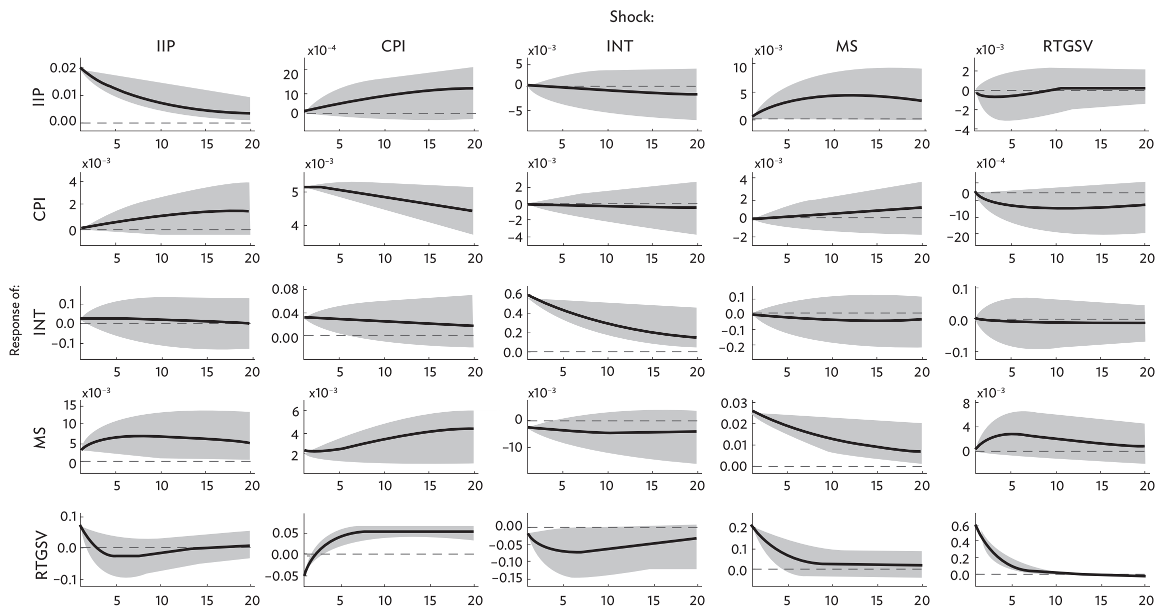
In our baseline BVAR, we identified the shocks by placing RTGS last. However, it can be argued that online payment impacts the other variables in our model (IIP, CPI, INT, and money supply) contemporaneously, but itself is impacted by the other variables with a lag. Thus, we provide an alternate ordering where RTGS is placed before the output, price, and monetary variables. Figure 6.7 represents the impulse responses with such identification. The impulse responses indicate that the impact of RTGS on IIP and CPI is similar to our baseline model, but the impact of IIP on RTGS is not significant with such identification of shock.

Identification with Alternative Lag Selection Criteria

There are alternative procedures to select the number of lags for the endogenous variables in a VAR model (Bańbura, Giannone, and Lenza 2015). In our baseline model, we chose the lag length of 1 based on DIC. However, the use of other lag selection criteria based on AIC, Hannan-Quinn Information Criteria, Bayesian Information Criteria, and similar methods is not uncommon (Chatziantoniou et al. 2013). Given our data, AIC suggests a lag length of 4. Thus, we re-estimate our model with four lags. Once again, the qualitative impulse responses remain unchanged between RTGS and IIP (see Figure 6.8).

Further, a few empirical studies (Ivanov and Kilian 2005; Carriero, Clark, and Marcelliano 2015) using monthly observations employ longer lag lengths to capture the long-run dynamics of the variables. Generally, the lag length is set to $p = 13$, which for any monthly data represents a year's worth of lags +1. Figure 6.9 presents the impulse responses using a lag length of 13. We find that the impact of RTGS on IIP is similar to those in the baseline model.

Figure 6.6: Impulse Responses – Bayesian VAR with RTGS Volume

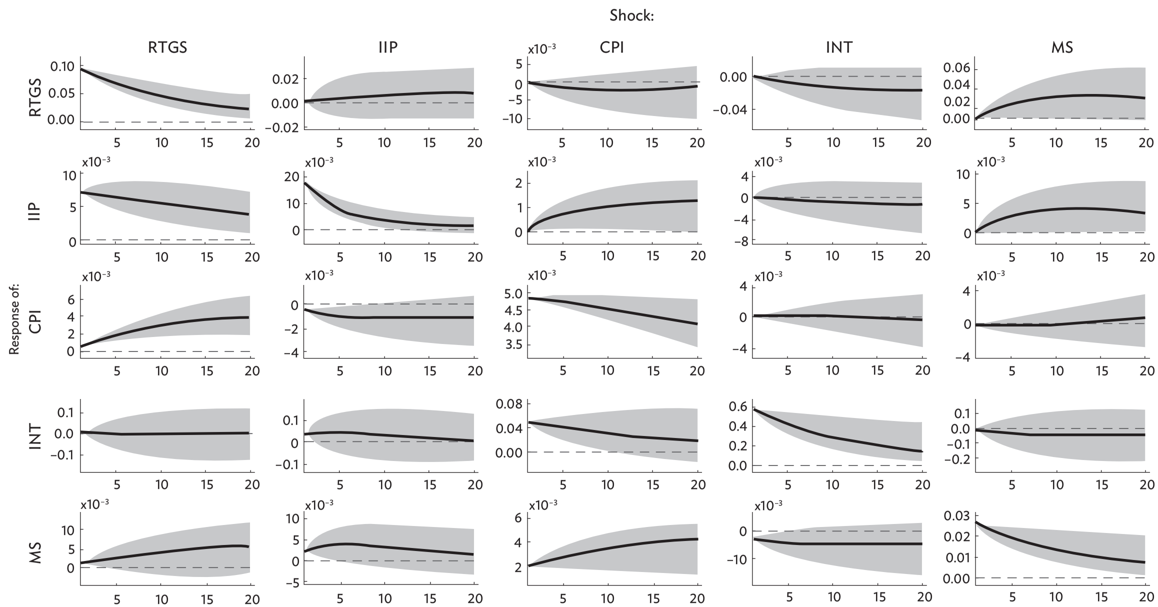


VAR = vector autoregression.

Note: Each column represents a shock; rows show the impulse responses due to shocks in the rows. The shocks are represented as follows: IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply, RTGSV is the volume of real-time gross settlement. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, IIP, CPI, INT, MS, RTGSV. The shocks are identified using the Cholesky decomposition. The solid black line is the median posterior response, and the shaded area represents 68% confidence interval.

Source: Authors' calculations.

Figure 6.7: Impulse Responses – Bayesian VAR with the Alternate Ordering of RTGS

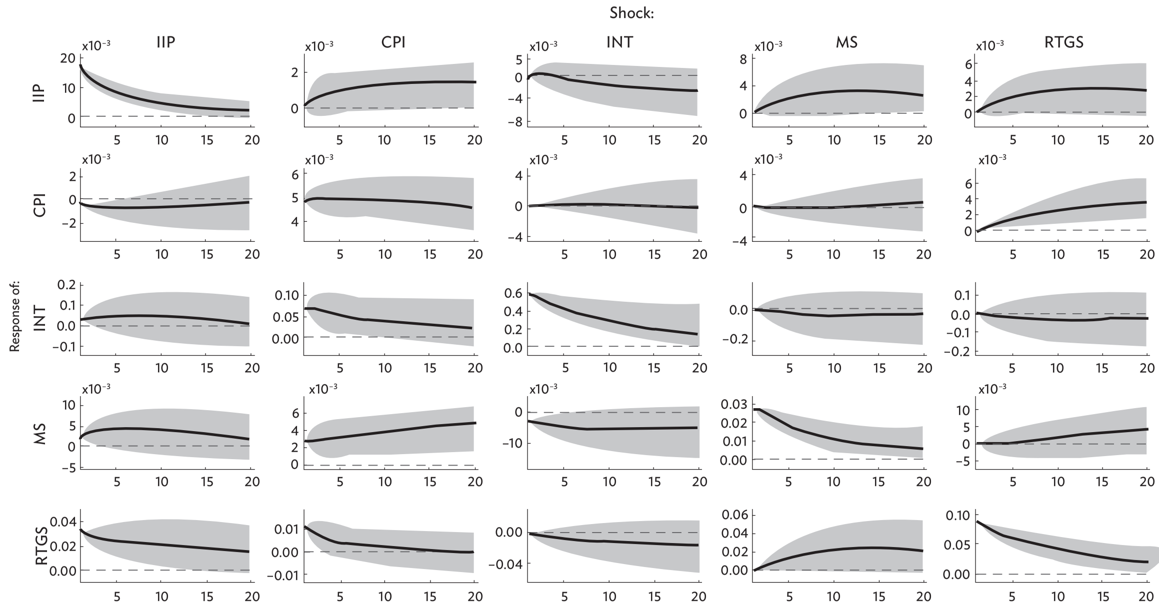


VAR = vector autoregression.

Note: Each column represents a shock; rows show the impulse responses due to shocks in the rows. The shocks are represented as follows: RTGS is the value of real-time gross settlement, IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, RTGS, IIP, CPI, INT, MS. The shocks are identified using the Cholesky decomposition. The solid black line is the median posterior response, and the shaded area represents 68% confidence interval.

Source: Authors' calculations.

Figure 6.8: Impulse Responses – Bayesian VAR with a Lag Length of 4 (AIC)



VAR = vector autoregression, AIC = Akaike information criterion.

Note: Each column represents a shock; rows show the impulse responses due to shocks in the rows. The shocks are represented as follows: RTGS is the value of real-time gross settlement, IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, IIP, CPI, INT, MS, RTGS. The shocks are identified using the Cholesky decomposition. The solid black line is the median posterior response, and the shaded area represents 68% confidence interval.

Source: Authors' calculations.

Identification with an Exogenous Variable that Captures the Inflation-targeting Regime Change

Following an agreement between the Government of India and the RBI, a monetary policy committee was constituted in February 2015 with the mandate to target CPI inflation from 5 August 2016 to 31 March 2021. The objective was to keep the rate of inflation of 4%, with a band of two percentage points on either side. To capture this structural change, we use a dummy variable indicating the shift in policy change and use it as an exogenous variable in our model. In this specification, our baseline VAR includes an exogenous dummy (0 and 1) after July 2016 to account for the changes in the monetary policy stance. The impulse responses presented in Figure 6.10 reveal that the introduction of this exogenous variable does not affect the primary findings of our analysis.

Use of Alternate Measure of Payment System

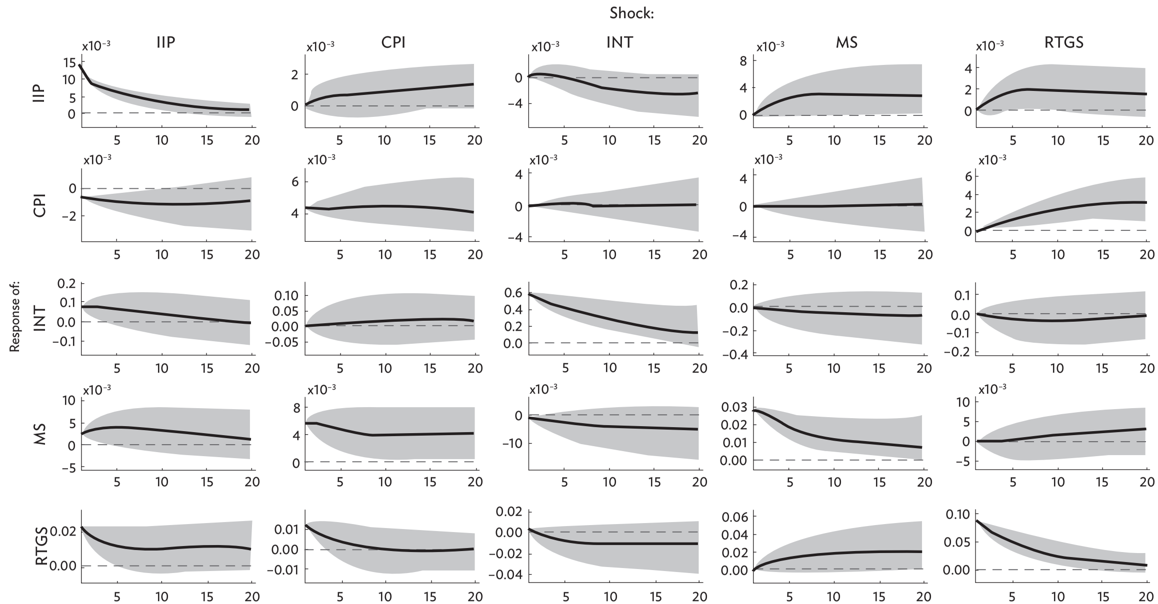
Next, we use the other most frequently used digital mode of the payment system in our analysis. This variable captures the retail electronic clearing service (RECS), which includes Electronic Clearing Service (both credit and debit), National Electronic Funds Transfer, Immediate Payment Services, and National Automated Clearing House to compare with our baseline model and we use the value of RECS in this specification. In 2018–19, RECS constituted about 36% in volume and about 9% in the value in the transactions for all kinds of payment system indicators. Figure 6.11 plots the impulse responses with RECS as the measure of the payment system. We find that the impact of RECS on IIP and other variables is weaker and insignificant, indicating that the value of such a mechanism is yet to develop in India and it has not been able to create any significant impact on the other macroeconomic indicators.

Using Interpolated Real GDP as a Measure of Economic Activity

Finally, we use real monthly GDP (GDPM) as the measure of real economic activity. We use linear interpolation to convert the quarterly real GDP into monthly observations using the interpolation method based on the Chow-Lin procedure (Silva and Cardoso 2001). The other parameters remain the same as our baseline BVAR, including the lag length of 1. Figure 6.12 plots the impulse responses with GDP as the measure of economic activity. We find the impulse responses resemble those of IIP.

Therefore, even after using several different specifications in our robustness analysis, we find no major shift from our initial finding of bidirectional causality between RTGS and economic growth in India.

Figure 6.9: Impulse Responses – Bayesian VAR with a Lag Length of 13

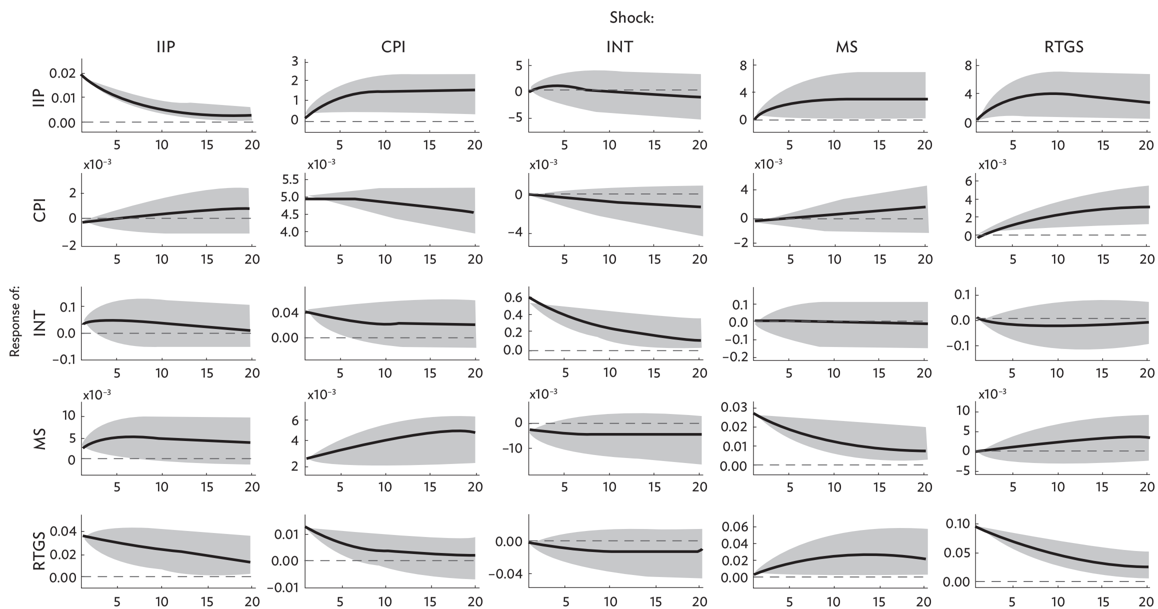


VAR = vector autoregression.

Note: Each column represents a shock; rows show the impulse responses due to shocks in the rows. The shocks are represented as follows: RTGS is the value of real-time gross settlement, IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, IIP, CPI, INT, MS, RTGS. The shocks are identified using the Cholesky decomposition. The solid black line is the median posterior response, and the shaded area represents 68% confidence interval.

Source: Authors' calculations.

Figure 6.10: Impulse Responses – Bayesian VAR with Exogenous Variable

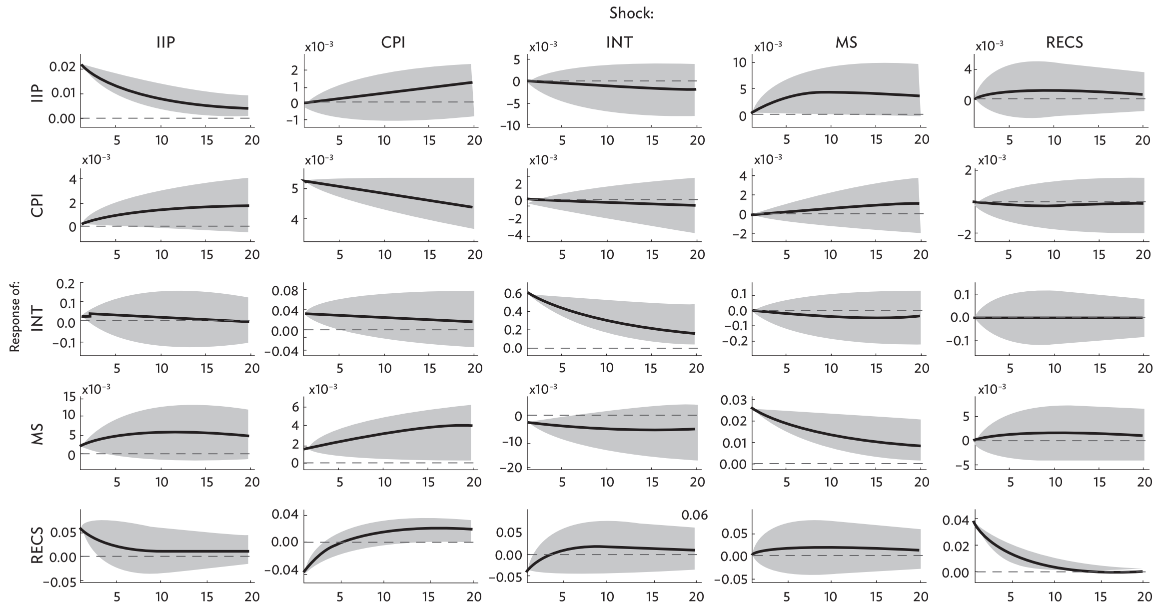


VAR = vector autoregression.

Note: Each column represents a shock; rows show the impulse responses due to shocks in the rows. The shocks are represented as follows: RTGS is the value of real-time gross settlement, IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, IIP, CPI, INT, MS, RTGS. The shocks are identified using the Cholesky decomposition. The solid black line is the median posterior response, and the shaded area represents 68% confidence interval.

Source: Authors' calculations.

Figure 6.11: Impulse Responses – Bayesian VAR with RECS

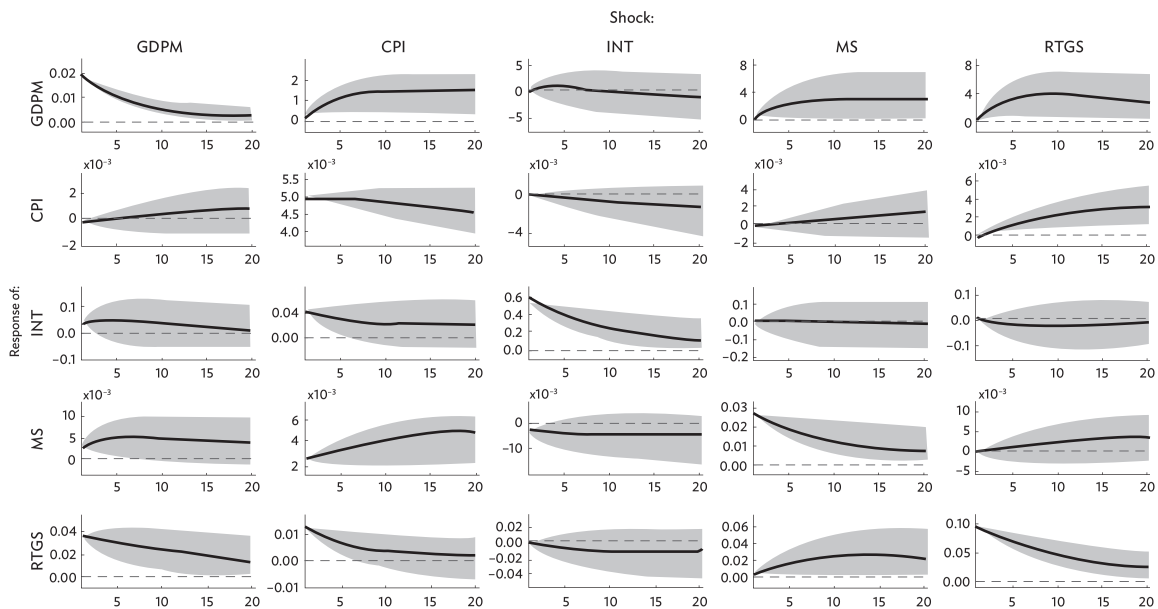


VAR = vector autoregression.

Note: Each column represents a shock; rows show the impulse responses due to shocks in the rows. The shocks are represented as follows: IIP is an index of industrial production, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply, RECS is the value of transactions using retail electronic clearing system. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, IIP, CPI, INT, MS, RECS. The shocks are identified using the Cholesky decomposition. The solid black line is the median posterior response, and the shaded area represents 68% confidence interval.

Source: Authors' calculations.

Figure 6.12: Impulse Responses – Bayesian VAR with GDP as a Measure of Economic Activity



VAR = vector autoregression, GDP = gross domestic product.

Note: Each column represents a shock; rows show the impulse responses due to shocks in the rows. The shocks are represented as follows: RTGS is the value of real-time gross settlement, GDPM is the interpolated monthly real GDP, CPI is consumer price index, INT is short-term interest rate, MS is nominal money supply. The impulse responses are generated from the five-variable Bayesian VAR with Minnesota prior including, in this order, GDPM, CPI, INT, MS, RTGS. The shocks are identified using the Cholesky decomposition. The solid black line is the median posterior response, and the shaded area represents 68% confidence interval.

Source: Authors' calculations.

Hence, we conclude that our baseline model is robust to any changes in the specifications.

6.6 Conclusion

The world is expanding the use of digital technology, and the banking sector is no different. The digital payment system is increasingly being adopted by central banks to streamline the financial sector. However, quantitative literature examining the role of the electronic payment system in driving economic growth is still underexplored. Therefore, in this study, we use a multivariate BVAR model to capture the relationship between the online payment system and economic growth and add several important endogenous variables that may affect both the payment system and economic growth. The BVAR model is helpful in this setting as it simultaneously addresses the misspecification problem and the "curse of dimensionality," which may arise due to the incorporation of multiple endogenous variables in a simultaneous equations setup. Also, this is the first study of its kind to analyze the relationship between a payment system and economic growth using uniquely available data on India in monthly frequencies.

Our results from the BVAR model after controlling for several endogenous variables (such as consumer price index, monetary policy variables, and nominal money supply) suggest that RTGS positively impacts economic growth in India. At the same time, economic growth also leads to an increase in the value and volume of RTGS, indicating the presence of bidirectional causality between RTGS and economic growth. The forecast error variance decomposition also suggests a strong association between RTGS and economic growth where a change in one variable (say, RTGS) causes a change in the other (say, economic growth), and vice versa. Several robustness checks using alternative measures of the online payment system, the inclusion of an exogenous variable, and a change in the lag structure not only preserve our primary findings but also provide additional support for the bidirectional causality between RTGS and economic growth, as is evident from our baseline model. We also find that an increase in RTGS leads to an increase in money supply and price level as indicated by the CPI. This finding indicates that when the economy is performing well and incomes are rising, thereby increasing demand in the economy, people tend to indulge in more electronic transactions and thus enhance economic growth.

Electronic payment modes are cost-effective, fast, and convenient; the increasing use of online payments thus has a potential economic effect. While the promotion of online payment systems will accelerate economic growth, our findings also indicate that greater usage of digital payments can also lead to higher price levels. Given that monetary policy has no significant impact on inflation and online payment systems, we need to explore further the channels through which payment systems and monetary policy are linked.

We also find that agents involved in retail transactions still prefer conventional modes of payment rather than a digitalized payment system. Thus, we do not find any effect of retail electronic payments on economic growth. With increasing penetration and digitalization of the banking sector, a detailed micro-level analysis could shed more light on the role of digital payment at the retail level, such as the impact of mobile banking or payment banking on a particular sector of the economy, e.g., agriculture or daily wage earners.

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PART II

Capital Flows and Systemic Risk in the Digital Age

7

The Impact of Banking Integration on East Asian Commercial Banks

Dung Thuy Thi Nguyen, Ivan Diaz-Rainey, and Helen Roberts[1]

7.1 Introduction

Financial integration is the term used to refer to closely linked financial markets at the subnational, national, regional, or global level. It encapsulates concepts such as financial openness, free movement of capital, and integration of financial services (Agénor 2001; Fung, Tam, and Yu 2008). The key expected benefits of financial integration are efficient capital allocation and international risk-sharing; however, financial integration also poses substantial risks to a country's financial and macroeconomic stability, including capital volatility and the transmission of shocks across markets (Agénor 2001; Allen et al. 2011). The dual nature of financial integration means that academic researchers, financial sector practitioners, and policy makers are all challenged by the longstanding question: "How can a country maximize the benefits and mitigate the costs of financial integration to ensure its financial and macroeconomic stability?"

Across the finance industry, the banking sector best illustrates both the potential costs and benefits of financial integration (World Bank 2018). Research dedicated to international banking activities has

1 We sincerely thank participants at the Asian Development Bank Institute conference on "Macroeconomic Stabilization in the Digital Age" (2019), the Vietnam Symposium in Banking and Finance (VSBF 2018 and 2019), the New Zealand Finance Colloquium (NZFC 2019), the Financial Markets and Corporate Governance conference (FMCG 2018), and seminar participants at the University of Otago, Vietnam National Economics University, and the Vietnam National University for providing useful comments on the three empirical studies (Nguyen et al. 2020a; Nguyen et al. 2020b; Nguyen et al. 2020c) summarized in this chapter. The first author gratefully acknowledges the Otago Doctoral Scholarship that financed her doctoral study.

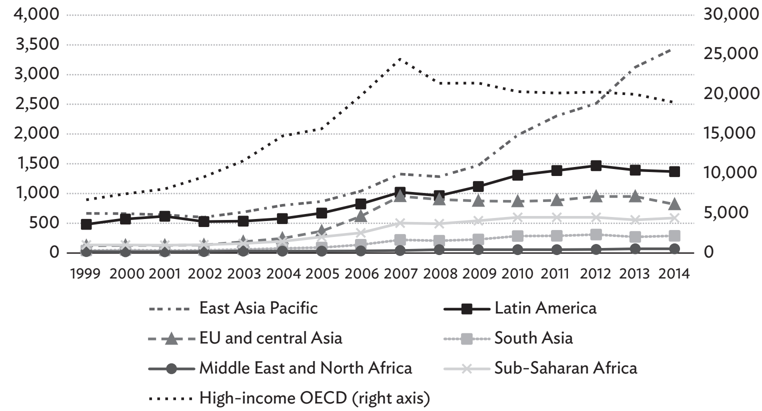
produced inconclusive evidence. On the positive side, foreign bank presence induces technological know-how and management expertise, thereby leading to a more competitive and efficient banking sector for the host countries (Claessens, Demirgüc-Kunt, and Huizinga 2001). Similarly, foreign capital channeled by international banks enables funding diversification and risk-sharing (Allen et al. 2011). On the negative side, local market consolidation because of fierce competition with foreign banks can lower overall bank efficiency (Casu and Girardone 2009). Excessive liquidity because of capital inflows leads local banks to take risks (Acharya and Naqvi 2012). On balance, some research suggests that institutional quality (Mian 2006; Detragiache, Tressel, and Gupta 2008) and financial development (Kose, Prasad, and Taylor 2011) serve as essential prerequisites for a country to reap net benefits from banking integration.

The latest reversal and regionalization trends in the international banking landscape following the global financial crisis further motivate the examination of the long-standing research concern from two new perspectives, namely the level and the types of banking integration. Specifically, the first trend is the reversal in international banking activities that is mainly observed in developed countries (World Bank 2018). Figure 7.1 documents the substantial decline experienced by the foreign banking claims on high-income Organisation for Economic Co-operation and Development countries during the post-crisis period. Further, a series of financial crises in the 1990s made the International Monetary Fund (IMF) soften their insistence on full financial liberalization, i.e., the so-called institutional view (IMF 2012). Taken together, the recent reversal following the global financial crisis increases the attention given to the level of banking integration and, in particular, identifying the point beyond which its costs outweigh its benefits.

Figure 7.1 also shows that, in contrast to the retrenchment among developed countries, the post-crisis period has witnessed the expansion of international banks from other regions. These emerging international banks have started expanding primarily within their region of origin (Claessens and Van Horen 2015). This is described as the trend of regionalization in the post-crisis international banking landscape (World Bank 2018). As the potential benefits and costs of financial regionalization remain largely unknown (World Bank 2018), the impact of different types of banking integration with regard to their geographical origination should be thoroughly examined.

Another related lens to view the foreign banking capital is its methods of extension. Specifically, international banks can extend foreign claims across borders or use local affiliates set up by international banks in the recipient countries. As seen in Figure 7.2, local claims, which carry more knowledge than cross-border claims, were resilient during the

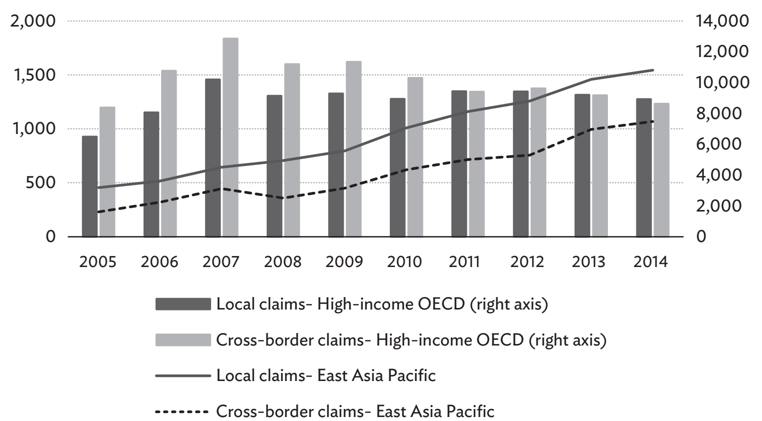
Figure 7.1: Foreign Banking Claims on Counterparty Regions in the World ($ billion)



EU = European Union, OECD = Organisation for Economic Co-operation and Development.

Source: Compiled from Bank for International Settlements' Consolidated Banking Statistics on Immediate Counterparty basis (BIS-IC), bank type "All excluding 4C banks, excluding domestic position".

Figure 7.2: Foreign Banking Claims (Classified by Methods of Extension) on High-Income OECD and East Asia Pacific Region ($ billion)



OECD = Organisation for Economic Co-operation and Development.

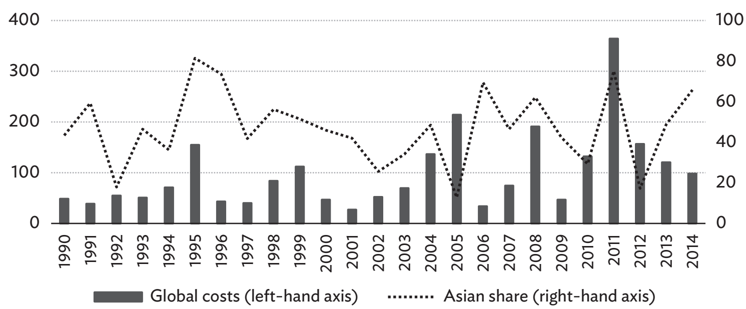
Source: Compiled from Bank for International Settlements' Consolidated Banking Statistics on Ultimate Risk basis (CBS-UR), bank type "Domestic banks, excluding domestic position".

global financial crisis. The variation in resilience is another motive for studying the impact of different types of banking integration with regard to their methods of extension in addition to their geographical source (regionalization).

Following the recent reversal and regionalization trend of international banking activities, this chapter reveals the impact of banking integration on the banking sector from three studies (Nguyen et al. 2020a; Nguyen et al. 2020b; Nguyen et al. 2020c). Specifically, the first study (Nguyen et al. 2020a) explores the non-monotonic relationship between banking integration and bank cost efficiency. The second study (Nguyen et al. 2020b) examines the impact of different types of banking integration, i.e., classified by their geographical origin and methods of extension bank default risk. Finally, the third study (Nguyen et al. 2020c) brings together issues related to the impact of natural disasters and banking integration. As shown in Figure 7.3, Asia has borne a considerable share of damage from natural disasters. Given the potential impact of disastrous events on the banking and financial system, the final study investigates the impact of natural disasters on a broad range of bank performance measures and, in particular, explores whether banking integration moderates these impacts.

The chapter focuses on commercial banks in East Asia. The 1997 Asian financial crisis led to high-profile bank defaults and a painful economic contraction in many East Asian economies (ADB 2008). Despite this troubled history, banking integration in the region has reached a new level of development, especially after the global financial crisis (Figure 7.1). More interestingly, East Asian countries

Figure 7.3: The Global Economic Damage of Natural Disasters ($ billion) and the Asian Share of Those Damages (%)



Source: Compiled from the Emergency Events Database (EM-DAT). https://www.emdat.be/ (accessed 20 September 2020).

are proactively promoting intraregional integration (ADB 2018). These features highlight the region as an important case to examine.

To address their research concerns, three studies employ different econometric methods. In the first study (Nguyen et al. 2020a), stochastic frontier analysis (SFA) consistently reports the non-monotonic impact of banking integration on bank cost efficiency. This result suggests that a healthy amount of banking integration is likely to be beneficial for bank cost efficiency. Given this finding, the revision by policy makers, such as the IMF, about the need for full capital financial liberalization would seem to be justified—crudely put, banking integration is a good thing but only up to a point. The chapter also investigates the optimal degree of banking integration. As studies about the IMF's institutional view mainly focus on the effect of capital management tools and the impact of foreign capital flows on financial crisis (Kawai and Takagi 2010; Guichard 2017), the point that financial liberalization, generally, and banking integration specifically, should be pursued remains ambiguous in the academic literature—an important gap that is addressed in this chapter.

Employing the system generalized method of moments (GMM) modelling technique, the second study (Nguyen et al. 2020b) reports that neighboring foreign capital is associated with lower information asymmetry and is beneficial to the financial stability of recipient countries. Neighboring foreign capital is extended either by banks from other Asian countries or foreign affiliates of international banks established in the recipient countries. These results highlight that regionalism still matters even as Asian financial systems and banks become more digital (McKinsey and Company 2018; Ernst and Young 2018).[2] Further, these results are proven to hold even during the periods of local shocks following natural disasters as reported by the third study summarized in this chapter (Nguyen et al. 2020c). We report that foreign banking claims extended by Asian neighbors prove to be an alternative source of finance to support the post-disaster recovery process. In short, these findings imply that distance matters to international banking activities.

Overall, the book chapter highlights the importance of the level and type of banking integration. Existing research, notably Mian (2006), Detragiache, Tressel, and Gupta (2008), and Kose, Prasad, and Taylor (2011) suggests that countries should meet a certain threshold of

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2 McKinsey and Company (2018) reports that, in Asia, digital transactions are 1.6 to 5 times as frequent as branch transactions during the surveyed period of 2014–17. Financial institutions associated with members of the Association of Southeast Asian Nations members also have high digital adoption rate; 45.6% of these institutions have initiated digital projects (Ernst and Young 2018).

institutional quality and financial development to reap the net benefits of financial integration. Given the findings from this chapter, in response to the longstanding question of "How could a country maximize benefits and mitigate the costs of financial integration to ensure its financial and macroeconomic stability?", policy makers and practitioners can find their answers by further examining the level and type of banking integration, respectively.

The chapter proceeds as follows. Section 7.2 reviews the literature related to the three studies. Methodology, data, and sample information is described in Sections 7.3, 7.4, and 7.5, respectively. Section 7.6 presents and discusses the key findings. Section 7.7 contains concluding remarks.

7.2 Literature Review

7.2.1 The Impact of Banking Integration on Bank Cost Efficiency

The first study (Nguyen et al. 2020a) tests whether a non-monotonic relationship between banking integration and bank cost efficiency exists. There have been arguments, theoretical models, and propositions advanced in the literature that suggest a non-monotonic impact of financial integration on bank performance. For example, based on portfolio diversification theory, Allen et al. (2011) hypothesize that the marginal benefits of integration diminish while its marginal costs rise as the level of financial integration increases. Following this hypothesis, there is an optimal level of financial integration such that additional integration efforts adversely impact capital allocation efficiency and international risk-sharing benefits. A mathematical model developed by Bacchetta and van Wincoop (2016) proves that when a country passes a certain threshold of financial integration, it exposes itself to greater risk.

Empirical findings from the bank efficiency literature suggest a non-monotonic relationship between financial integration and cost efficiency. For instance, Fries and Taci (2005) suggest that the association between a country's progress in banking reform and cost efficiency is nonlinear. Casu, Deng, and Ferrari (2017) find that financial liberalization improves bank cost efficiency; the effect is more evident in countries with pronounced regulatory change and less so in the case of limited liberalization. Unfortunately, these studies only highlight the potential existence of the non-monotonicity but do not formally test it. Additionally, these studies focus on the impact of financial reforms and financial liberalization, which are considered as a prerequisite for financial integration (Vo and Daly 2007; Kim and Lee 2008). The first study addresses this important gap in the literature by formally testing, for the first time, the non-monotonic impact of banking integration on bank cost efficiency.

7.2.2 Different Forms of Banking Integration and Their Impacts on Bank Default Risk

The second study examines the impact of foreign banking claims on bank default risk and whether the types of foreign banking claims (i.e., classified by their geographical origin and methods of extension) moderate that relationship.

With regard to the impact of foreign banking claims on bank default risk, the existing literature provides limited and contrasting findings. For instance, Dinger and Kaat (2017) report that inflows of foreign capital lead to higher impaired loans, while Karolyi, Sedunov, and Taboada (2018) show that cross-border banking flows lower systemic risk in the banking sector. To shed more light on the impact of foreign banking claims on bank default risk, the second study provides additional evidence from East Asia, a dynamic and growing region, which relies increasingly on foreign claims from international banks (Figure 7.1).

After establishing the baseline result, the study explores the impact of different types of foreign banking claims classified by their lenders' nationality and methods of extension. Concerning the former, foreign banking claims are extended either by regional (Asian) lenders or by distant (non-Asian) lenders. Regarding the latter, foreign claims are extended via local affiliates set up by international banks in the recipient countries or extended by international banks across borders

We propose that each type of capital is associated with different levels of information asymmetry. Specifically, regional (Asian) claims face less information asymmetry in comparison with their non-Asian counterparts due to the geographical, cultural, and institutional proximity between Asian lenders and their regional borrowers (Mian 2006; Claessens and Van Horen 2014). Similarly, the extension of funds via local affiliates rather than across borders involves some forms of foreign direct investment (García-Herrero and Martínez Pería 2007), which also helps to obtain local knowledge. Therefore, the information advantage associated with regional claims and local claims arguably creates an effective discipline mechanism and a strong competitive pressure over banks in the recipient countries, thus leading to lower risk-taking behavior. Although the rationale for expecting the preferential impact of regional claims and local claims is highly intuitive, there is currently no research that has investigated this possibility. Therefore, the second study addresses this important gap in the literature.

7.2.3 The Moderating Role of Banking Integration on the Relationship between Natural Disasters and Bank Performance

The third study summarized in this chapter (Nguyen et al. 2020c) examines the impact of natural disasters on a broad range of bank performance measures before investigating the moderating effect of foreign banking claims on that relationship. The study then explores whether the moderating role varies by several types of foreign banking claims classified by lenders' nationality and methods of extension, as in the second analysis.

Cross-country analyses are rare in studying the impact of natural disasters on the banking sector. Prior studies include Klomp (2014) and Brei, Mohan, and Strobl (2019), which report the negative impact of disasters on the aggregated country-level measures of bank performance. The third study augments these by examining the impact of disasters on various measures of bank-level performance (including deposits ratio, liquidity, credit risk, profitability, and default risk).

The unconstrained and immediate access to finance is important for post-disaster recovery. Bank deposits and credit, insurance, and government support are key domestic sources of finance post-disaster; additionally, foreign capital could serve as an alternative post-disaster funding source in times of local shocks (Noy 2009). However, the literature provides opposing predictions on the potential moderating role of banking integration. On the one hand, foreign banking capital could compensate for the volatility of domestic credit (De Haas and Van Lelyveld 2006; Allen et al. 2011), thus assisting the post-disaster recovery. On the other hand, the likelihood of associated international capital outflows (Yang 2008; David 2011) could amplify the shortage of funds, thereby slowing down the recovery process. This study aims to confirm which effect is present (or is dominant) for the case of commercial banks located in the disaster-prone region of East Asia.

As postulated in the second study, each type of foreign banking claim is associated with a different level of information asymmetry. More specifically, the neighboring claims that are either regional (Asian) claims or local claims are associated with lower information asymmetry. The information advantage is crucial to maintaining the credit supply, as lenders face severe information asymmetry when disasters destroy customer information as well as collateral (Chavaz 2014; Cortés and Strahan 2017). Relying on this line of argument, the third study re-investigates the preferential effect of neighboring claims in moderating the relationship between disasters and bank performance.

7.3 Model Specification and Estimation Method

7.3.1 Bank Cost Efficiency and Determinants of Inefficiency

Bank efficiency is defined as the distance to a best-performance frontier that is not explained by statistical noise. SFA is a well-established empirical approach for measuring bank efficiency, which allows a single-step approach to estimate the best-practice frontier and the determinants of the inefficiency term. More specifically, the chapter applies the SFA non-monotonic efficiency effect model developed by Wang (2002). The model is presented in the context of panel data as follows:

$$TC_{it} = f\,(W_{it}; Q_{it}) + v_{it} + u_{it} \qquad (1)$$
$$u_{it} \sim N+\,(\mu_{it}, \sigma^2_{it});\ v_{it} \sim N\,(0, \sigma^2_v)$$

$$u_{it} = \delta_0 + \delta Z_{it} \qquad (2)$$

$$\sigma^2_{it} = \exp\,(\gamma_0 + \gamma Z_{it}) \qquad (3)$$

where TC_{it} is the total cost for bank i at time t; W_{it} and Q_{it} are, respectively, vectors of input prices and outputs; v_{it} is a normally distributed error term with zero mean and variance (σ^2_v); and the non-negative component u_{it} follows a truncated normal distribution with an observation-specific mean (μ_{it}) and variance (σ^2_{it}) that measures the inefficiency term.

As presented in Equations 2 and 3, the model allows both the mean and variance of the pre-truncated distribution to be expressed as the function of some environmental variables (Z_{it}). The non-monotonic impact of a Z_{it} variable is measured by its marginal effect on the inefficiency term.[3] The non-monotonicity means that Z_{it} can positively (negatively) affect the mean and variance of the inefficiency term when its values are within a certain range, and then change to negative (positive) for values outside the range. In linear efficiency effect models, the impact of Z_{it} is either positive or negative, but not both.

[3] The marginal effect depends on the slope coefficients from both the mean and the variance functions (as presented in Equations 2 and 3) and an adjustment function. To make statistical inferences, the standard error and confidence interval of the marginal effect are obtained by bootstrapping. For the detailed equations, please see Wang (2002).

The parameters of the model are estimated by the maximum likelihood method. Specifically, Equation 1 is specified in the trans-log functional form with two outputs and three input prices to represent the underlying cost structure of the banking industry. With respect to the function of the level and variance of the inefficiency term given by Equations 2 and 3, the environmental group of variables Z_{it}, include several bank-specific, country-specific and event-specific variables in addition to banking integration indicators. Please refer to Appendix 7.1 for the detailed specification of these equations and Appendix 7.2 for the definition of variables.

7.3.2 Different Forms of Banking Integration and Their Impacts on Bank Default Risk

The second study adopts a dynamic specification to examine the impact of banking integration on bank default risk. More specifically, the first-order dynamic model of bank default risk is specified as in Equation 4.

$$RISK_{ijt} = \beta_0 RISK_{ijt-1} + \beta_1 INTEG_{jt} + \beta_k BANK^k{}_{ijt} + \beta_m COUNTRY^m{}_{jt} + \theta_i + \gamma_j + \mu_t + \varepsilon_{ijt} \quad (4)$$

The default risk (measured via the distance to default z-score) of bank *i* in year *t* for country *j* is written as a function of its past level, banking integration (INTEG), a vector of *k* bank-level variables reflecting the characteristics of each bank *i* (BANK), and a vector of *m* variables reflecting the macroeconomic condition to all banks including bank regulation and supervision (COUNTRY) for any given country *j*. θ_i is the bank- specific fixed effect to control for unobserved time-invariant factors for each bank. γ_j and μ_t are the country and time dummies, respectively; ε_{ijt} is the error term. The definitions and construction details for all variables are provided in Appendix 7.2.

To examine the impact of different types of banking integration, the aggregate measure of banking integration ($INTEG_{jt}$) in Equation 4 is replaced by the specific measure to represent the Asian claims, non-Asian claims, local claims and cross-border claims, respectively.

To estimate the dynamic model presented in Equation 4, the chapter employs the two-step system GMM developed by Arellano and Bover (1995) and Blundell and Bond (1998).

7.3.3 The Moderating Role of Banking Integration on the Relationship between Natural Disasters and Bank Performance

Similar to the second study, a dynamic panel data model of bank performance ratios is constructed to reveal the short-term and contemporaneous response of banks toward disasters. The two-step system GMM is also used to estimate this dynamic relationship.

$$Y_{ijt} = \beta_0 Y_{ijt-1} + \beta_1 DAMAGE_{jt} + \beta_2 INTEG_{jt} + \beta_k BANK^k{}_{ijt} + \beta_m COUNTRY^m{}_{jt} + \theta_i + \gamma_j + \mu_t + \varepsilon_{ijt} \quad (5)$$

Y_{ijt} is the dependent variable (such as deposits ratio, liquidity, credit risk, profitability, and distance to default) for bank *i* in country *j* at time *t*. Other notations remain unchanged from Equation 4. The variable of interest is DAMAGE; its coefficient β_1 reflects the relation between bank response and contemporaneous shocks from disasters occurring in year *t*. The definitions and construction details for all variables are provided in Appendix 7.2.

Equation 6 examines the moderating role of banking integration on the relationship between natural disasters and bank performance, by including the interaction term between the measures of banking integration (INTEG) and disasters impact (DAMAGE) in Equation 5:

$$Y_{ijt} = \beta_0 Y_{ijt-1} + \beta_1 DAMAGE_{jt} + \beta_2 INTEG_{jt} + \beta_3 DAMAGE_{jt} * INTEG_{jt} + \beta_k BANK^k{}_{ijt} + \beta_m COUNTRY^m{}_{jt} + \theta_i + \gamma_j + \mu_t + \varepsilon_{ijt} \quad (6)$$

To examine the moderating role of each type of banking integration, the aggregate measure of banking integration in Equation 6 is estimated with specific factors to represent the Asian, non-Asian, local and cross-border claims, respectively.

7.4 Banking Integration Measures and Data

The first study measures the level of banking integration (i.e., $INTEG_{jt}$) by the foreign bank penetration and the receipt of foreign banking capital. The percentage of foreign banks relative to the total number of banks in a country (FOR) proxies for the former. The data for foreign bank ownership are sourced from Claessens and Van Horen (2015). FOR has been widely studied as a determinant of bank efficiency (Lensink, Meesters, and Naaborg 2008; Pasiouras, Tanna, and Zopoinidis 2009).

Another measure is the foreign claims of international banks on a country to the gross domestic product (GDP) of that country (CLAIM). The data of the foreign claims are sourced from the Consolidated Banking Statistics (CBS) on Intermediate Counterparty basis (IC) published by the Bank for International Settlements (BIS).[4] Foreign claims are originally reported on a quarterly basis. The chapter estimates annual claims by taking the stock data on the last quarter of each year in the sampled period. Bilateral claims of a source-recipient country pair are then aggregated by the recipient country. After these steps, the year- and country-level claims on each of the sampled countries are obtained. The foreign claims are then scaled by the GDP of the corresponding sampled countries to construct the variable CLAIM. In short, CLAIM is relevant to assess the size of the international banking activities of one country in comparison with its GDP. Higher values of CLAIM are associated with more participation in the international banking activities and greater banking integration.

For the second and third studies, the chapter only focuses on the receipt of foreign banking claims as the main measure of banking integration. Specifically, being extended by all lenders regardless of their nationality or methods of extension, CLAIM is regarded as the aggregate measure of banking integration. To classify the total foreign claims by lenders' nationality, the chapter draws data on the Asian claims and non-Asian claims from the CBS-IC report. To break down the foreign claims by the methods of extension, data for local claims and cross-border claims are sourced from the CBS on Ultimate Risk (CBS-UR) basis.[5] Following the same procedure of construction as CLAIM, these statistics are then scaled by the GDP of the sampled countries to construct the variables, namely ASIAN, NON_ASIAN, LOCAL, and CROSS, respectively.[6]

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4 Though not originally designed with the borrower perspective in mind, BIS CBS statistics are one of the few publicly available sources to provide information on the reliance of a borrower country on foreign bank credit (Cerutti, Claessens, and McGuire 2012). However, one limitation of CBS is that its data are subject to break-in-series and exchange-rate adjustment. To rule out this concern, following Karolyi et al. (2018), we checked and ensured that the reported statistics for the sampled countries do not exceed 100% increase in their absolute values.

5 The CBS-UR separately reports cross-border claims and local claims while the CBS-IC does not provide a clear-cut distinction between these two measures. There are additional differences in the reporting basis of CBS-IC and CBS-UR. For instance, while CBS-IC looks at the immediate relationship between borrowers and lenders, CBS-UR tracks the counterparty who is ultimately responsible for servicing any outstanding obligations in the event of a default by the immediate borrower (BBIS 2015). Since July 2019, CBS-UR changed its name to CBS on a guarantor basis (CBSG) to closely reflect its nature of reporting. Furthermore, CBS-UR is only available since 2005, while CBS-IC is available since the 1980s.

6 Please refer to Appendix 7.3, Panel B and C, for the descriptive statistics of these measures.

7.5 Sample

The chapter focuses on commercial banks in East Asia; however, due to data availability, there are slight variations in the samples used for each study. Specifically, an unbalanced sample of 3,628 bank-year observations (about 386 banks) from nine economies (including the People's Republic of China; Hong Kong, China; Indonesia; Malaysia; the Philippines; the Republic of Korea; Singapore; Thailand; and Viet Nam) during the period 1997–2014 is examined in the first study (Nguyen et al. 2020a). An unbalanced sample of 2,280 bank-year observations (about 393 banks) over the period 1999–2014 is applied to the second study (Nguyen et al. 2020b); Viet Nam is dropped from the list of the sampled countries.[7] A sample of 2,219 commercial bank-year observations (about 379 banks) for the period 1999–2014 is analyzed in the third study (Nguyen et al. 2020c); Singapore is dropped from the list of the sampled countries.[8]

Bank-level data are obtained from Bankscope. Banks with less than three consecutive years of available financial data for all bank-specific variables are excluded. All mergers and acquisitions and bank failures during the sample period are accounted for in the dataset so that both active and inactive banks are included to avoid survivorship bias. All bank-level data are winsorized at the top and bottom 0.5th percentile.

7.6 Key Findings

7.6.1 The Non-Monotonic Impact of Banking Integration on Bank Cost Efficiency

The first study tests whether the non-monotonic impact of banking integration on bank cost efficiency exists (Nguyen et al. 2020a). Table 7.1 reports the sample mean of the marginal effect of banking integration indicators on the inefficiency term, as well as the average marginal effect of the 25th, 50th, 75th, and 90th percentile (ordered by value

[7] Bank regulation and supervision are among important determinants of bank risks (Laeven and Levin 2009), thus the sample of the second study relies on availability of this data. Accordingly, the examined period starts from 1999, which is the first available year of regulation data. Comparing the country sample used in the first study, Viet Nam is removed due to the unavailability of regulation data. Otherwise, the sample remains unchanged.

[8] Comparing to the second study, the list of countries remains unchanged except for Singapore, which reported no natural disasters.

Table 7.1: The Non-Monotonic Impact of Banking Integration Indicators on the Inefficiency Term

	The marginal impact of CLAIM		The marginal impact of FOR	
Statistics	**on E(u)**	**on V(u)**	**on E(u)**	**on V(u)**
Panel A: The whole sample				
INTEG				
Average	-0.0036**	0.0004	-0.0021**	0.0010
25th per.	-0.0067**	-0.0009	-0.0042***	-0.0009
50th per.	-0.0024**	-0.0004	-0.0003	0.0002
75 per.	-0.0003	0.0002	0.0018**	0.0013**
90 per.	0.0018**	0.0016***	0.0045***	0.0037***
Panel B: The low-integration group countries				
INTEG				
Average	-0.0069***	0.0058***	0.0020	0.0010*
25th per.	-0.0320***	0.0010***	-0.0038***	-0.0006
50th per.	-0.0060***	0.0020***	0.0008	0.0007
75th per.	0.0077***	0.0042***	0.0033	0.0021
90th per.	0.0239***	0.0172***	0.0054**	0.0040**

Notes: This table reports the marginal impact of banking integration indicators (at the average, 25th, 50th, 75th, and 90th percentile levels ordered by the value of the marginal effect) on the mean and variance of the inefficiency term, i.e., E(uit) and V(uit), respectively. The significance levels are calculated based on the bootstrapping confidence intervals and standard errors produced from 1,000 replications. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. CLAIM refers to the foreign claims of international banks on a country as compared to the gross domestic product of that country. FOR refers to the percentage of foreign banks relative to the total number of banks in a country.

Source: Nguyen et al. (2020a)

of the marginal effect).[9] The change in the sign of the marginal effect across the percentiles illustrates the non-monotonic impact of banking integration on cost inefficiency. The marginal effect of CLAIM reported in Column 1 (Panel A) is taken as an example. At the 25th percentile, a 1-percentage-point increase in CLAIM reduces total cost approximately

9 The marginal impact of other environmental variables is not reported to save space, but available on request.

by 0.67%.[10] As we move from the 25th percentile to the 75th percentile, the benefit diminishes substantially. At the 90th percentile, an increase in CLAIM increases total cost approximately by 0.18%. In the case of FOR (reported in Column 3), the efficiency reduction starts at the 75th percentile.

To assist the interpretation of the findings, the top left-hand panel of Figure 7.4 identifies the turning point of the marginal effect when the value of CLAIM reaches 100%. This means that policy makers should be concerned when the foreign banking claims reach this level, as they may become detrimental to cost efficiency. Similarly, the level of inefficiency rises (see the top right-hand panel of Figure 7.4) when more than 40% of banks are owned by foreign investors.

To summarize, the results imply that initially, the foreign banking capital and foreign bank presence provide competitive incentives for managers to be cost-effective (Lin, Doan, and Doong 2016; Casu et al. 2017). However, at higher levels of banking integration, additional costs will be incurred from updating bank products and services to keep up with greater competition or managing excess risk-taking behavior due to the open financial market (Fries and Taci 2005; Lensink, Meesters, and Naaborg 2008; Casu and Girardone 2009). These findings support the theoretical prediction of Allen et al. (2011) on the non-monotonic impact of banking integration on bank cost efficiency (see Section 2.1).

Regarding the impact of CLAIM (FOR) on the variance of the inefficiency term (as reported in Columns 2 and 4), only the positive impact is significant. Cost performance becomes more variable for banks operating in more competitive and financially integrated systems.

As seen in Panel B of Table 7.1, the non-monotonicity still holds when Wang's 2002 model is applied for the low-group countries (specifically, all the sampled countries excluding the two financial centers Hong Kong, China; and Singapore).[11] This is to address the concern that the non-monotonic relationship between banking integration and cost

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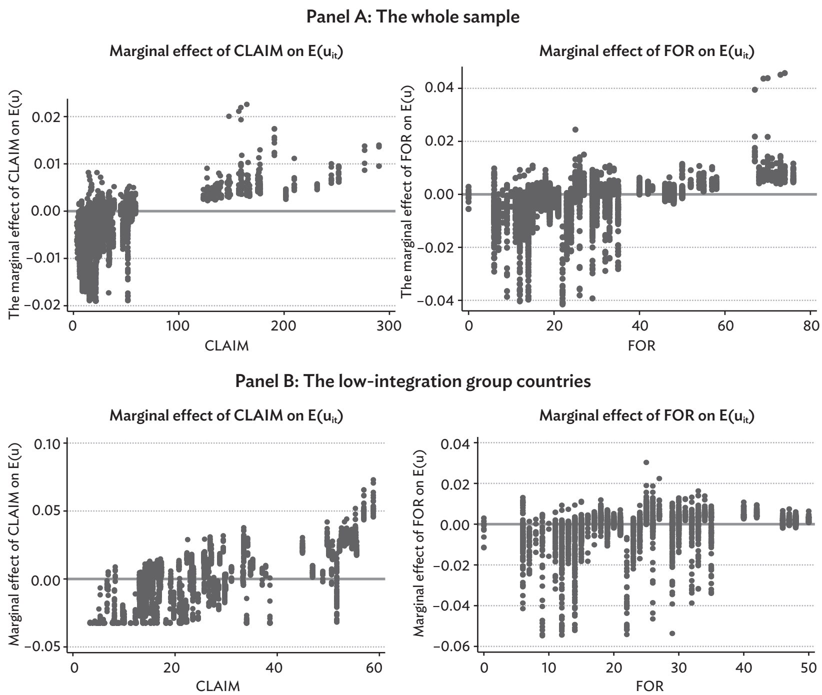
10 The negative sign of the marginal effect of the Z variable on E(u) implies that Z does not cause an overuse of inputs, which in turn helps to lower costs (and vice versa). In other words, the negative sign indicates the decrease in inefficiency level, which suggests an increase in cost efficiency. With regard to the economic impact, the percentage increase in costs due to inefficiency could be obtained based on the approximation formula: u=ln (actual cost/minimum cost). For instance, the average marginal effect of the first quantile is (-0.0067); this means that a 1-percentage-point increase in CLAIM is translated into a (0.0067*100) 0.67% decrease in total cost.

11 Panel A of Appendix 7.3 provides descriptive statistics to highlight the heterogeneity in the level of banking integration among the sampled countries.

Figure 7.4: The Non-Monotonic Impact of Banking Integration Indicators on Bank Cost Efficiency



CLAIM refers to the foreign claims of international banks on a country as compared to the gross domestic product of that country. FOR refers to the percentage of foreign banks relative to the total number of banks in a country.

Source: Nguyen et al. (2020a).

efficiency may originate from the heterogeneity in the level of banking integration between the two groups of countries (low-integration and high-integration). Moreover, the lower panels of Figure 7.4 indicate that the turning point for the marginal impact of CLAIM on the inefficiency level occurs at 55%, while the turning point for FOR remains at 40%.

7.6.2 Different Forms of Banking Integration and Their Impacts on Bank Default Risk

The second study (Nguyen et al. 2020a) examines the impact of foreign banking claims on bank default risk and whether the types of foreign banking claims moderate that relationship. Table 7.2 reports key findings

Table 7.2: The Impact of Foreign Banking Claims and Its Components On Bank Default Risk

	(1)	(2)	(3)	(4)	(5)
L.LN(zscore)	0.423***	0.460***	0.434***	0.464***	0.455***
	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)
CLAIM	0.046*				
	(0.02)				
ASIAN		0.071**			
		(0.03)			
NON_ASIAN			0.013		
			(0.03)		
LOCAL				0.101**	
				(0.04)	
CROSS					0.046
					(0.05)
Bank-level control variables	Yes	Yes	Yes	Yes	Yes
Country-level control variables	Yes	Yes	Yes	Yes	Yes
Constant	-6.383*	0.246	-3.777	-15.697*	-4.613
	(3.58)	(3.02)	(4.17)	(8.53)	(6.40)
# Obs.	836	836	836	615	615
# Banks	202	202	202	156	156
# IV	100	100	100	80	80
AR(2) test (p value)	0.342	0.308	0.397	0.103	0.150
Hansen-J test (p value)	0.602	0.643	0.655	0.509	0.415

Notes: The table reports the impact of banking integration on bank default risk from Equation 4. The dependent variable is the natural logarithm of Z-score to proxy for bank default risk (LN(zscore)). Banking integration indicators include CLAIM, ASIAN and NON_ASIAN, and LOCAL and CROSS. Bank-level control variables include bank size (SIZE), equity ratio (CAP), credit risk (CRERISK), cost management ratio (COST), income diversification (INC_DIV), bank charter value (CHARTER), market concentration (CON), and a dummy variable to proxy for bank ownership (ODUM). Country-level control variables include gross domestic product growth rate (GDP), the inflation rate (IFL), interest rates (INT), financial development (PRICE), dummies to proxy for a bank crisis (CRISIS) and insurance scheme (INS), and regulation and supervision variables (ACT, SUP, and PRIMON). For the definition and construction of these variables, see Appendix 7.2. Bank FE, country and time dummies are included, but not reported to save space. All models are estimated by the system generalized method of movements. The robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Nguyen et al. (2020b).

for these research concerns. As seen in Column 1, the coefficient of CLAIM is positive and significant. This implies that banking integration is associated with the increase in bank Z-score (or reduction in bank default risk). The significant and positive coefficients of ASIAN and LOCAL, reported in Columns 2 and 4, contrast with the coefficients for NON_ASIAN and CROSS, reported in Columns 3 and 5. These results imply that Asian claims and local claims contribute to the higher stability of banks in the recipient countries.[12] Overall, these findings confirm the link between lower information asymmetry and regional lending as well as local affiliates-based lending.

7.6.3 The Moderating Role of Banking Integration on the Relationship between Natural Disasters and Bank Performance

The third study (Nguyen et al. 2020c) examines the impact of natural disasters on a broad range of bank performance measures before investigating the moderating effect of foreign banking claims as well as their components (i.e., classified by lenders' nationality and methods of extension) on that relationship. Table 7.3 presents our key findings. From Column 1 of Table 7.3, disasters significantly lower the deposits ratio.[13] The result is consistent with evidence of deposit withdrawal in the small Eastern Caribbean islands following disasters reported by Brei, Mohan, and Strobl (2019). The finding implies that depositors in East Asian countries withdraw cash from banks to cope with losses.

As seen in Column 2, the coefficient of the interaction term between CLAIM and DAMAGE is significant and positive, indicating that the total foreign banking claims help to alleviate the bank deposit decline during the aftermath of disasters. The result suggests that foreign banking claims serve as an alternative source of finance (in addition to bank deposits) to support the post-disaster recovery of households and firms.

Columns 3 to 6 report the detailed evidence of the moderating impact of foreign claims classified by the lenders' nationality. The coefficient for the interaction term between ASIAN and DAMAGE

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12 These findings also hold for the sub-sample of low-integration countries (i.e., the whole sample except for Hong Kong, China; and Singapore). These findings are not reported but available upon request.

13 Other than deposits ratio, this study finds no significant impact of disasters on liquidity, credit risk, profitability, and default risk. This finding implies that the East Asian commercial banking system has become more resilient after the Asian financial crisis. These results are not reported but available upon request.

Table 7.3: The Impact of Disasters on Bank Deposits and the Moderating Role of Banking Integration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
L.DEPO	0.694***	0.699***	0.717***	0.709***	0.694***	0.695***	0.726***	0.725***	0.678***	0.684***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)	(0.11)	(0.11)	(0.09)	(0.09)
DAMAGE	-0.720**	-6.739***	-1.075***	-3.725**	-0.552***	-1.573	-0.972*	-3.782*	-0.529	-0.765
	(0.28)	(1.68)	(0.31)	(1.53)	(0.21)	(0.98)	(0.52)	(2.10)	(0.45)	(3.59)
CLAIM	-0.195	-0.599**								
	(0.21)	(0.26)								
DAMAGE_CLAIM		0.243***								
		(0.06)								
ASIAN			-0.809***	-0.698**						
			(0.30)	(0.29)						
DAMAGE_ASIAN				0.294*						
				(0.16)						
NON_ASIAN					0.229	0.061				
					(0.32)	(0.44)				
DAMAGE_NONASIAN						0.121				
						(0.11)				
LOCAL							-0.787*	-0.971**		
							(0.45)	(0.48)		
DAMAGE_LOCAL								0.189		
								(0.14)		

continued on next page

Table 7.3 *continued*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CROSS									-0.084	-0.196
									(0.43)	(0.41)
DAMAGE_CROSS										0.026
										(0.61)
Bank-level variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-level variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Obs.	810	810	810	810	810	810	589	589	589	589
# Banks	194	194	194	194	194	194	148	148	148	148
# IV	95	96	95	96	95	96	74	75	74	75
AR(2) test (p value)	0.196	0.191	0.184	0.172	0.107	0.120	0.208	0.209	0.179	0.18
Hansen-J test (p value)	0.653	0.738	0.648	0.665	0.628	0.590	0.656	0.674	0.555	0.552

Notes: The table reports the impact of disasters on bank deposits ratio, and the moderating role of banking integration on the impact of disasters on bank deposits ratio as in Equations 5 and 6. Disaster damage is proxied via the ratio of economic loss to a country's previous year gross domestic product (DAMAGE). Banking integration indicators include CLAIM, ASIAN and NON_ASIAN, and LOCAL and CROSS. Bank-level control variables include equity ratio (CAP), credit risk (CRERISK), cost management ratio (COST), income diversification (INC_DIV), loans to assets ratio (LOANS), bank charter value (CHARTER), market concentration (CON), and a dummy variable to proxy for bank ownership (ODUM). Country-level control variables include gross domestic product growth rate (GDP), the inflation rate (IFL), interest rates (INT), financial development (PRICE), dummies to proxy for a bank crisis (CRISIS) and insurance scheme (INS), and regulation and supervision variables (ACT, SUP, and PRIMON). For the definition and construction of other control variables, see Appendix 7.2. Bank fixed effect, country and time dummies are included, but not reported to save space. All models are estimated by the system generalized method of moments. The robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Nguyen et al. (2020c)

reported in Column 4 is significant and positive. This contrasts with the insignificance of non-Asian claims reported in Column 6. The significant Asian interaction term suggests that Asian claims help to alleviate the decline in bank deposits ratio following disasters.

Columns 7 to 10 report the models estimated when the total foreign banking claims are classified into local claims and cross-border claims. Reported in Columns 8 and 10, the coefficients for the interaction terms between either LOCAL or CROSS and DAMAGE are positive as expected; however, the standard errors are quite large, making the coefficients insignificant. This could be due to the lack of variation in the response of local claims and cross-border claims to natural disasters. Overall, the evidence on the moderating role of both local and cross-border claims is unclear.

7.7 Conclusion

The chapter summarizes three empirical studies that examine the impact of banking integration, with a focus on the level and type of integration and the moderating impact of natural disasters. The first study (Nguyen et al. 2020a) consistently reports the non-monotonic impact of banking integration on bank cost efficiency. Specifically, while banking integration initially improves bank cost efficiency, it eventually reduces it. Turning points of the non-monotonicity occur when more than 40% of banks are foreign and the foreign claims of international banks exceed 100% of GDP. In the sub-sample of low-integration countries, the turning point of the foreign bank ratio is 40% and the foreign banking claims ratio is 55%. These findings can inform national policy makers in East Asia concerning the degree country-level financial integration. In the wider context of financial globalization, these findings provide empirical evidence to support the more nuanced policy toward the full capital financial liberalization adopted by the IMF.

Our second study (Nguyen et al. 2020b) finds that banking integration lowers bank default risk in the recipient countries. The impact is primarily driven by the foreign claims either extended by regional (Asian) lenders or via local affiliates of international banks. The preferential impact of regional claims points to the benefit of financial regionalization since close proximity between lenders and borrowers alleviates information asymmetry, allowing for effective monitoring and disciplining of the loan relationship. The presence of international banks through local affiliates in the recipient countries and the extension of funds via this channel also leads to an equivalent impact. These two options of the neighboring foreign claims are complementary, providing East Asian policy makers with flexibility in their choice of preferred form of banking integration. Future research could examine whether this result also holds for digital institutions. Intuitively, fintech companies providing banking services via online platforms (i.e. peer-to-peer lending) rather than the traditional brick-and-mortar approach may face different types and levels of information asymmetry (Yan, Yu, and Zhao 2015; Cummins et al. 2019). Empirical validation of this argument can inform policy concerning digital-era banking and financial stability. Notwithstanding this suggestion, it is clear that Asian financial systems have become more digital generally (McKinsey and Company 2018; Ernst and Young 2018); yet our evidence shows that regionalism still matters even as financial systems have become more digital.

The third study (Nguyen et al. 2020b) finds that natural disasters significantly lower the bank deposits ratio. Further, it shows that foreign banking claims, specifically those extended by regional (Asian) lenders, help to alleviate the decline in deposits in the aftermath of natural disasters. These results highlight the role of commercial bank deposits and regional banking claims as sources of finance for post-disaster recovery. Accordingly, policy makers in East Asia have additional evidence to support the intra-regional financial integration; this recommendation is also robust during the episodes of local shocks.

Overall, the chapter generally points to the beneficial impacts of banking integration in terms of bank efficiency and stability. Furthermore, the chapter emphasizes the importance of considering the level and nature of banking integration to obtain such benefits. Findings from the chapters can assist policy makers to design their policy to reap net benefits from integration and maintain their financial stability.

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Appendix 7.1: Model Specification of Bank Cost Efficiency

The underlying cost structure of the banking industry is represented by the trans–log functional form. Equations 1, 2, and 3 are specified in the system of Equations A1, A2, and A3, respectively:

$$ln(\frac{TC}{w3}) = \beta_0 + \beta_1\, ln(\frac{w1}{w3}) + \beta_2\, ln(\frac{w2}{w3}) + \beta_3\, ln(q_1)$$
$$+ \beta_4\, ln(q_2) + \beta_5 \frac{1}{2}(ln\, (\frac{w1}{w3}))^2 + \beta_6 ln(\frac{w1}{w3})\, ln(\frac{w2}{w3}) + \beta_7 \frac{1}{2}(ln\, (\frac{w2}{w3}))^2$$
$$+ \beta_8 \frac{1}{2}(ln\, (q_1))^2 + \beta_9 ln(\frac{w1}{w3})\, ln(q_1) + \beta_{10} ln(\frac{w2}{w3})\, ln(\frac{w2}{w3}) + \beta_{11} \frac{1}{2}(ln\, (q_2))^2$$
$$+ \beta_{12} ln(\frac{w1}{w3})\, ln(q_2) + \beta_{13} ln(\frac{w2}{w3})\, ln(q_2) + \beta_{14} ln(q_1)\, ln(q_2) + \beta_{15}\, T$$
$$+ \beta_{16}\, T^2 + \beta_{17}\, \text{HIGH} + v_{it} + u_{it} \qquad \text{(A1)}$$

$$\mu_{it} = \delta_0 + \delta_1 \text{SIZE}_{it} + \delta_2 \text{CRERISK}_{it} + \delta_3 \text{CAP}_{it} + \delta_4 \text{CON}_t$$
$$+ \delta_5 \text{INTEG}_t + \delta_6 \text{IFL}_t + \delta_7 \text{PRICRE}_t + \delta_8 \text{YEAR1997}$$
$$+ \delta_9\, \text{YEAR1998} + \delta_{10} \text{YEAR1999} + \delta_{11} \text{YEAR2007}$$
$$+ \delta_{12} \text{YEAR 2008} + \delta_{13} \text{YEAR 2009} \qquad \text{(A2)}$$

$$\sigma^2_{it} = \exp\, (\gamma_0 + \gamma_1 \text{SIZE}_{it} + \gamma_2 \text{CRERISK}_{it} + \gamma_3 \text{CAP}_{it}$$
$$+ \gamma_4 \text{CON}_t + \gamma_5 \text{INTEG}_t + \gamma_6 \text{IFL}_t + \gamma 7\, \text{PRICRE}_t$$
$$+ \gamma_8 \text{YEAR1997} + \gamma_9 \text{YEAR1998} + \gamma_{10} \text{YEAR1999}$$
$$+ \gamma_{11} \text{YEAR2007} + {}_{12} \text{YEAR2008} + \gamma_{13} \text{YEAR2009}) \qquad \text{(A3)}$$

In addition to two outputs (q1, and 2) and three input prices (w1, w2, and w3), Equation A1 also includes the first- and second-order time trends (T and T^2) to account for the effect of technological changes. A dummy variable (HIGH) is added to control for the difference between two groups, namely most countries in the sample and the two financial centers, Hong Kong, China; and Singapore. Following Fiordelisi, Marques-Ibanez, and Molyneux (2011) and Luo, Tanna, and De Vita (2016), the environmental group of variables Z_{it} (in Equations A2 and A3) include bank-specific, country-specific and event-specific variables such as bank size (SIZE), credit risk (CRERISK), and equity capital ratio (CAP); market concentration (CON); banking integration indicators (INTEG); inflation (IFL) and credit to private sector (PRICRE); and year dummy variables to account for the effects of the Asian and global financial crisis.

In several (unreported) robustness tests, additional control variables are included such as other measures of banking integration (i.e., TOTAL, KAOPEN) and regulation variables (i.e., REG, ACT). The detailed definition and specification of all variables are provided in Appendix 7.2.

Appendix 7.2: Variables Definition and Specification

Variables	Definition	Source
Bank cost efficiency variables		
TC	Total costs= total interest expenses + total non-interest expenses	Bankscope and author's calculation
W1	Prices of funds = Total interest expenses/ total customer deposits	Bankscope and author's calculation
W2	Price of physical capital = Overhead expenses net of personnel expenses / Total assets	Bankscope and author's calculation
W3	Price of labor = Personnel expenses/ Total assets	Bankscope and author's calculation
Q1	Output = Gross loans	Bankscope
Q2	Output = Total securities	Bankscope
Other bank-level variables		
LN(zscore)	Default risk = Natural logarithm of bank Z-score. Z-score = [ROA+ (Equity/total assets)]/ [Std. (ROA)]. The Std. (ROA) is calculated over a three-year rolling window.	Bankscope and author's calculation
DEPO	Deposits ratio = total customers deposits/ total assets (%)	Bankscope and author's calculation
ROA	Profitability = Net Income/ Total assets (%)	Bankscope
CRERISK	Credit risk = Non-performing loans/ Gross loans (%)	Bankscope
LIQ	Liquidity = Liquid assets/deposits and short-term funding (%)	Bankscope
SIZE	Natural logarithm of total assets	Bankscope and author's calculation
CAP	Equity ratio = total equity/ total assets (%)	Bankscope and author's calculation
INC_DIV	Income diversification = (non-interest income/ total income) (%)	Bankscope and author's calculation
COST	Overhead cost = Total non-interest operating expenses/total assets (%)	Bankscope and author's calculation
CHARTER	Charter value = customer demand deposits/ total assets (%)	Bankscope and author's calculation
LOANS	Loans to assets = gross loans/ total assets (%)	Bankscope and author's calculation
CON	Market concentration = Top 3 largest banks assets/ total banks assets (%)	Bankscope and author's calculation

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A 7.2 *continued*

Variables	Definition	Source
ODUM	Foreign ownership equals 1, otherwise	Claessens and Van Horen (2015)
Banking integration variables		
FOR	Numbers of foreign banks to Total number of banks (%)	Claessens and Van Horen (2015)
CLAIM	Foreign claims extended by international banks/ GDP (%)	BIS CBS-IC
ASIAN	Foreign claims extended by Asian international banks/ GDP (%)	BIS CBS-IC
NON_ASIAN	Foreign claims extended by non-Asian international banks/ GDP (%)	BIS CBS-IC
CROSS	Foreign claims extended across border by international banks/GDP (%)	BIS CBS-UR
LOCAL	Foreign claims extended via local affiliates of international banks/GDP (%)	BIS CBS-UR
Country-level control variables		
IFL	Inflation rate = Annual % change of average consumer price index (%)	Global Financial Development (GFD)
GDP	GDP growth rate = Annual % change of GDP (%)	GFD
PRICRE	Private credit to GDP = Bank credit to private sector/ GDP (%)	GFD
INT	Real interest rate (%)	World Development Indicator (WDI)
CRISIS	Dummy variable that takes a value of 1 for the year of the financial crisis	Laeven and Valencia (2012)
INS	Dummy variable to proxy for the deposit insurance coverage of a country. INS equals 1 when the country has explicit deposit insurance and other wise	Demirgüç-Kunt, Kane, and Laeven. (2014)
HIGH	A dummy variable equals 1 for countries with high level of integration (Hong Kong and Singapore); otherwise	The descriptive analysis of the sample
TOTAL	Stocks of foreign assets and liabilities = the sum of the gross stocks of foreign assets and liabilities to GDP	Lane and Milesi-Ferretti (2007)
KAOPEN	Capital account openness	Chinn and Ito (2008)

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A 7.2 *continued*

Variables	Definition	Source
REGQ	Quality of regulation: The indicator measures the ability of the government to formulate and implement sound policies and regulations that permit and promote market competition and private sector development. The "estimate" score is used. Higher values mean higher quality of regulation.	World Governance Indicators (WGI)
ACT	Overall restrictions on banking activities index measures the degree to which banks are allowed to engage in securities, insurance, real estate investment, and ownership of non-financial firms. Higher value indicates more restrictiveness.	Barth, Caprio, and Levine (2013)
SUP	Supervisory power index measures whether the supervisory authorities have the authority to take specific actions to prevent and correct problems. Higher value denotes that supervisory agencies are authorized more oversight power.	Barth, Caprio, and Levine (2013)
PRIMON	Private monitoring index measures the degree of private monitoring which requires banks to release accurate and comprehensive information to the public. Higher value indicates greater regulatory empowerment of the monitoring of banks by private investors.	Barth, Caprio, and Levine (2013)

Source: Authors.

Appendix 7.3: Descriptive Statistics for Banking Integration Indicators

Panel A

	CLAIM (%)				FOR (%)			
	Mean	Std.	Min	Max	Mean	Std.	Min	Max
Full sample	34.31	42.74	3.36	290.07	28.26	15.82	0.00	76.00
High group	171.52	39.58	123.44	290.07	64.65	9.21	43.00	76.00
Low group	23.32	14.79	3.36	58.82	25.18	11.96	0.00	50.00

The table reports descriptive statistics for the banking integration indicators used in the first study. Nine economies (including the People's Republic of China; Hong Kong, China; Indonesia; Malaysia; Philippines; Republic of Korea; Singapore; Thailand; and Viet Nam) during 1997–2014 are sampled. The high–group economies include Hong Kong, China; and Singapore. The remaining economies are in the low group. Std. refers to standard deviation, Min and Max are the minimum and maximum observations for each variable in the sample.

Panel B

	Mean	Std.	Min	Max
CLAIM (%)	28.136	38.240	3.357	290.071
ASIAN (%)	5.126	7.063	0.644	50.360
NON_ASIAN (%)	16.230	26.975	1.718	189.181
LOCAL (%)	14.388	27.132	1.446	186.572
CROSS (%)	8.035	7.915	1.761	50.262

The table reports descriptive statistics for the different types of banking integration measures used in the second study. Eight economies (including the People's Republic of China; Hong Kong, China; Indonesia; Malaysia; Philippines; Republic of Korea; Singapore; and Thailand) during 1999–2014 are sampled. Std. refers to standard deviation, Min and Max are the minimum and maximum observations for each variable in the sample.

Panel C

	Mean	Std.	Min	Max
CLAIM (%)	25.043	33.933	3.357	290.071
ASIAN (%)	4.431	0.644	50.360	5.762
NON_ASIAN (%)	14.148	1.718	189.181	24.155
LOCAL (%)	13.071	1.446	25.906	186.572
CROSS (%)	7.443	1.761	6.891	50.262

The table reports descriptive statistics for the different types of banking integration measures used in the third study. Seven economies (including the People's Republic of China; Hong Kong, China; Indonesia; Malaysia; Philippines; Republic of Korea; and Thailand) during 1999–2014 are sampled. Std. refers to standard deviation, Min and Max are the minimum and maximum observations for each variable in the sample.

Source: Authors.

8

Does Fintech Contribute to Systemic Risk? Evidence from the United States and Europe

Lavinia Franco, Ana Laura García, Vigor Husetović, and Jessica Lassiter

8.1 Introduction

Since the global financial crisis of 2007–2009, systemic risk, how to recognize it, how to evaluate it, and how firms (specifically financial firms) can contribute to it have received considerable attention. We define systemic risk here following Das and Uppal (2004, 2810), who stated that systemic risk is, "the risk from infrequent events that are highly correlated across a large number of assets." Adrian and Brunnermeier (2016) developed a measure of systemic risk, ΔCoVaR, which shows the change in value at risk (VaR) of one institution or system based on the state of distress of another institution or system.

The purpose of this chapter is to analyze the fintech industry's contribution to systemic risk in the United States (US) and in Europe by conducting a ΔCoVaR analysis of a sample of publicly traded fintech firms. As important as it was to evaluate the landscape of the financial system and factors such as systemic risk that contributed to the financial crisis, it is also important to remember that the landscape of financial institutions prior to the financial crisis has changed since that event. This is due in large part to the rise of financial technology, which has the potential to disrupt business models, transform processes, redefine customer relations, bypass, enhance, or change regulatory oversight, and provide new innovative products (Depository Trust & Clearing Corporation 2017). It is imperative to study and evaluate this changing landscape, particularly its effect on systemic risk.

Fintech is a reference either to financial innovation itself—whether it emerged inside or outside the financial industry—or to institutional forms that engage in the use of fintech. In our analysis, we were interested in the second type: corporations utilizing fintech. Some recent innovations in fintech have been cryptocurrencies, blockchain, machine learning, artificial intelligence, robo-advising, peer-to-peer (P2P) lending, mobile payment systems, crowdfunding, and others (Philippon 2016). For the purposes of this chapter, the fintech firms that we analyzed fall into seven categories: 1) alternative financing, 2) data analytics, 3) digital banks, 4) market and trading support, 5) payments and remittances, 6) robo-advisors and personal finance, and 7) software solutions and information technology. We will discuss these categories in greater detail in section 8.4.

The remainder of this chapter is as follows: section 8.2 reviews the relevant literature, section 8.3 presents the theoretical discussion and hypothesis, section 8.4 describes the data and methodology, section 8.5 provides the results, and section 8.6 concludes the chapter.

8.2 Review of the Literature

Fintech has grown significantly in recent years. According to an Ernst & Young (2017) report, which surveyed more than 22,000 consumers in 20 markets, consumers are becoming more aware of fintech: their awareness grew from 62% in 2015 to 84% in 2017. Additionally, the adoption (the movement from being a non-user to being a user) of fintech has grown to 33% across those 20 markets in the last 2 years, an increase of 16% from the previous study in 2015 (EY 2017). In 2017, PricewaterhouseCoopers (PwC) also initiated a global survey regarding the use of fintech, but, rather than consumers, the survey focused on chief executive officerss and other leaders in companies within the financial services industry in 71 countries. The survey found that 88% of the leaders of those businesses believe that they are losing revenue to innovative financial technology, 77% intend to increase their own efforts to innovate, and 82% expect to increase their partnerships with fintech in the next 3 to 5 years (PwC 2017). These reports, when taken together, show that both individuals and financial sector corporations are increasing their fintech use. Lee and Teo (2015) further discussed the growth of fintech in reference to global investments in fintech ventures. From 2013 to 2014, investments grew more than three times, from \$4.05 billion to \$12.21 billion (Lee and Teo 2015). KPMG (2018) estimated that investments in fintech (ranging from mergers to venture capitalism) totaled roughly \$31 billion in 2017.

Fintech has, alternatively, *evolved* significantly in the 100 years, and its last evolution has been recent and fast. It has seen three periods:

the first was the analog era (telegraphs, railroads, etc.), the second was digitalization (technology for communications and transfers), and the third and current era began in 2008 (Arner, Barberis, and Buckley 2016).

The critical difference in Fintech 3.0 (from the second era) lies in: first, who provides financial services, with start-ups and technology firms supplanting banks in providing niche services to the public, business and the banks themselves; and second, the speed of development. In many markets, there has been a shift in customer mindset as to who has the resources and legitimacy to provide financial services, combined with an entirely new speed of evolution, particularly in emerging markets. (Arner, Barberis, and Buckley 2016).

Both Lee and Teo (2015) and Arner, Barberis, and Buckley (2016) discussed the ever-increasing role of fintech in emerging markets. In these markets, where there is little or no access to banking, fintech has the potential to make large impacts.

Fintech has not only affected the financial sector but is also becoming increasingly integrated with it via partnering with financial institutions (PwC 2017). The past literature has found that the interconnectedness of the financial sector leads to spillover or contagion when one area experiences distress. Allen and Gale (2000), in fact, postured that the interconnectedness and whether it is complete can determine the strength of the spillover effects. According to Magnuson (2018, 1191), interconnectedness becomes an issue because, "If firms in a market are highly dependent on each other, by for example relying on other participants for essential parts of their business or having contracts and agreements that require the cooperation (and solvency) of the others, then it will be more likely for shocks in one institution to spread to other institutions." Meanwhile, Allen, Babus, and Carletti (2012) suggested that the degree of contagion within a financial system is due to the degree to which institutions have overlapping portfolios.

Adrian and Brunnermeier (2016) developed the methodology that this chapter used. ΔCoVaR is a measure of systemic risk that evaluates the tail dependency between one institution or system and another institution or system. In this measure, one might see that an institution is individually systemic or that a group of institutions is systemic as a whole, which the authors referred to as "systemic as a herd" (Adrian and Brunnermeier 2016). The CoVaR of a system is the VaR of the whole system given the particular state that the institution is experiencing. Then ΔCoVaR is the difference in the system given that the institution has moved from one state to another (generally from its median state of VaR to some lower state that represents distress). Essentially, ΔCoVaR captures the tail co-movements of the system and the institution.

Other researchers have taken Adrian and Brunnermeier's 2016 risk measurement and extended its application to other or more specific areas. Examples of this include extending ΔCoVaR to sovereign credit default swap (Fong and Wong 2011), to regional banks (Fong et al. 2011), and to risk spillovers (Adams, Füss, and Gropp 2014). There are many other types of systemic risk measures as well. Acharya, Engle, and Richardson (2012) and Brownlees and Engle (2016) developed systemic risk indicators that measure the decrease in equity given the market stress condition. Billio et al. (2012) introduced a systemic risk measure that they based on Granger causality between companies.

8.3 Theoretical Discussion and Hypothesis

Hypothesis: Fintech firms do not contribute greatly to systemic risk at this time.

The methodology that this study used, ΔCoVaR, is a measure of systemic risk that considers the co-movements of tail distributions of the institution and the financial system (Adrian and Brunnermeier 2016). Which factors can contribute to systemic risk and do fintech firms display those attributes? To define systemically important financial institutions, Thomson (2010) proposed five ways (size and the four Cs) in which institutions may have a systemic impact, and the Financial Stability Board (2017a) recommended an additional way, substitution:

- size—while not the only factor to consider, institutions that make up at least 10% of activities or assets in any single financial sector may be large enough to be systemically important;
- contagion—it is possible to consider institutions for which their failure could have real spillover effects on other institutions as systemically important. Examples include locking up of essential payment systems, creating illiquidity in institutions accounting for up to a third of the assets in the financial system, and collapsing important financial markets;
- correlation—this factor of systemic risk occurs when institutions take risks that are highly correlated across many others. In this way, many smaller institutions can have a systemic impact akin to that of large ones;
- concentration—a small number of firms engaging in key financial activities (such as essential payment processes) can give rise to systemic importance, since the role of that firm is not easy for other firms that engage in the same activities to fill;
- substitution—similar to the concept of concentration, if firms are engaging in key financial activities for which there are no easy substitutions, this can give rise to systemic risk; and

- conditions/context—these refer to the phenomena of an institution becoming systemically important due to the state of the economy or financial market.

Fintech and Size

According to Statista (2018), the value of the total transactions in the fintech market amounted to over $4.22 trillion in 2018, as of May. The transactions value in the digital payment sector of fintech accounted for over $3.26 trillion, approximately 77% of the total transactions in the fintech market, followed by the alternative lending sector with 12% of the total and personal finance with 10%. Similarly, in 2016 and 2017, the digital payment sector dominated the total transaction value. Therefore, in relation to the size factor, digital payment (as section 8.4.1 denominates, according to our categories, payments and remittances) is the sector that is more likely to have a systemic impact. On the other hand, while fintech institutions may have a large impact in the realm of digital transactions, their overall portion of assets in the financial sector remains relatively small, with Market Watch (French 2017) reporting that the largest fintech firm in the US at the end of 2017 was Stripe, with $9.2 billion in assets, while the largest financial institution in the US was J.P. Morgan Chase & Co., with $2.5 trillion in assets, as Bankrate reported (Dixon 2018).

Fintech and Contagion

Fintech, through its mere existence, is increasing interconnectedness. Connections are easier and faster, particularly in payment processing, but there are also fintech firms that provide data analytic services to other corporations, which integrate that service into their own operations. Fintech firms undertake human resource activities (hiring, tax reporting, payroll management, etc.) to make these activities more expedient, more trackable, and more accurate. According to the Financial Stability Board (FSB 2017b), fintech increases the interconnectedness of the financial sector, and this effect carries macrofinancial risks. On the other hand, the same report mentioned that the decentralization potential of some fintech activities, such as P2P lending, could have the effect of lessening interconnectedness by providing traditional financial activities outside of the traditional network.

Fintech and Correlation

Financial institutions' portfolio risks might become highly correlated in a period of financial distress, as financial institutions might have an incentive "to take on risks that are highly correlated with other institutions because policymakers are less likely to close an institution if many other institutions would become decapitalized at the same time" (Thomson 2010, 140). This concept does not directly apply to the fintech sector; however, there are other factors that might matter in terms of correlation for the fintech industry. According to the FSB (2017b, 19), the cyber-risk, on one side, can undermine some fintech companies, since a "greater use of technology and digital solutions expand the range and number of entry points cyber hackers might target." On the other side, the same work underlined how fintech can increase competition and reduce the systemic relevance of a single cyberattack. We can therefore expect that, if the risks due to cyber-attacks are correlated, then the fintech sector faces strong exposure to that risk. Another factor related to correlation among fintech companies regards the possibility of taking correlated risks of unbanked consumers. "FinTech in many cases attempts to fill the gap by providing easy to understand and convenient services, which tend to lower costs of adoption and lower barriers to access for customers" (FSB 2017b, 35). Indeed, fintech can increase social inclusion, which might bring some correlated risks.

Fintech and Concentration

Fintech could affect the concentration of activities in the financial sector. The caveat is that fintech has the potential to change the concentration in the market. Fintech could increase the number of players in financial activities by providing alternatives to traditional players ((DTCC 2017), an example being P2P lending, which provides credit to borrowers as an alternative to a traditional bank. On the other hand, fintech could lead to a situation in which there is only a small number of players in key financial activities, as it potentially provides new services that other firms do not provide, or, from a geographic standpoint, enters new markets in which there are not many players.

Fintech and Substitution

According to the Depository Trust & Clearing Corporation (2017), people should consider the risk that the substitutability of fintech firms poses on a case-by-case basis. The concentration might be such that one firm can easily substitute another, as is likely to be the case with electronic payment systems. P2P lending might be an area, however, in which substitutability is low, since the lender often supplies individuals or businesses that might have difficulty obtaining this service from a traditional bank (De Roure, Pelizzon, and Tasca 2016).

Fintech and Context/Conditions

As Thomson (2010, 142) put it, "Firms that might be made systemically important by conditions/context are probably the most difficult to identify in advance." Not only are they difficult to identify, but they are also dependent on the probability of occurrence of the condition that would cause said firms to become systemically important (Thomson 2010). Fintech would not necessarily be immune to conditional systemic importance, but there have not been instances of this occurring either.

Keeping these indicators of systemic importance in mind and relating them to the current and "historical" states of fintech, our hypothesis is that *fintech firms do not contribute greatly to systemic risk at this time.*

8.4 Data and Methodology

8.4.1 Data

In our analysis, we used a unique dataset composed of 75 fintech companies quoted on the Nasdaq and Frankfurt stock exchanges. We based the sample of companies on the KBW Nasdaq Financial Technology Index (KFTX) for the Nasdaq Stock Exchange and on the CedarIBS FinTech Index (CIFTI) for the Frankfurt Stock Exchange. According to Nasdaq (2017), the KFTX "is designed to track the performance of financial technology companies that are publicly traded in the U.S." The index began in July 2016, and it currently includes 50 companies. According to IBS Intelligence's website, "the CIFTI is a unique equity index comprising of selected FinTech companies from around the world, across 25 exchanges" (IBS 2018). The CIFTI comprises four key indexes that track the performance of 50 large fintech companies (CIFTI 50) and large-, medium-, and small-cap fintech companies (respectively, CIFTI Large Cap, CIFTI Mid Cap, and CIFTI Small Cap). For the scope of our analysis, among these companies, we selected only the companies quoted on the Frankfurt Stock Exchange.

The final sample includes 39 fintech companies for the US stock exchange and 53 fintech companies for the European stock exchange.[1] Seventeen companies are quoted on both stock exchanges and therefore the panel comprises a total of 75 fintech companies. We obtained the estimations that section 8.4.2 reports separately for the US and the European sample. The panel of companies extends from January 2010 to December 2017 and is unbalanced, since, given the recent evolution of the fintech industry, it also includes companies that began operation

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1 Note that the number of companies that we included is smaller than the original number (48 companies for the Nasdaq index and 73 companies for the IBS index related to the Frankfurt Stock Exchange) due to data availability.

and/or became publicly quoted after 2010. Table A8.1 classifies the fintech companies according to the following categories:

- alternative financing—firms that provide credit (loans) to individuals and/or businesses but do not fall into the bank classification because they do not engage in other traditional banking activities;
- data analytics—firms that provide solutions via data analytics;
- digital banks—firms that provide banking services without bricks and mortar;
- market and trading support—markets that provide financial services and firms that provide support via technological solutions for trading activities;
- payments and remittances—firms that provide payment systems and products;
- robo-advisors and personal finance—firms that provide advice and/or management for financial assets for individuals; and
- software solutions and IT—firms that provide software and information technology solutions for business processes, including human resources, supply chain management, cloud-based services, security, and so on.

Since we chose to use stock indices in the market, we did not control the number of firms that fell into each category. As such, some categories contained relatively few (or no) firms; for example, in our analysis of European fintech firms, no firms fell into the category of alternative financing. In reality, regardless of the popularity of P2P lending, not many P2P lending firms have public listings, and none are listed on the Frankfurt Stock Exchange. Therefore, we had none in the category for alternative financing for Europe and only one in that category for the US. Other categories in our list included a relatively low number of firms (with the payment and remittances and the software solutions and information technology categories comprising the bulk) as a result of the indices that we used.

We also included a representative sample of the US and European financial industries to determine the impact that fintech companies have on systemic risk within the entire financial industry. We obtained the estimations in section 8.4.2 using the US and European fintech samples and their respective financial industry. We based the US financial industry sample on the panel of companies that Brownlees and Engle (2016) selected to measure the contribution of a financial firm to systemic risk. According to the authors, "the panel contains all US financial firms with a market capitalization greater than 5 bln USD as of the end of June 2007" (Brownlees and Engle 2016, 15). We based the European financial industry sample on the panel of companies that the Center for Risk Management at Laussane (CRML) selected to measure systemic risk in Europe. The CRML's systemic risk measures follow the methodology that Engle, Jondeau, and Rockinger (2014) developed and the sample of "financial institutions involve several categories, including banks, insurance companies, and real estate firms" (CRML 2018). The final sample of the US financial industry consists of 41 companies, and the final sample of the European financial industry contains 54 companies[2] (Table A8.1.2 reports the list of companies).[3]

We obtained the daily adjusted closing prices, the daily market capitalization, and the daily beta from Thomson Reuters Eikon, and we obtained the quarterly balance sheet data for the book value (total assets and total shareholders' equity) from Orbis. We used the market capitalization, the total assets, and the total shareholders' equity to compute the market value of assets (MVA) of each firm. We then took the growth rate of the MVA to estimate the ΔCoVaR. We computed the MVA of each firm as follows:

$$MVA_{it} = \, total\, assets_{it} * \frac{market\ capitalization_{it}}{shareholders'\ equity_{it}} \qquad (1)$$

We used the total assets (as a proxy for the company's size) and the beta to estimate the correlation table (see Table A8.1.3 for a detailed description of the variables). The estimations have a weekly frequency. We obtained the weekly data using the last available daily point of each week. Following the Federal Reserve Bank of Cleveland's method for using quarterly data more frequently (Federal Reserve Bank of Cleveland 2016), we assigned to each week the respective quarter (therefore, quarterly data repeat over the 3-month period).

Tables A8.1.4 and A8.1.5 report the summary statistics for the set of variables that we used to estimate the ΔCoVaR measure, broken down

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2 The original sample of Brownlees and Engle (2016) contained 95 companies, and the original sample of the CRML consisted of 87 companies. Our samples are restricted due to data availability (in particular, our US sample is restricted with respect to the sample of Brownlees and Engle, since a portion of companies merged or failed following the financial crisis).

3 From now on, we will refer to the US financial system to indicate the representative sample of the US financial industry and those fintech firms that are part of the KBW Nasdaq Financial Technology Index. Similarly, we will refer to the European financial system to indicate the representative sample of the European financial industry and those fintech firms that are part of the CedarIBS FinTech Index and are quoted on the Frankfurt Stock Exchange.

by the type of firm—either from the traditional financial industry or from the corresponding fintech category—for the US and the European sample, respectively. Concerning the market capitalization of the US sample, we can classify the median fintech firm as mid-cap (between \$5.9 billion and \$8.6 billion), whereas the median financial industry firm corresponds to the large-cap category (about \$15 billion). As for the European sample, the median market capitalization in each category ranges from \$2.9 billion to \$7.8 billion, thereby corresponding to mid-cap stocks. The higher market capitalization of firms in the traditional financial system, compared with fintech, reflects the degree of maturity of the two sectors; however, it is worth mentioning that, in the case of Europe, the maximum market capitalization is generally higher for fintech firms (about \$23 billion) than for those in the traditional financial system. Similarly, shareholders' equity for the median fintech firm is smaller than for that in the traditional financial sector; the median shareholders' equity of fintech firms represents about 10% of that of the traditional financial companies.

As one might expect, since many fintech firms are in relatively early stages of development with respect to the whole financial sector, the median of the weekly stock returns is higher for the former (apart from the alternative financing category). Thus, the median stock returns for the US (European) traditional financial firms is 0.2% (–0.1%) and about 0.4% (0.2%) for fintech firms.

In terms of total assets, fintech firms represent around 2% (1%) of the traditional financial firms in the US (European) sample. Indeed, as section 8.3 mentioned, the overall portion of assets of fintech institutions in the financial sector remains relatively small.

8.4.2 Estimation of CoVaR and ΔCoVaR Measures

As section 8.2 mentioned, CoVaR and ΔCoVaR became widely known measures of systemic risk after Adrian and Brunnermeier's 2016 seminal paper. We used their method for our purpose of assessing whether fintech firms contribute to systemic risk based on the observed average of these indicators within the period 2010–2017.

It is possible to interpret the CoVaR measure, which makes possible the calculation of the ΔCoVaR afterwards, as the VaR of a firm (or system) x conditional on firm y already being at its value at risk. This definition requires us to take one step back to explain what the latter is.

Value at Risk

There are different ways to estimate VaR; nevertheless, here we will just focus on the methodology that we used for our estimations. Estimating the historical empirical distribution of stock returns of a firm enables the calculation of a threshold at which the firm itself is in distress. It is worth mentioning that the researcher decides the level associated with distress, but it is typically 5%, which is the threshold that we utilized. Taking this into consideration, we can write VaR as:

$$Pr\left(Z^i \leq VaR^i_{0.05}\right) = 5\% \tag{2}$$

This means that we consider the observed stock return at the 5th percentile of the empirical distribution as a signal of concern regarding the performance of the firm, since this percentile contains the lowest returns observed during the period under consideration (see Figure A8.2.1 for a graphical representation of VaR). Hence, identifying the VaR for each firm comprised in our sample represents the basis of the estimations to evaluate finally how a distressed fintech firm affects the entire financial system when the latter is also at its VaR.

Conditional Value at Risk

After identifying the 5% VaR of firm *i*, we must check how the VaR of the financial system comoves with (conditional on) each of the former, which is what the measure will indicate, as the following equations show:

$$Pr\left(Z^{system|i_{0.05}} \leq CoVaR^{system|i_{0.05}}_{0.05}\right) = 5\% \tag{3}$$

$$CoVaR^{system|i_{0.05}} = \hat{\alpha}^i_{0.05} + \hat{\beta}^i_{0.05} VaR^i_{0.05} \tag{4}$$

As one can observe, to calculate the CoVaR, we need the estimates of α and β at the 5th percentile, which we can obtain through a quantile regression of the form:

$$X^{sys} = \alpha^i_{0.05} + \beta^i_{0.05} X^i + \epsilon \tag{5}$$

Unlike ordinary least squares (OLS) regression, quantile regression coefficients capture the change in a specified quantile of the dependent variable that a one unit change in the regressors produces. As Bjarnadottir (2012, 9) stated, “when estimating CoVaR the focus is on a specific low quantile of a distribution and hence it is convenient to use quantile regression here.”

Considering the data definitions that section 8.4.1 introduced, our specification for this estimation took into account the modification that Lopez-Espinosa et al. (2012) proposed of regressing the sum of the asset returns of each financial institution in the system, weighted by its lagged MVA (X^{sys}), on the asset returns of firm i (X^i), just as Adrian and Brunnermeier (2016) did but excluding firm i from X^{sys} to avoid a spurious relationship with the regressor. This means that we computed N (number of firms) different X^{sys} variables, each one omitting each firm i at a time.

ΔCoVaR

Having calculated the 5% CoVaR for each firm, we then estimated the median CoVaR, which represents the VaR of the financial system conditional on firm i being in its normal state.

Together, both CoVaR estimations allowed us to identify how much the fact that firm i is distressed contributes to the financial system VaR. Adrian and Brunnermeier (2016) estimated this as the difference between the 5% and the 50% CoVaR:

$$CoVaR_{0.05}^{system|i} = CoVaR_{0.05}^{system|VaR_{0.05}^{i}} - CoVaR_{0.05}^{system|VaR_{0.5}^{i}} \quad (6)$$

which it is possible to reduce to:

$$\Delta CoVaR_{0.05}^{system|i} = \hat{\beta}_{0.05}^{i}\left(VaR_{0.05}^{i} - VaR_{0.5}^{i}\right) \quad (7)$$

To sum up, the output obtained from these computations will yield the contribution of each firm to systemic risk, denoted as a negative ΔCoVaR, which we will ultimately rank from least to greatest.

8.4.3 Spearman's Rank Correlation

Finally, to evaluate whether the ranking that we derived from the ΔCoVaR estimation contributes to improving the systemic risk measurement—in addition to variables such as size or volatility associated with the systemic importance of firms—we computed Spearman's rank correlation coefficients.

This statistic calculates the level of association of two ranked variables using the following formula:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (8)$$

where d_i is the difference in ranks for each firm and n is the number of firms in our final sample.

Afterwards, we needed to verify the significance of this correlation coefficient by testing the null hypothesis of no monotonic correlation. Section 8.5 presents both the correlation coefficients and the p-values.

8.5 Results

Our results seem to be in line with previous evidence that has excluded the fintech industry from systemic risk estimations in the sense that the empirical literature, such as Brownlees and Engle (2016), and regulatory authorities, as in the case of the European Banking Authority, have already recognized many of the financial companies that our estimations identified as systemic—that is, Citigroup and Morgan Stanley in the US and Banco Bilbao Vizcaya Argentaria (BBVA) and Credit Suisse in Europe—as some of the most systemically risky financial firms.[4] Although identifying systemic financial firms is beyond the scope of this chapter, those results ultimately allowed us to validate our findings for the fintech industry using the methodology proposed.

Having said this, the ΔCoVaR computations showed that we cannot consider fintech companies as systemically important according to their historical performance in comparison with other financial companies. In the remainder of this section, we will provide a detailed explanation of the results for each particular sample.

8.5.1 United States

Within the whole financial system, 20 fintech companies—out of 36 in our final sample—contribute to systemic risk, 0.03% being the maximum contribution of any individual fintech firm (see Table A8.1.6). In fact, among the 10 fintech companies that contribute the most to systemic risk, the majority corresponds to firms of which the main business relates to payments and remittances and market and trading support. In addition, it is worth mentioning that LendingClub, the only fintech providing alternative financing in our sample, has the second-highest contribution within this "Top 10."

Another interesting result from our estimations is that the remaining 16 fintech firms alleviate systemic risk. We can consider this as partial evidence for the previous literature conceiving fintech as an emerging alternative to the traditional financial system.

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4 For the updated list of global systemically important institutions for 2017, see http://www.eba.europa.eu/risk-analysis-and-data/global-systemically-important-institutions/2017.

The second step consisted of implementing the ΔCoVaR methodology while isolating the fintech industry in an attempt to identify those firms that are leading the sector's performance. The results in Table A8.1.8 are very similar to those of the exercise for the whole financial system; indeed, fintech companies related to payments and remittances seem to be highly relevant when assessing the risk of the industry.

As we mentioned in section 8.4, we computed the Spearman's rank correlation to evaluate whether the ranking that we derived from the ΔCoVaR measure surpasses the identification of systemic firms based on their size (respectively beta) or whether the latter alone is sufficient; that is, the bigger (respectively the more volatile in relation to the market) the firm is, the more systemic it is and vice versa. Before discussing the overall correlation, Figures A8.2.2 and A8.2.3 present these relationships by firm and the corresponding category, and we can observe that it is not possible to associate greater size (respectively beta) with either high or low ΔCoVaR. As for the Spearman correlation, the results indicate that the two measures are positively and fairly correlated ($\rho = 0.51$), which means that the ΔCoVaR measure indeed contributes to a better identification of systemic risk rather than drawing conclusions based just on the size ranking. This supports previous advice from financial authorities, such as the Office of Financial Research in the US (2017, 6), which highlighted that "size is not always a good proxy for systemic importance." Additionally, we computed the Spearman correlation associating the ΔCoVaR ranking with that of the beta of the firms. In this case, the correlation between the two rankings was low, $\rho = 0.31$, meaning that a more volatile firm is not highly associated with its systemic importance (according to ΔCoVaR) and vice versa (see Table A8.1.10 for a summary of the results).

8.5.2 Europe

In the European financial system, the results show that 32 fintech firms, out of 53, contribute to systemic risk. However, the individual contribution of each firm is nearly 0% (see Table A8.1.7) and the aggregate contribution is roughly 0.05%. As in the US case, the remaining fintech firms (21) reduce systemic risk by 0.11%, which also supports their little relevance within the industry under our methodology. Table A8.1.9 shows the results from the estimation of the ΔCoVaR within the fintech industry. Interestingly, contrary to the US industry, fintech firms providing software solutions and information technologies seem to contribute the most to the risk of the sector.

Finally, the Spearman's rank correlation between the ranking of the ΔCoVaR measure and the firm size indicates a slightly higher correlation between the two of them, $\rho = 0.58$, in comparison with the US results. Nevertheless, this still supports the contribution of our estimations to improving the assessment of systemic risk. Regarding the additional correlation with the beta, we found that the correlation is $\rho = 0.59$—slightly higher than that with size—suggesting that the volatility of European fintech firms could also help in evaluating their systemic importance (see Table A8.1.8 for a summary of the results and Figures A8.2.4 and A8.2.5 for the disaggregated representation).

8.5.3 Final Remarks on the Results

Despite the fact that our results confirmed that fintech firms are not contributing significantly to systemic risk, we endeavored to conduct further research regarding the increase in partnering between them and financial companies. Since our main concern is systemic risk, we focused on those financial firms in the "Top 10" of the ΔCoVaR estimations, given that previous empirical research has already identified most of them as systemic.

With respect to the US sample, out of the 10 most systemic financial companies, seven of them are partnering and/or investing in fintech. For instance, according to the media company Bank Innovation (Kulkarni 2018), Citigroup Inc. is among the top global banks that invest in fintech and has 26 fintech firms in its portfolio; another example is Goldman Sachs, which owns 27 fintech firms, adding six new ones in 2017 (CB Insights 2018).

In the case of the top systemic European financial companies, six of them are partnering and/or investing in fintech. BBVA (2018), which has recently announced an investment in the UK online mortgage brokerage Trussle, is an example. In addition, Groupe Crédit Agricole (2018) has participated in the private fundraising of SETL—an institutional payment and settlement infrastructure provider that uses blockchain technology.

8.6 Conclusions

This chapter tackles the role that fintech might have in systemic risk. Using a unique dataset of European and US fintech companies, we estimated the ΔCoVaR, which captures the tail dependency between the financial system and a specific institution. This allowed us to rank firms by how much their individual distress contributes to the VaR of the whole system. We conducted the exercise both for the fintech industry and for the entire financial system to capture, respectively, the fintech firms that are leading the risk of the industry and the position of the fintech firms within the entire financial sector.

The results that section 8.5 reported show that, for the US, the payment and remittances and the market and trading support categories contribute the most to the VaR of the fintech industry. Instead, in Europe, fintech firms that provide software solutions and information technologies seem to be contributing the most to the risk of the sector. The estimation that includes fintech firms and the representative sample of the financial sectors show that fintech firms are not systemically important. Within the US financial system, the fintech companies that do contribute to systemic risk increase it by around 0.03%, while, in Europe, fintech firms contribute very little to the systemic impact (close to 0%). The Spearman's rank correlation between a fintech firm's ΔCoVaR and its respective size and between a fintech firm's ΔCoVaR and its beta strengthens the importance of our estimations for a better assessment of systemic risk rather than just relying on the size and the beta of the firms to determine their likely contribution to systemic risk.

While our results show that these fintech firms do not contribute greatly to systemic risk, confirming our hypothesis of section 8.3, we should approach that conclusion with caution because of the interconnectedness of the financial industry with fintech and fintech firms. As the DTCC (2017, 4) stated, "The boundaries between fintech start-ups and traditional incumbents are blurring quickly as they become increasingly interconnected." As section 8.5 mentioned, financial companies such as Citigroup Inc. and BBVA are partnering with and/or investing in fintech, and there are many other examples.

Some limitations of our study include the scope of our analysis method (ΔCoVaR), the representation of the fintech sector, and the analysis of only two markets. ΔCoVaR represents "the increase in system-wide risk due to the distress of a financial institution" (Castro and Ferrari 2014, 12), but disregards some firm-specific factors, such as the capital shortfall or the leverage of a firm, since ΔCoVaR is the measure of tail co-movement between the system and the firm. Methods such as SRISK, which Brownlees and Engle (2016) proposed, and the leverage ratio exposure measure of the European Banking Authority (2017) take these into account. While we chose to use indices that theoretically should be representative of fintech in their respective markets, as we mentioned previously, some categories (i.e., alternative financing or digital banks) do not have a large representation among *public* fintech firms either because not many are publicly traded or they were simply not part of the indices. As such, it is difficult to draw safe conclusions on which categories of fintech companies have a greater potential impact on systemic risk because of the sample considered. Another limitation of our study is the fact that our analysis concerned only two markets, both of which are developed markets, but fintech has different potential in emerging markets (Lee and Teo 2015). This is apparent from the P2P lending and other fintech activities in the People's Republic of China (PRC), where the adoption rate of fintech for consumers is 69% while the global average is 33% (EY 2017).

Given the diversity of fintech firms, micro-level data analysis focusing on each individual fintech category could reveal the specific risks attached to each of them, highlighting key research lines. For instance, Buchak et al. (2017) analyzed lending fintech firms using loan-level data for the US, whereas, as section 8.2 mentioned, both Ernst and Young (2017) and PwC (2017) have started implementing surveys to track fintech evolution.

Beyond further research, it is important to include fintech firms when considering the regulation of the financial industry. Even though our analysis did not show that fintech contributes greatly to systemic risk at this moment, we agree with the former managing director of the International Monetary Fund (Lagarde 2018) on fintech regulation. According to Lagarde (2018), it is necessary to consider and develop a regulatory framework now, before fintech contributes to risk in the financial system. On the other hand, she cautioned against regulating in such a way that hinders the evolution of technology, stating, "We must guard against emerging risks without stifling innovation" (Lagarde 2018, 9). We see that "regulatory sandboxes" are emerging in many economies to give fintech a place to "play." In other words, a sandbox is a framework that regulators set up (generally for a limited period) and that allows fintech to grow, change, or evolve in a live but controlled setting (European Commission 2018). Given these considerations, our chapter is an initial contribution giving policy makers and regulators a better understanding of fintech, which is necessary to regulate fintech firms without inhibiting innovation.

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Appendix 8.1: Tables

Table A8.1.1: Fintech Samples

Alternative Financing	Data Analytics	Digital Banks	Market and Trading Support	Payments and Remittances	Robo-Advisors and Personal Finance	Software Solutions/ Information Technology
United States						
LendingClub	FactSet IHS Markit Moody's S&P Global Verisk Analytics	Green Dot Corporation	Cboe CME Group Intercontinental Exchange MarketAxess Nasdaq Virtu Financial	ACI Worldwide American Express Blackhawk Network Holdings Cardtronics Euronet Worldwide Evertec, Inc. First Data Fiserv FLEETCOR Global Payments Mastercard PayPal Square Verifone Visa Western Union WEX, Inc. Worldpay	Envestnet MSCI SEI Investments Company	Broadridge Financial Solutions Equifax Jack Henry & Associates SS&C Technologies Thomson Reuters
Europe						
	FactSet FICO IHS Markit PRGX Global, Inc. Teradata	Genpact	Amber Road Inc.	American Express Blackhawk Network Holdings Cognizant Euronet Worldwide Everi Evertec, Inc. First Data Fiserv FLEETCOR Global Payments Ingenico Mastercard MercadoLibre MoneyGram SafeCharge TSYS Verifone Western Union WEX, Inc. Wirecard	Envestnet Intuit IRESS	ADP CANCOM China Information Tech Diebold Nixdorf, AG Diebold Nixdorf, Inc. DST Systems DXC Technology Equifax FIS Jack Henry & Associates Luxoft Model N NCR PFSweb Points SAP ServiceSource Syntel Temenos Tungsten Corporation Virtusa Wipro Xero

Source: Authors.

Table A8.1.2: Financial Industry Samples

United States	Europe
Citigroup, Inc.	Aareal Bank
Legg Mason	Albaraka Turk Katilim Bankasi AS
Principal	Alpha Bank
Goldman Sachs	Banca Carige
BNY Mellon	Banca Monte dei Paschi di Siena
Morgan Stanley	Banca Popolare di Sondrio
T. Rowe Price	Banco Bilbao Vizcaya Argentaria
Janus Henderson Group	Banco BPI
Northern Trust	Banco BPM
AGNC Investment Corp.	Banco Comercial Portugues
PNC Financial Services	Banco de Sabadell
CBRE Group	Banco Santander
New York Community Bank	Bank of Ireland Group
Comerica	Bankia
U.S. Bancorp	Barclays
M&T Bank	BNP Paribas
State Street Corporation	BPER Banca
BB&T	CaixaBank
Marsh & McLennan Companies	Commerzbank
Fifth Third Bank	Crédit Agricole
KeyCorp	Credit Suisse
Synovus	Credito Emiliano
Western Union	Deutsche Bank
Bank of America	Dexia
Ameriprise Certificate Company	EFG International
Suntrust Banks	Erste Group
Wells Fargo Company	Eurobank Ergasias
TD Ameritrade	ING Group
Blackrock	Intesa Sanpaolo
E-Trade	Jyske Bank
Freddie Mac	London Stock Exchange Group
Charles Schwab	Marfin Investment Group
People's United Financial	National Bank of Greece
Fannie Mae	Nordea Bank
Franklin Resources	Oldenburgische Landesbank
Regions Financial Corporation	Permanent TSB Group
Zions Bancorporation	Piraeus Bank
Capital One	Plaza Centers N.V.
SLM Corporation	Raiffeisen Bank International
CIT Group	RBS Group
Huntington Bancshares	Sekerbank
	Skandinaviska Enskilda Banken

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Table A8.1.2 *continued*

United States	Europe
	Société Générale
	Standard Chartered
	Svenska Handelsbanken AB
	Swiss Life
	TP ICAP
	Turkiye Halk Bankasi
	Turkiye Vakiflar Bankasi
	UBS Group AG
	UniCredit
	UBI Banca
	VTB Bank
	Wuestenrot & Wuerttembergische

Source: Authors.

Table A8.1.3: Variable Definitions

Variable	Formula	Financial Statements	Definition	Source
Total Assets	Fixed Assets + Current Assets	Fixed Assets	Total amount (after depreciation) of non-current assets (intangible assets + tangible assets + other fixed assets)	Orbis
		Intangible Fixed Assets	All intangible assets, such as formation expenses, research expenses, goodwill, development expenses, and all other expenses with a long-term effect	
		Tangible Fixed Assets	All tangible assets, such as buildings, machinery, and so on	
		Other Fixed Assets	All other fixed assets, such as long-term investments, shares and participations, pension funds, and so on	
		Current Assets	Total amount of current assets (stocks + debtors + other current assets)	
		Stocks	Total inventories (raw materials + in progress + finished goods)	
		Debtors	Trade receivables (from clients and customers only)	
		Other Current Assets	All other current assets, such as receivables from other sources (taxes, group companies), short-term investment of money and cash at bank and in hand	
Total Shareholders' Equity	Capital + Other Shareholders' Funds	Capital	Issued share capital (authorized capital)	Orbis
		Other Shareholders' Funds	All shareholders' funds not linked with the issued capital, such as reserve capital and undistributed profit, also including minority interests if any	
Adjusted Stock Price	Closing Price	Closing Price	The latest available closing price. If there are no trades for the most recent completed tradable day, the most recent prior tradable day with trading activity is used, provided the last tradable day for the instrument is within 378 completed calendar days (54 weeks).	Thomson ReutersEikon
Market Capitalization	Number of Outstanding Shares* Current Stock Price	Market Cap.	The company market capitalization represents the sum of market value for all relevant issue-level share types. The issue-level market value is calculated by multiplying the requested share type by the latest close price. This item supports default, free float, and outstanding share types. The default share type is the most widely reported outstanding shares for a market and is most commonly issued, outstanding, or listed shares.	Thomson ReutersEikon
Beta	Covariance (r_i, r_m) / Variance (r_m)	Beta	CAPM beta: a measure of how much the stock moves for a given move in the market. It is the covariance of the security's price movement in relation to the market's price movement. Based on data availability, various look-back periods can be used to calculate it. In order of preference, the beta 5Y monthly, beta 3Y weekly, beta 2Y weekly, beta 180D daily, and beta 90D daily are used in the calculation.	Thomson ReutersEikon

Note: The total assets and total shareholders' equity are book values.

Source: Authors.

Table A8.1.4: Summary Statistics: United States Financial System

	N	Mean	Median	Min.	Max.	SD
Financial Industry						
Market Capitalization	14,808	32.5	15.3	0.2	311.7	48.0
Stock Returns (%)	14,808	0.2	0.2	−48.5	79.4	4.2
Total Assets	14,808	384.8	105.8	2.5	3,345.5	686.0
Shareholders' Equity	14,808	31.8	9.8	0.1	272.5	55.9
Fintech						
Alternative Financing						
Market Capitalization	117	20.3	8.6	1.1	240.8	32.8
Stock Returns (%)	117	−1.0	−0.7	−70.4	23.2	10.2
Total Assets	117	5.4	5.6	4.6	5.9	0.4
Shareholders' Equity	117	1.0	1.0	0.9	1.1	0.0
Data Analytics						
Market Capitalization	1,576	17.4	6.6	0.3	253.8	30.5
Stock Returns (%)	1,576	0.3	0.3	−31.3	15.7	3.0
Total Assets	1,576	4.6	4.7	0.6	14.6	3.3
Shareholders' Equity	1,576	1.2	0.6	0.0	8.4	1.7
Digital Banks						
Market Capitalization	208	19.2	7.3	0.9	195.2	32.6
Stock Returns (%)	208	0.4	0.4	−27.0	26.9	4.9
Total Assets	208	1.6	1.7	1.1	2.2	0.3
Shareholders' Equity	208	0.6	0.7	0.4	0.8	0.1
Market Trading and Support						
Market Capitalization	1,514	16.1	6.4	0.3	250.9	29.3
Stock Returns (%)	1,514	0.4	0.4	−18.8	20.4	3.4
Total Assets	1,514	14.2	3.5	0.3	78.5	23.5
Shareholders' Equity	1,514	4.8	0.5	0.2	22.4	7.0
Payments and Remittances						
Market Capitalization	5,287	16.4	6.7	0.3	258.4	29.0
Stock Returns (%)	5,287	0.3	0.4	−54.8	22.8	4.0
Total Assets	5,287	8.5	3.6	0.5	68.0	12.0
Shareholders' Equity	5,287	3.2	0.9	0.0	32.9	6.6

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Table A8.1.4 *continued*

	N	Mean	Median	Min.	Max.	SD
Robo-Advisors and Personal Finance						
Market Capitalization	766	15.4	6.2	0.3	249.2	26.5
Stock Returns (%)	766	0.4	0.5	–28.7	22.1	4.2
Total Assets	766	1.7	0.9	0.1	3.4	1.3
Shareholders' Equity	766	0.7	0.4	0.1	1.7	0.6
Software Solutions/IT						
Market Capitalization	1,956	15.3	5.9	0.3	210.2	25.5
Stock Returns (%)	1,956	0.3	0.4	–28.2	13.3	2.9
Total Assets	1,956	9.0	3.0	1.2	36.0	11.7
Shareholders' Equity	1,956	4.5	1.3	0.7	20.2	6.0

IT = information technology.

Note: The table reports key characteristics, over the period 2010–17, for the US financial industry and for the fintech firms that are part of the KBW Nasdaq Financial Technology Index. It presents the market capitalization, total assets, and shareholders' equity in $ billion. We calculated stock returns as the weekly difference of log stock prices.

Source: Authors.

Table A8.1.5: Summary Statistics: European Financial System

	N	Mean	Median	Min.	Max.	SD
Financial Industry						
Market Capitalization	16,061	19.1	7.8	0.0	125.6	23.1
Stock Returns (%)	16,061	−0.2	−0.1	−188.8	142.9	7.5
Total Assets	16,061	531.1	197.6	0.3	2,800.1	662.4
Shareholders' Equity	16,061	27.5	11.9	0.0	128.4	32.0
Fintech						
Data Analytics						
Market Capitalization	1,730	10.5	3.2	0.0	162.4	21.1
Stock Returns (%)	1,730	0.2	0.2	−28.2	19.8	4.0
Total Assets	1,730	1.9	1.2	0.1	14.6	2.9
Shareholders' Equity	1,730	1.0	0.5	0.0	8.4	1.6
Digital Banks						
Market Capitalization	417	9.6	2.9	0.0	127.3	18.6
Stock Returns (%)	417	0.2	0.2	−20.3	12.5	3.4
Total Assets	417	2.6	2.7	1.8	3.4	0.4
Shareholders' Equity	417	1.3	1.3	1.2	1.6	0.1
Market Trading and Support						
Market Capitalization	194	10.5	3.7	0.1	157.2	22.3
Stock Returns (%)	194	−0.4	0.1	−25.3	25.3	7.0
Total Assets	194	0.1	0.1	0.1	0.1	0.0
Shareholders' Equity	194	0.0	0.0	0.0	0.1	0.0
Payments and Remittances						
Market Capitalization	6,921	10.1	3.1	0.0	159.7	19.7
Stock Returns (%)	6,921	0.3	0.3	−72.1	28.4	4.6
Total Assets	6,921	13.8	3.7	0.0	181.1	35.1
Shareholders' Equity	6,921	2.7	1.1	0.0	21.9	4.6
Robo-Advisors and Personal Finance						
Market Capitalization	960	9.3	3.2	0.0	121.0	17.1
Stock Returns (%)	960	0.3	0.2	−24.9	18.0	4.1
Total Assets	960	2.2	0.9	0.1	5.8	2.2
Shareholders' Equity	960	1.0	0.4	0.1	3.6	1.1

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Table A8.1.5 *continued*

	N	Mean	Median	Min.	Max.	SD
			Software Solutions/IT			
Market Capitalization	8,213	9.7	3.0	0.0	161.7	18.7
Stock Returns (%)	8,213	0.2	0.3	−61.8	64.2	5.4
Total Assets	8,213	6.6	1.6	0.0	51.1	11.3
Shareholders' Equity	8,213	2.6	0.6	0.0	30.6	4.9

IT = information technology.

Note: The table reports key characteristics, over the period 2010–17, for the European financial industry and for the fintech firms that are part of the CedarIBS FinTech Index and that are quoted on the Frankfurt Stock Exchange. It presents the market capitalization, total assets, and shareholders' equity in $ billion. We calculated the stock returns as the weekly difference of log stock prices.

Source: Authors.

Table A8.1.6: ∆CoVaR Results: United States Financial System

Rank	Company	Category	∆CoVaR (%)
1	Citigroup, Inc.	Financial Industry	−2.297
2	Legg Mason	Financial Industry	−1.702
3	Principal	Financial Industry	−1.553
4	Goldman Sachs	Financial Industry	−1.453
5	BNY Mellon	Financial Industry	−1.393
6	Morgan Stanley	Financial Industry	−1.364
7	T. Rowe Price	Financial Industry	−1.198
8	Janus Henderson Group	Financial Industry	−1.191
9	Northern Trust	Financial Industry	−1.186
10	AGNC Investment Corp.	Financial Industry	−1.131
11	PNC Financial Services	Financial Industry	−1.113
12	CBRE Group	Financial Industry	−1.098
13	New York Community Bank	Financial Industry	−1.094
14	Comerica	Financial Industry	−1.074
15	U.S. Bancorp	Financial Industry	−1.065
16	M&T Bank	Financial Industry	−0.992
17	State Street Corporation	Financial Industry	−0.937
18	BB&T	Financial Industry	−0.928
19	Marsh & McLennan Companies	Financial Industry	−0.925
20	Fifth Third Bank	Financial Industry	−0.915
21	KeyCorp	Financial Industry	−0.902
22	Synovus	Financial Industry	−0.752
23	Western Union	Financial Industry	−0.721
24	Bank of America	Financial Industry	−0.713
25	Ameriprise Certificate Company	Financial Industry	−0.616
26	Suntrust Banks	Financial Industry	−0.593
27	Wells Fargo Company	Financial Industry	−0.581
28	TD Ameritrade	Financial Industry	−0.487
29	Blackrock	Financial Industry	−0.455
30	E-Trade	Financial Industry	−0.422
31	Freddie Mac	Financial Industry	−0.405
32	Charles Schwab	Financial Industry	−0.381
33	People’s United Financial	Financial Industry	−0.212

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Table A8.1.6 *continued*

Rank	Company	Category	ΔCoVaR (%)
34	Fannie Mae	Financial Industry	−0.186
35	First Data	Payments and Remittances	−0.027
36	LendingClub	Alternative Financing	−0.026
37	Virtu Financial	Market and Trading Support	−0.014
38	Square	Payments and Remittances	−0.009
39	CME Group	Market and Trading Support	−0.007
40	Blackhawk Network Holdings	Payments and Remittances	−0.006
41	MarketAxess	Market and Trading Support	−0.006
42	Mastercard	Payments and Remittances	−0.005
43	IHS Markit	Data Analytics	−0.005
44	PayPal	Payments and Remittances	−0.004
45	Jack Henry & Associates	Software Solutions/IT	−0.003
46	WEX, Inc.	Payments and Remittances	−0.003
47	Global Payments	Payments and Remittances	−0.003
48	Cboe	Market and Trading Support	−0.003
49	Broadridge Financial Solutions	Software Solutions/IT	−0.003
50	Equifax	Software Solutions/IT	−0.002
51	Thomson Reuters	Software Solutions/IT	−0.002
52	Fiserv	Payments and Remittances	−0.001
53	S&P Global	Data Analytics	−0.001
54	MSCI	Robo-Advisors and Personal Finance	0.000
55	Verifone	Payments and Remittances	0.001
56	Verisk Analytics	Data Analytics	0.001
57	ACI Worldwide	Payments and Remittances	0.001
58	Western Union	Payments and Remittances	0.001
59	Cardtronics	Payments and Remittances	0.001
60	Nasdaq	Market and Trading Support	0.001
61	Visa	Payments and Remittances	0.002
62	Evertec, Inc.	Payments and Remittances	0.002
63	Worldpay	Payments and Remittances	0.003
64	Moody’s	Data Analytics	0.004
65	FactSet	Data Analytics	0.004

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Table A8.1.6 *continued*

Rank	Company	Category	ΔCoVaR (%)
66	FLEETCOR	Payments and Remittances	0.009
67	SS&C Technologies	Software Solutions/IT	0.011
68	Euronet Worldwide	Payments and Remittances	0.022
69	Envestnet	Robo-Advisors and Personal Finance	0.036
70	Green Dot Corporation	Digital Banks	0.041
71	Franklin Resources	Financial Industry	0.109
72	Regions Financial Corporation	Financial Industry	0.178
73	Zions Bancorporation	Financial Industry	0.182
74	Capital One	Financial Industry	0.220
75	SLM Corporation	Financial Industry	0.258
76	CIT Group	Financial Industry	0.529
77	Huntington Bancshares	Financial Industry	1.273

IT = information technology.
Source: Authors.

Table A8.1.7: ∆CoVaR Results: European Financial System

Rank	Company	Category	∆CoVaR (%)
1	Turkiye Vakiflar Bankasi	Financial Industry	−6.667
2	Turkiye Halk Bankasi	Financial Industry	−5.863
3	Credito Emiliano	Financial Industry	−5.796
4	Banco Bilbao Vizcaya Argentaria	Financial Industry	−5.434
5	Credit Suisse	Financial Industry	−4.996
6	CaixaBank	Financial Industry	−4.874
7	Raiffeisen Bank International	Financial Industry	−4.838
8	ING Group	Financial Industry	−4.282
9	Crédit Agricole	Financial Industry	−4.061
10	Plaza Centers N.V.	Financial Industry	−3.733
11	Nordea Bank	Financial Industry	−3.640
12	Albaraka Turk Katilim Bankasi AS	Financial Industry	−3.260
13	Intesa Sanpaolo	Financial Industry	−3.040
14	Commerzbank	Financial Industry	−2.789
15	Marfin Investment Group	Financial Industry	−2.784
16	Société Générale	Financial Industry	−2.760
17	Skandinaviska Enskilda Banken	Financial Industry	−2.724
18	BNP Paribas	Financial Industry	−2.443
19	Banco Santander	Financial Industry	−2.378
20	Jyske Bank	Financial Industry	−2.328
21	Svenska Handelsbanken AB	Financial Industry	−2.040
22	Banco de Sabadell	Financial Industry	−1.917
23	UniCredit	Financial Industry	−1.852
24	Banca Popolare di Sondrio	Financial Industry	−1.804
25	Permanent TSB Group	Financial Industry	−1.538
26	London Stock Exchange Group	Financial Industry	−1.483
27	Sekerbank	Financial Industry	−1.340
28	Piraeus Bank	Financial Industry	−1.114
29	RBS Group	Financial Industry	−1.049
30	Swiss Life	Financial Industry	−0.989
31	Banco Comercial Portugues	Financial Industry	−0.829
32	Dexia	Financial Industry	−0.781
33	Banco BPM	Financial Industry	−0.662

continued on next page

Table A8.1.7 *continued*

Rank	Company	Category	ΔCoVaR (%)
34	Standard Chartered	Financial Industry	−0.614
35	UBI Banca	Financial Industry	−0.604
36	Banca Carige	Financial Industry	−0.450
37	Alpha Bank	Financial Industry	−0.445
38	Aareal Bank	Financial Industry	−0.407
39	Erste Group	Financial Industry	−0.401
40	Oldenburgische Landesbank	Financial Industry	−0.323
41	UBS Group AG	Financial Industry	−0.286
42	Bank of Ireland Group	Financial Industry	−0.237
43	VTB Bank	Financial Industry	−0.196
44	Banca Monte dei Paschi di Siena	Financial Industry	−0.188
45	TP ICAP	Financial Industry	−0.080
46	Eurobank Ergasias	Financial Industry	−0.019
47	Barclays	Financial Industry	−0.011
48	Bankia	Financial Industry	−0.009
49	Envestnet	Robo-Advisors and Personal Finance	−0.005
50	Points	Software Solutions/IT	−0.004
51	Blackhawk Network Holdings	Payments and Remittances	−0.002
52	Verifone	Payments and Remittances	−0.002
53	FICO	Data Analytics	−0.002
54	China Information Tech	Software Solutions/IT	−0.002
55	Cognizant	Payments and Remittances	−0.002
56	DXC Technology	Software Solutions/IT	−0.002
57	Tungsten Corporation	Software Solutions/IT	−0.002
58	MercadoLibre	Payments and Remittances	−0.002
59	CANCOM	Software Solutions/IT	−0.002
60	Diebold Nixdorf, AG	Software Solutions/IT	−0.002
61	Xero	Software Solutions/IT	−0.001
62	DST Systems	Software Solutions/IT	−0.001
63	Model N	Software Solutions/IT	−0.001
64	NCR	Software Solutions/IT	−0.001
65	TSYS	Payments and Remittances	−0.001

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Table A8.1.7 *continued*

Rank	Company	Category	ΔCoVaR (%)
66	SafeCharge	Payments and Remittances	−0.001
67	American Express	Payments and Remittances	−0.001
68	Wirecard	Payments and Remittances	−0.001
69	PFSweb	Software Solutions/IT	−0.001
70	ServiceSource	Software Solutions/IT	−0.001
71	Virtusa	Software Solutions/IT	−0.001
72	WEX, Inc.	Payments and Remittances	−0.001
73	FactSet	Data Analytics	−0.001
74	First Data	Payments and Remittances	−0.001
75	Ingenico	Payments and Remittances	−0.001
76	Euronet Worldwide	Payments and Remittances	0.000
77	SAP	Software Solutions/IT	0.000
78	Intuit	Robo-Advisors and Personal Finance	0.000
79	IHS Markit	Data Analytics	0.000
80	Global Payments	Payments and Remittances	0.000
81	Syntel	Software Solutions/IT	0.000
82	Jack Henry & Associates	Software Solutions/IT	0.000
83	FLEETCOR	Payments and Remittances	0.000
84	Luxoft	Software Solutions/IT	0.001
85	FIS	Software Solutions/IT	0.001
86	Everi	Payments and Remittances	0.002
87	Wipro	Software Solutions/IT	0.002
88	MoneyGram	Payments and Remittances	0.002
89	Fiserv	Payments and Remittances	0.002
90	Western Union	Payments and Remittances	0.002
91	Genpact	Digital Banks	0.002
92	IRESS	Robo-Advisors and Personal Finance	0.003
93	Mastercard	Payments and Remittances	0.004
94	Teradata	Data Analytics	0.004
95	ADP	Software Solutions/IT	0.004
96	Temenos	Software Solutions/IT	0.006
97	PRGX Global, Inc.	Data Analytics	0.010

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Table A8.1.7 *continued*

Rank	Company	Category	ΔCoVaR (%)
98	Amber Road Inc.	Market and Trading Support	0.010
99	Diebold Nixdorf, Inc.	Software Solutions/IT	0.012
100	Evertec, Inc.	Payments and Remittances	0.021
101	Equifax	Software Solutions/IT	0.025
102	National Bank of Greece	Financial Industry	0.062
103	Banco BPI	Financial Industry	0.227
104	Wuestenrot & Wuerttembergische	Financial Industry	0.379
105	EFG International	Financial Industry	0.483
106	BPER Banca	Financial Industry	1.154
107	Deutsche Bank	Financial Industry	1.170

IT = information technology.

Source: Authors.

Table A8.1.8: ∆CoVaR Results: United States Fintech Industry

Rank	Company	Category	∆CoVaR (%)
1	First Data	Payments and Remittances	−0.107
2	LendingClub	Alternative Financing	−0.039
3	MarketAxess	Market and Trading Support	−0.030
4	CME Group	Market and Trading Support	−0.024
5	Square	Payments and Remittances	−0.019
6	Global Payments	Payments and Remittances	−0.018
7	Thomson Reuters	Software Solutions/IT	−0.015
8	WEX, Inc.	Payments and Remittances	−0.015
9	PayPal	Payments and Remittances	−0.013
10	Western Union	Payments and Remittances	−0.007
11	Equifax	Software Solutions/IT	−0.005
12	Blackhawk Network Holdings	Payments and Remittances	−0.003
13	Jack Henry & Associates	Software Solutions/IT	0.000
14	Intercontinental Exchange	Market and Trading Support	0.000
15	MSCI	Robo-Advisors and Personal Finance	0.000
16	Evertec, Inc.	Payments and Remittances	0.001
17	American Express	Payments and Remittances	0.001
18	SEI Investments Company	Robo-Advisors and Personal Finance	0.002
19	Worldpay	Payments and Remittances	0.003
20	Visa	Payments and Remittances	0.003
21	Virtu Financial	Market and Trading Support	0.003
22	Broadridge Financial Solutions	Software Solutions/IT	0.004
23	Fiserv	Payments and Remittances	0.004
24	FLEETCOR	Payments and Remittances	0.006
25	Mastercard	Payments and Remittances	0.006
26	ACI Worldwide	Payments and Remittances	0.008
27	Verisk Analytics	Data Analytics	0.008
28	Nasdaq	Market and Trading Support	0.009
29	Cardtronics	Payments and Remittances	0.010
30	Cboe	Market and Trading Support	0.011
31	SS&C Technologies	Software Solutions/IT	0.011

continued on next page

Table A8.1.8 *continued*

Rank	Company	Category	ΔCoVaR (%)
32	IHS Markit	Data Analytics	0.012
33	S&P Global	Data Analytics	0.014
34	Green Dot Corporation	Digital Banks	0.019
35	Moody’s	Data Analytics	0.021
36	FactSet	Data Analytics	0.025
37	Euronet Worldwide	Payments and Remittances	0.034
38	Envestnet	Robo-Advisors and Personal Finance	0.041
39	Verifone	Payments and Remittances	0.074

IT = information technology.

Source: Authors.

Table A8.1.9: ∆CoVaR Results: European Fintech Industry

Rank	Company	Category	∆CoVaR (%)
1	PFSweb	Software Solutions/IT	−0.013
2	Blackhawk Network Holdings	Payments and Remittances	−0.012
3	DXC Technology	Software Solutions/IT	−0.009
4	ServiceSource	Software Solutions/IT	−0.008
5	MercadoLibre	Payments and Remittances	−0.007
6	Tungsten Corporation	Software Solutions/IT	−0.007
7	China Information Tech	Software Solutions/IT	−0.006
8	Intuit	Robo-Advisors and Personal Finance	−0.005
9	Diebold Nixdorf, AG	Software Solutions/IT	−0.005
10	Xero	Software Solutions/IT	−0.005
11	Cognizant	Payments and Remittances	−0.005
12	Points	Software Solutions/IT	−0.004
13	SafeCharge	Payments and Remittances	−0.004
14	Verifone	Payments and Remittances	−0.004
15	TSYS	Payments and Remittances	−0.004
16	DST Systems	Software Solutions/IT	−0.002
17	NCR	Software Solutions/IT	−0.002
18	FactSet	Data Analytics	−0.002
19	Mastercard	Payments and Remittances	−0.002
20	First Data	Payments and Remittances	−0.001
21	FIS	Software Solutions/IT	−0.001
22	Euronet Worldwide	Payments and Remittances	−0.001
23	SAP	Software Solutions/IT	−0.001
24	ADP	Software Solutions/IT	−0.001
25	Teradata	Data Analytics	−0.001
26	Ingenico	Payments and Remittances	−0.001
27	WEX, Inc.	Payments and Remittances	−0.001
28	IHS Markit	Data Analytics	−0.001
29	Wipro	Software Solutions/IT	−0.001
30	Virtusa	Software Solutions/IT	−0.001
31	FICO	Data Analytics	−0.001

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Table A8.1.9 *continued*

Rank	Company	Category	ΔCoVaR (%)
32	Global Payments	Payments and Remittances	0.000
33	FLEETCOR	Payments and Remittances	0.000
34	Temenos	Software Solutions/IT	0.001
35	Syntel	Software Solutions/IT	0.001
36	Genpact	Digital Banks	0.001
37	Fiserv	Payments and Remittances	0.001
38	Luxoft	Software Solutions/IT	0.001
39	American Express	Payments and Remittances	0.002
40	Jack Henry & Associates	Software Solutions/IT	0.002
41	Envestnet	Robo-Advisors and Personal Finance	0.002
42	MoneyGram	Payments and Remittances	0.003
43	Model N	Software Solutions/IT	0.004
44	Equifax	Software Solutions/IT	0.004
45	PRGX Global, Inc.	Data Analytics	0.005
46	Diebold Nixdorf, Inc.	Software Solutions/IT	0.005
47	Western Union	Payments and Remittances	0.006
48	Evertec, Inc.	Payments and Remittances	0.006
49	CANCOM	Software Solutions/IT	0.006
50	Wirecard	Payments and Remittances	0.008
51	IRESS	Robo-Advisors and Personal Finance	0.010
52	Amber Road Inc.	Market and Trading Support	0.016
53	Everi	Payments and Remittances	0.018

IT = information technology.
Source: Authors.

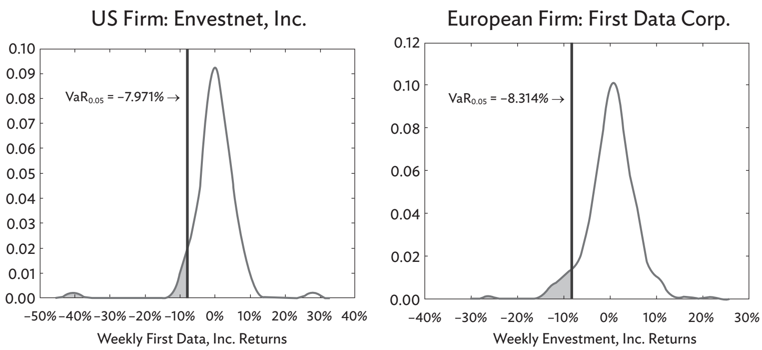
Table A8.1.10: Spearman's Rank Correlation with ΔCoVaR

Sample	Size	Beta
United States		
Coefficient	0.505	0.305
p-value	0.000	0.042
Europe		
Coefficient	0.581	0.591
p-value	0.000	0.000

Source: Authors.

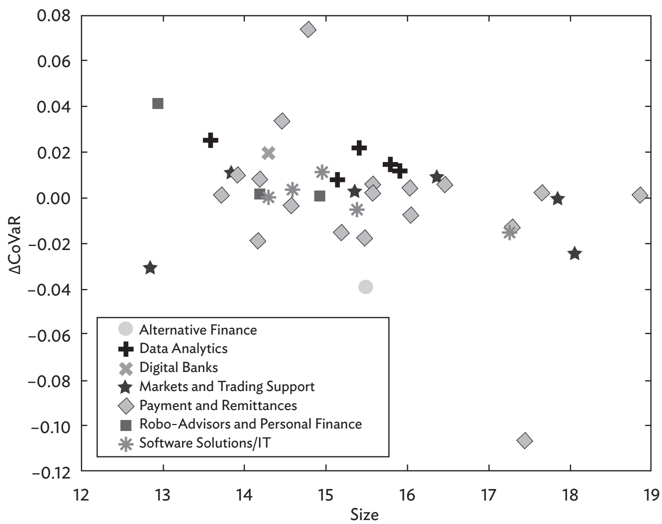
Appendix 8.2: Figures

Figure A8.2.1: Value at Risk



Source: Authors.

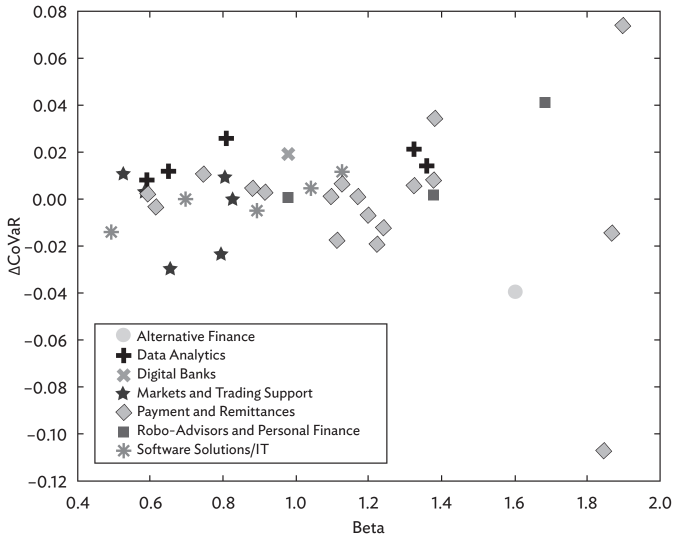
Figure A8.2.2: United States Fintech: ΔCoVaR and Size



IT = information technology.

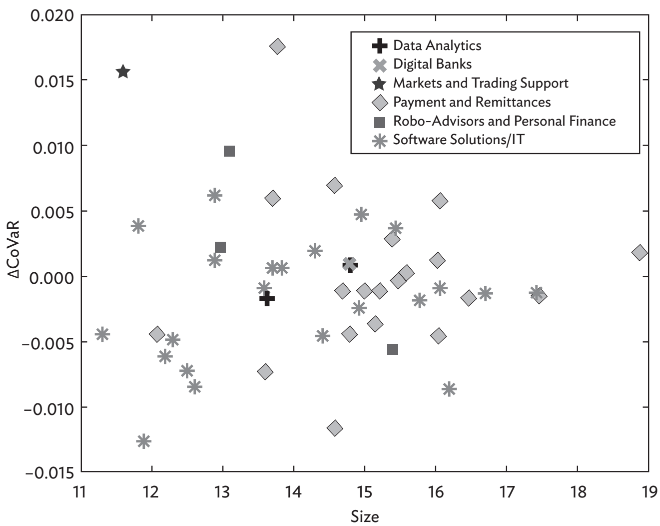
Source: Authors.

Figure A8.2.3: United States Fintech: ΔCoVaR and Beta



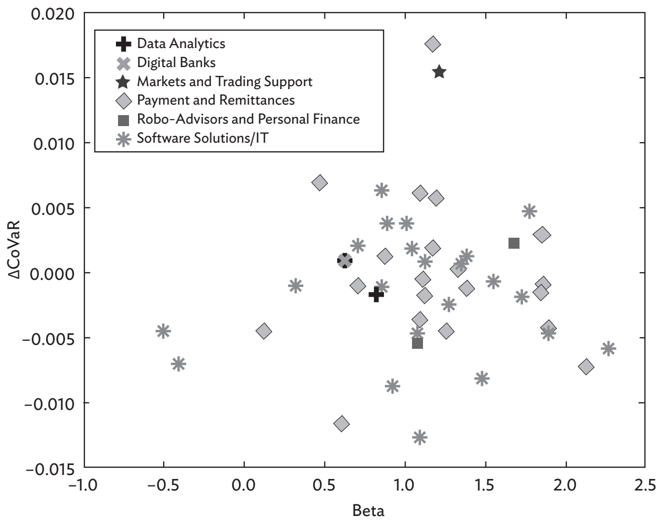
IT = information technology
Source: Authors.

Figure A8.2.4: European Fintech: ΔCoVaR and Size



IT = information technology
Source: Authors.

Figure A8.2.5: European Fintech: ΔCoVaR and Beta



IT = information technology

Source: Authors.

9

The Nexus of Safe Asset Shortage, Credit Growth, and Financial Instability

Sujin Kim

9.1 Introduction

Does a safe asset shortage (SAS) sow the seeds of financial instability? This is an important and timely question given the resurgence of credit booms during the subdued global recovery[1] since the 2008 global financial crisis. Despite fully fledged macroprudential measures[2] implemented to moderate excessive credit creation, rapid credit growth in economies such as the People's Republic of China (PRC)[3] is deepening policy makers' woes.

In terms of bank credit flows to the private nonbanking sector (Figure 9.1a), a simple comparison of the average annual increase in credit-to-gross domestic product (GDP) ratios in 38 countries[4] in the post-crisis period (2009–2017) against the pre-crisis period (2000–2007) reveals that only 32% of the sample countries, most of which were hit by the global financial crisis, resumed to delever after the crisis. In the subgroup of 18 that experienced the 2007–2008 banking crisis (Laeven and Valencia 2018), only 60% saw a drop in terms of credit-to-GDP,

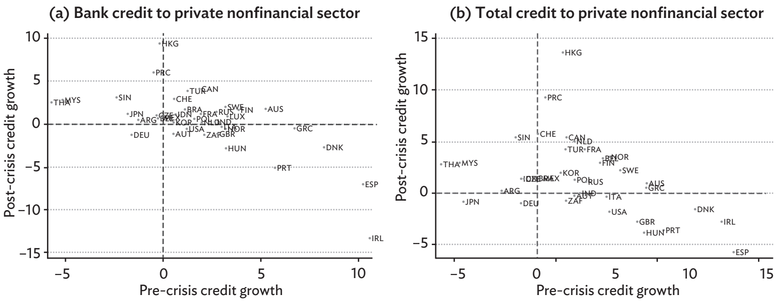
1 At the time of writing in 2018.

2 Refer to Alam et al. (2019) for the extensive use of macroprudential policies after the GFC.

3 In terms of total credit to the private nonfinancial sector, Canada, the Netherlands, Singapore, and Switzerland. See also the even more rapid surge of credit growth in the post-crisis period (see Figure 9.1b).

4 See Appendix A9.1: List of Economies.

Figure 9.1: Private Credit Growth: Pre- and Post-Crisis Comparison



Note: (a) and (b) plot a simple annual average percentage point increase of bank credit (total credit) to private nonfinancial sector relative to nominal GDP level in the post-crisis period 2009–2017 in comparison to records in the pre-crisis period 2000–2007. There are 38 sample countries (37 without Luxembourg). See Appendix List A9.1 List of Economies for abbreviations.

Source: Bank for International Settlements (BIS); author's calculation.

whereas the credit level in the rest[5] reached a record high. Moreover, 26% of the sample countries, mainly emerging economies,[6] swung from a deleverage to a leverage position after the crisis.

The surging credit volume in some developed economies does not seem to be in tune with secularly low private investment. Moreover, it is surprising to observe a sudden switch to leverage in emerging economies after the global financial crisis, especially some leverage at an alarming pace,[7] given that the economic structure might not crave greater credits in a period of weakened economic growth. A suspicion emerges that an endogenous credit supply within a financial system is at play. What is the key factor or condition in triggering risky upturns in credit cycles? Is an SAS playing a role? This is a pivotal question that might help account for the global financial crisis as well as prevent a future one.

A growing strand of literature on safe assets has argued for (macroeconomic) shortages of safe assets as a potential root of (global) financial instability (Gourinchas and Jeanne 2012; Gorton and Ordonez

5 Including France, Luxembourg, the Netherlands, the Russian Federation, Sweden, and Switzerland.

6 Specifically, the PRC; Hong Kong, China; Singapore; Malaysia; and Thailand.

7 The credit-to-GDP in the PRC has escalated to 156% (245%) in 2017 from 106% (151%) in 2007.

2013; Gorton 2016; Gourinchas and Rey 2016; Caballero, Farhi, and Gourinchas 2017; Golec and Perotti 2017; Kacperczyk, Perignon, and Vuillemey 2017). To read its main view, with a focus on the question of this chapter,[8] the demand for safe assets is generally assumed to increase proportionally with output or wealth (Caballero, Farhi, and Gourinchas 2017),[9] with a search for a reliable store of value, liquid collaterals for banks, key components of prudential regulation, and capital preservation in portfolio construction (Gorton and Ordonez 2013). On the other hand, the supply of safe assets can be constrained by the level of financial development, the fiscal capacity of the sovereign, the track record of the central bank for inflation and exchange rate stability, and the willingness of central banks to "backstop" government debts (Gourinchas and Jeanne 2012). The seeds of financial instability are sowed when excessive (insufficient) demand (supply) arises for safe assets. Such a shock to safe asset shortages distorts an incentive of the financial system to issue "private label safe assets"[10] by utilizing the input of excessive risky claims on firms and households (Gourinchas and Jeanne 2012).[11] The whole process consequently spurs the volume of credits independently from real factors (Golec and Perotti 2017).

Despite empirical evidence attesting to the presence of an SAS either in the form of safety premiums[12] or a fall in natural interest

8 The issue has been discussed in the separate fields of international macro and finance. Accordingly, macro shortage is more closely related to the real sector of households and firms, while its origin in the latter field is found in the financial system. However, recently, as in Golec and Perotti (2017), we have seen an increasing effort to understand the nexus of safe assets and financial stability in a more unified framework.

9 This has been assumed in the literature, such as for a model for "global" demand for safe assets, or in the context of foreign reserve accumulation by emerging economies and their demand for United States (US) treasury securities or international liquidity. For a critical review, see Bordo and McCauley (2017).

10 Bernanke et al. (2011) note that such private label safe assets are non-safe to a negative aggregate shock even though they are expected to be the most safe, as seen in Gourinchas and Jeanne (2012). Moreover, Kacperczyk, Perignon, and Vuillemey (2017) empirically demonstrate that the supply of private safe assets fails during episodes of market stress.

11 Gourinchas and Jeanne (2012) present the mechanism but argue that the demand for safe assets "primarily" comes from a precautionary motive from firms and households owing to financial frictions, not from within the financial system.

12 See Gorton, Lewellen, and Metrick (2012), Krishnamurthy and Vissing-Jorgensen (2012) and (2015), and Gorton (2016). On the other hand, Jordà et al. (2019) have recently questioned the shortage of safe assets, documenting that risk premiums stay around their historical average. I will discuss the issue based on a sample average correlation analysis in Section 9.3.

rates,[13] the economic growth-based safe asset demand, often adopted as a constant in the literature, remains an elusive concept to apply. For instance, why should changes in wealth (economic growth or savings) inflate a safe rather than risky asset demand, or why should we assume that the composition of demand for risky and riskless assets is fixed? As an alternative step forward to the real economy, I propose two long-run trends as key determinants of safe asset demand and supply. One is population aging, which has progressed globally in recent decades. The other is an increasing tendency to use some rule-based fiscal policy, at least in developed economies, to manage the level of public debt around certain rates.[14]

Demographic factors affect demand through two channels. First, an increasing life expectancy stimulates precautionary savings that search for safe stores of value, providing a huge funding source on the liability side of balance sheet of banks and institutional investors, such as insurance and pension funds. As a consequence, financial institutions also need more "safe debt securities" as sound collateral, as well as to match their increasing asset liabilities (Greenwood and Vissing-Jorgensen 2018). Second, population aging shifts up an aggregate demand for safe assets in an economy (composition effects) via age-dependent or household life cycle portfolio choice on risky and riskless assets. Numerous empirical studies support a hump-shaped (an approximate U-shaped) age profile of risky (safe) share in household portfolios (see Cocco, Gomes, and Maenhout [2005], and Chang, Hong, and Karabarbounis [2018] for the US case; Brunetti and Torricelli [2010] for the Italian; and Fagereng, Gottlieb, and Guiso [2017] for the Norwegian). Therefore, in the case that government bonds are the only safe assets, a wave of aging, driving demand for safe assets, could constitute a potential contributor to financial vulnerability when it meets a specific condition, such as counter-cyclical fiscal policy.

The purpose of this chapter is to empirically explore the hypothesis of safe asset shortage-induced excess credit booms and financial instability. Despite vigorous debates on the issue since the global financial crisis, empirical evidence on how it works remains rather

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13 Refer to Caballero, Farhi, and Gourinchas (2017) and Del Negro et al. (2017). The former additionally argue that real interest rates adjust to safe asset shortages in incomplete markets. The secular fall in natural or the real risk-free interest rates, measured as an equilibrium outcome of such safe asset shortages, puts an economy into still deeper recession at the near Zero Lower Bound. Only a reduction in wealth decreases the shortage. These authors focused more on the consequences of deeper safe asset shortages since the crisis and on policy responses.

14 Jordà, Schularick, and Taylor (2016) describe the long-run evolution of public debts in advanced economies as counter-cyclical.

scarce. A domestic focus (excluding the US) is even rare. Against this backdrop, the study makes a couple of contributions. First, I construct a new SAS index that reflects the trends of aging and fiscal policies. To my knowledge, this is the first attempt of its kind at the time of writing. The index for each country is built on a data set for old-age dependency ratios and central government debt (CGD) from 18 developed economies in 1960–2017.[15] The new stylized fact I found is that the sample average of the individual SAS index in terms of year-over-year differences depicts some cyclical behavior, specifically a deep shortage before crises (see Figure 9.4a). The cyclical feature has been mainly affected by the supply side (changes in government debt) up to year 2009, and then markedly driven by aging factors after the global financial crisis (see Figure 9.4b).

Second, the paper adds new empirical evidence regarding the hypothesis. The SAS-financial instability hypothesis is assessed in two steps. In the first part, I evaluate the validity of the SAS index, its link to bank credits and their interaction as a predictor of domestic banking crises. The empirical exercise uses the classification model of Jordà, Schularick, and Taylor (2016) (hereafter JST [2016]) and Schularick and Taylor (2012) (hereafter ST [2012]). The credit expansion in the private sector is adopted as a proxy for the endogenous build-up of aggregate risks in a financial system that could result in an extreme event like a financial crisis such as in ST (2012). The study provides a basic framework in which only government debt or securities are narrowly classified into safe assets as stores of value. The test finds that it is not the level of government debt but its change (a decrease in safe asset supply) that is associated with risky private credit booms that potentially give rise to banking crises. Using the SAS index yields the same result. The estimation outcomes of the probabilistic models for 17 developed economies in 1960–2013 demonstrate that the high level of private credits at a time of increasing SAS is the most powerful indicator of a financial crisis.

As a second step, the study sets up a fixed-effect panel model, derived from the results of the previous exercise, and estimates the causality effects of an SAS on the growth of domestic bank credits to the private sector and the role of securitization in the presence of the shortage. The main mechanism is as follows. When the demand for safe assets intensifies at their limited supply, for instance a big wave (band) of retirement (to-be retirees) or a sudden drop in government bond issuance, it triggers an endogenous, bubbly credit supply by financial

15 The observation period and the sizes of the sample countries vary slightly for here and each empirical analysis in the paper, owing to data availability. The time series of the SAS index used for empirical exercise is also slightly different in terms of range.

intermediaries as in Shin (2009).[16] In the process, banks, using their balance sheets, exploit excessive demand for safe assets, either from households' portfolio channels or from outside the banking sector, such as institutional investors. Securitization enables banks to keep in leverage, inventing quasi-private-safe assets, constructed on loans on balance sheets, proceeds from whose sales are new funding sources to issue new credits.

The shortage pressure is eventually mitigated with excessive private credits, exposing the financial system's vulnerability to a negative shock like in the global financial crisis. In an open economy, such domestic risks can be reduced via capital outflows, exporting the shortage. Through introducing a capital-flow term in the model, the chapter also verifies whether cross-border investment flows economically increase or decrease domestic credit risks. The fixed effects estimation of the credit model for 18 developed economies in 1980–2016 confirms a positive effect of an SAS on a domestic bank credit growth. The total effect of an SAS on domestic credit booms is affected positively by securitization growth and negatively by capital outflows. The latter effect is estimated as considerably stronger than the former.

This study is inspired by broad strands of literature on safe assets, the link between credit cycles and financial stability, and capital flows. It benefits greatly from the literature on safe assets discussions when developing ideas and assumptions. To my knowledge, however, empirical studies on the nexus of SAS-credit growth-financial instability in a unified framework are rarely found in the literature. To present a few, scattered but directly relevant to the paper, my work is indebted to JST (2016) and ST (2012) in terms of empirical strategy and data. JST (2016) investigate the role of private and public debts and their interactions in causing financial crisis episodes. In an analysis of 17 developed countries in 1870–2012, the authors argue that it is mainly the private debt pile-up that induces financial crises, while public debt *ex ante* is scarcely relevant. Instead, the negative impact of public debt is evident in the aftermath of crises, as excessive public leverage tends to prolong the recession and is associated with weak growth after crises.

By contrast, this paper supports the strong interaction between public and private debt as the main crisis predictor. This distinctive result comes from the use of government debt. JST (2016) employ the level of general government debt for the interaction term with private credits, while my chapter uses the change in central government debt (CGD), that is, net safe asset supply. While the former studies focus only

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[16] Shin (2009) points to the endogeneity of credit supply as the origin of the subprime crisis.

on domestic factors, Cesa-Bianchi, Eguren-Martin, and Thwaites (2017) add a global factor to the credit banking crisis discussion. They study the impact of credit growth abroad on the risk of a domestic banking crisis, using data from 38 developed and emerging economies over 1970–2011. They empirically show a significant role of cross-border portfolio inflows as the main channel explaining the large positive effect of foreign credit booms on the probability of domestic banking crises. However, the study barely deals with structural factors behind the relationship. Perugini, Holscher, and Collie (2015) investigate the roots of financial instability, empirically estimating the relationship of inequality, credit growth, and financial crisis for 18 Organisation for Economic Co-operation and Development countries in the period 1970–2007. Authors find a positive, significant effect of income inequality on private debt growth, but their empirical model seems to miss a clear link, for instance, an interaction term of credit growth and inequality in the crisis model, to explain why inequality-driven credit booms are directly relevant to increasing the probability of banking crises. In terms of an asset index, Chen and Imam (2014) construct an "asset" shortage index and show its positive effect on banking crisis occurrences for 41 emerging economies for 1995–2008. They argue that one origin of banking crises, asset bubbles, and uphill capital flows in emerging markets lies in general asset shortages, not in safe asset shortages. Besides a different focus on the sample group, the indexing approach used in the paper, relying on flows of funds of assets, is distinct from this chapter, which constructs a structural factor-based SAS index for developed economies.

The chapter is organized as follows. Section 9.2 estimates the public debt (safe assets) to financial instability nexus in probabilistic models, and discusses the results. Section 9.3 describes the SAS index and the stylized facts of the data related to empirical exercises, and explores the role of the index in the crisis classification model. Section 9.4 presents the fixed-effects panel model for private credit growth and the estimation results. Section 9.5 concludes with policy implications.

9.2 Channel of Financial Instability: Government Debt and Bank Credit

I revisit the crisis classification model of JST (2016) to assess the relationship between an SAS and financial fragility via credit booms. The first empirical exercise replicates JST (2016) for the data selection check. Before creating the SAS index, it is necessary to examine the test results for a case using only the supply side of the SAS index, associated with government debt, and assess the suitability of the data set as a proxy for safe assets.

The empirical model is the following probability logit model, as in JST (2016) and ST (2012):

$$logit(p_{i,t}) = b_{0,i} + b_1(L)X_{i,t} + e_{i,t} \qquad (1)$$

where the log-odds ratio ($\text{logit}(p_{i,t}) = \ln(p_{i,t}/1 - p_{i,t})$) of a financial crisis episode in country (i) in year (t) is a linear function of lagged controls $X_{i,t}$ and country-fixed effects $b_{0,i}$. The lagged control variables include 5-year moving averages of changes in the private credit-to-GDP and the public debt-to-GDP. They are further augmented by lagged levels of the private and public debt-to-GDP, as well as an interaction term of them.

The analysis adopts the data set from JST (2017),[17] aside from public debt data. Given that the study limits safe assets to (central) government bonds as stores of value in its narrowest definition,[18] it opts for the CGD data from the International Monetary Fund (IMF) Global Debt Database (Mbaye, Badia, and Chae 2018),[19] which represents an extensive public debt database over a long-time horizon back to the year 1950. The CGD-to-GDP is employed as a proxy for safe assets[20] in the entire empirical models of the study. The sample include 17 developed economies as in JST (2016) (see List A2), but the observation period covers only the range of 1960–2013, shortened from the period of 1870–2012 in JST (2016).

Table 9.1 documents the main results. Private credit growth is still a strong crisis predictor as in Column (1), while public debt growth alone does not offer any information (see Column (2)). This is a similar outcome as in JST (2016). A new observation is found in Column (5). When we add the lagged level of public debt-to-GDP and the interaction term between the lagged private credit and public debt-to-GDP level to the model, the estimation of the specification yields further information to predict a crisis.

The result is substantially different from JST (2016) that found little association between private credit and public debt to predict crises. Column (5) shows that CGD both in change and in level play a role in restraining the occurrence of a financial crisis event, while a high level of public debt in the high level of private credit would raise the possibility of a future crisis. The coefficient of the interaction term

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17 See the Appendix Table A9.1, or visit http://www.macrohistory.net/data/#DownloadData for more information.

18 Golec and Perotti (2017) provide a good overview of the types of safe assets, classified by safety and liquidity and issuers. See Figure 1 (Golec and Perotti 2017, 7).

19 https://www.imf.org/external/datamapper/datasets/GDD for more information.

20 As for data selection background, refer to the safe shortage index description in Section 9.3.

Table 9.1: Financial Crisis Classification Ability: Central Government Debt

Classifier Logit Model	(1)	(2)	(3)	(4)	(5)
Change in private credit/GDP (5-year moving average)	34.59*** (3.81)		34.55*** (9.19)	23.66* (12.31)	
Change in public debt/GDP (5-year moving average)		−9.48 (8.82)	−0.20 (10.13)		−22.73* (11.80)
Lagged level of private credit/GDP				1.47 (1.53)	
Lagged level of public debt/GDP					−4.50** (1.74)
Interaction term[a]				0.36 (1.03)	6.18*** (1.85)
Observations	1810	987	987	999	996
AUROC	0.65 (0.03)	0.60 (0.06)	0.74 (0.05)	0.79 (0.04)	0.76 (0.05)

AUROC = area under the receiver operating characteristic curve, GDP = gross domestic product.

Notes: For the Netherlands, general government debts are used in all empirical exercises and indices as its CGD data are not available in the International Monetary Fund Global Debt Dataset.

Standard errors are in parentheses. *p<0.10, **p<0.05, ***p<0.01.

a The interaction between the lagged level of private credit-to-GDP and of public debt-to-GDP.

Source: Author's estimation. The government debt data is from the International Monetary Fund Global Debt Dataset and other data is from JST (2017).

in Column (5) is statistically significant. The AUROC[21] shows a better performance for Specification (5) than for the same specification in JST (2016). The different outcomes of this study and JST (2016) may result from the distinct sample period and data selection for public debt. However, what deserves our attention is that when government debt is approached as (safe) assets in the use of CGD in change, instead of as an indicator of general fiscal soundness in its level, the role of public debt and its interaction with private credits are positively verified as a useful information source in the model. The data selection of CGD for safe assets, based on the hypothesis, is assessed as appropriate.

Next, I generate an interaction term of lagged level of private credit-to-GDP ($c_{i,t-1}^{priv}$) and lagged yearly change in CGD-to-GDP ($\Delta d_{i,t-1}^{pub}$). Given that government debt is annually collected in terms of stock, its difference roughly approximates year-over-year net government bond

21 AUROC is a measure of the binary classification ability of the model. ST (2012) explain the method in detail.

Table 9.2: Financial Crisis Classification Ability in the Modified Model: Central Government Debt

Classifier logit model	(1)	(2)	(3)	(4)
Change in private credit/GDP (5-year moving average)	10.28 (11.67)	12.18 (12.18)		
Change in public debt/GDP (5-year moving average)			15.86 (10.68)	5.94 (14.74)
Lagged level of private credit/GDP	3.42** (1.54)	2.57* (1.44)	3.99*** (1.35)	3.26*** (1.03)
Interaction term: $(c_{i,t-1}^{priv})\ (\Delta d_{i,t-1}^{pub})$	–31.95** (9.34)		–41.38*** (8.38)	
Observations	984	968	984	968
AUROC	0.85 (0.04)	0.79 (0.05)	0.88 (0.03)	0.79 (0.05)

AUROC = area under the receiver operating characteristic curve, GDP = gross domestic product.
Note: Standard errors are in parentheses. *p<0.10, **p<0.05, ***p<0.01.
Source: Author's estimation.

issuance. This enables the interaction term to capture the effect of private credit expansion on financial risks at a time of a drop in safe asset supply.

Surprisingly, unlike the previous exercise, Columns (1) and (3) in Table 9.2 report that the level of private credit in response to the change in government debt (net government bond issuance) mainly accounts for future crises. The interaction term measuring the effect is the most powerful information source as a crisis predictor, followed by the private credit level. The coefficient estimates for the two terms are all statistically significant. The change in private credits or public debt loses its forecasting power when the former two control variables are added. Specifications (1) and (3) show better predictive ability compared to the result of Table 9.1. The AUROC of Specification (1) for the augmented model of private credit growth is 0.85 (standard error [SE.] of 0.04) and that of Specification (3) for the modified model of public debt growth is 0.88 (SE. 0.03).

It is the high private credit level at a time of diminishing public debt, that is, a drop in safe asset supply, which warns of a build-up of financial risks in developed economies over the period 1960–2013. Given that this result empirically supports the hypothesis of the chapter, the next section presents an SAS index combined with a demand component, and tests its validity in the same classification model.

9.3 Safe Asset Shortage Index, Data and Stylized Facts

9.3.1 Safe Asset Shortage Index (1970–2017)[22]

The SAS index is constructed on the assumption of household life cycle portfolio choice. Households' portfolio shares in risky (riskless) assets drop (increase) substantially with the age of household heads.[23] According to Fagerang, Gottlieb, and Guiso (2017) analyzing Norwegian household data, the portfolio share in risky assets is high and constant up to mid-phases of the life cycle, remaining at around 50%. Subsequently, households start gradually decreasing their risky asset shares until investors' age reaches around 65.[24] When they retire, most people exit the stock market.

Based on such empirical evidence on household portfolio choice in the micro data analyses, the study assumes that investors have two choices of risk and riskless assets (such as safe government bonds), and their demand for safe assets grows as they age.[25] Thus, an aggregate demand for safe assets evolves contingent on a demographic transition in the economy. I simplify the relationship into a relative term, such that a relative demand for safe assets to risky shifts contingent on the ratio of old to young people. The study takes the retirement age of 65[26] as the threshold for exiting from a risky asset market or at least the lowest and constant level of risky asset share in terms of life cycle investment. The old-age dependency ratio is a useful tool here. It efficiently summarizes the relative demand for riskless assets on aggregate in an economy. The empirical strategy is that the relative demographic shift toward old against that of the base-year proxies for the relative increase in the safe asset demand compared to the level in the base year.

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22 I present the index series ranging from 1970–2017 in this section. They were originally constructed from the year 1950, based on an unbalanced data set.

23 See again for empirical results, Cocco, Gomes, and Maenhout (2005) and Chang, Hong, and Karabarbounis (2018) for the US case and Brunetti and Torricelli (2010) for the Italian, especially Chang and colleagues in terms of participation rate.

24 According to the study, participation in the stock market also follows a hump shape. It increases rapidly with investors' age up to a high level at age 45, and stays constant or slightly grows afterwards but investors leave the stock market at retirement.

25 In the process, increasing precautionary savings on the balance sheet of banks and financial institutions also call for more safe assets. I abstract the financial sectors, linking their behavior to the motivation of household investors.

26 The threshold age or range could be adjusted to construct a better index.

It is formulated as in the first element on the right-hand side of Equation (2) for the SAS index. The index for demographics-based safe asset demand captures the relative increase of the old-age dependency ratio[27] against its level in 2000 of the base year ($\frac{old\_d_{i,t}}{old\_d_{i,2000}}$).

$$sas_{i,t} = \frac{old\_d_{i,t}}{old\_d_{i,2000}} - \frac{cg\_d_{i,t}}{cg\_d_{i,2000}}, \tag{2}$$

$$\Delta sas_{i,t} = \frac{old_{d_{i,t}} - old_{d_{i,t-1}}}{old_{d_{i,2000}}} - \frac{cg_{d_{i,t}} - cg_{d_{i,t-1}}}{cg_{d_{i,2000}}} \tag{3}$$

The supply of safe assets is determined by government bond issuance. The index for safe asset supply measures the relative increase of government debt-to-GDP against its level in the base year 2000 ($\frac{cg\_d_{i,t}}{cg\_d_{i,2000}}$). I opt for the central government debt series, which is compiled mostly by core debt instruments such as debt securities. Given that it reports the gross outstanding stock of government liabilities, the annual change of the stock approximately quantifies the net amount of safe asset issuances. The CGD-to-GDP is thus employed as a proxy for the safe asset supply as a portion of GDP.

A shortage of safe assets is assumed to occur when the government bond supply does not meet the age-dependent safe asset demand. The SAS index in Equation (2) measures the gap between two indices. There is no weight on each component. The relationship between two indices in the basic framework is simple and straightforward. Equation (3) presents the index in difference, which captures the annual gap between the yearly change in the size of new and old retirees relative to young, and the change in net government debt issuance to GDP.

Discussion. In terms of the baseline indices above, I assume that the ratio of the old generation's financial assets to the young generation is constant over time. In addition, the supply side of the index does not include the asset purchase by major central banks during and after the global financial crisis, despite its substantial shock to the amount of safe assets available to the public. However, such counterfactual elements are certainly worth testing. The extended indices to reflect them could be presented as follows.

$$e\_sas^{d}_{i,t} = w_{i,t} * \frac{old\_d_{i,t}}{old\_d_{i,2000}}, e\_sas^{s}_{i,t} = \frac{(cg\_d_{i,t} - z_{i,t})}{cg\_d_{i,2000}}, \tag{4}$$

where $w_{i,t} = \frac{old\_asset\_r_{i,t}}{old\_asset\_r_{i,2000}}$, $z_{i,t} = \frac{cb\_net\_purchase_{i,t}}{gdp_{i,t}}$,

[27] The number of people older than 64 years per 100 working age population aged 15–64.

$$\ln(e\_sas_{i,t}^{d}) = \ln(w_{i,t} * \frac{old\_d_{i,t}}{old\_d_{i,2000}}),\ \ln(e\_sas_{i,t}^{s}) = ln\frac{(cg\_d_{i,t} - z_{i,t})}{cg\_d_{i,2000}} \quad (5)$$

$$e\_sas_{i,t}^{shortage} = \ln\left(w_{i,t} * \frac{old\_d_{i,t}}{old\_d_{i,2000}}\right) - \ln(\frac{(cg_{d_{i,t}} - z_{i,t})}{cg\_d_{i,2000}}) \quad (6)$$

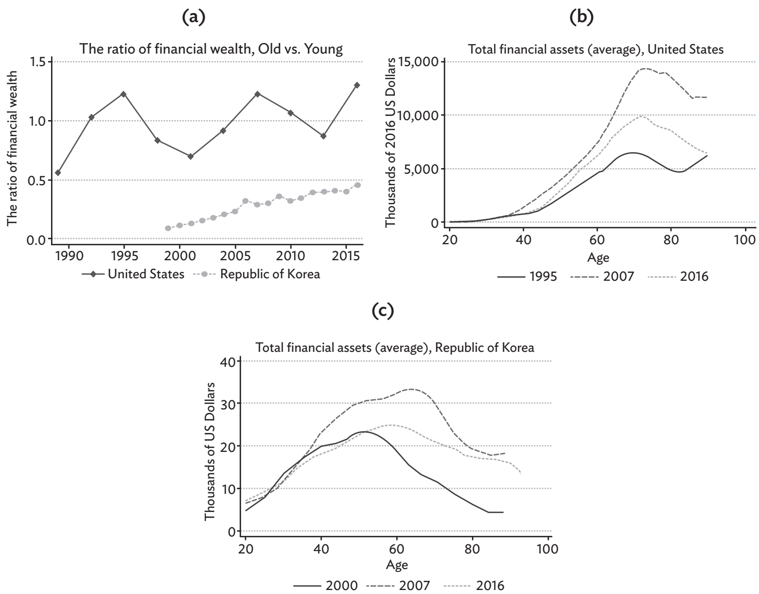
$$\Delta e\_sas_{i,t}^{shortage} = \Delta\ln\left(old\_d_{i,t}\right) + \Delta ln(old\_asset\_r_{i,t}) - \Delta ln(cg\_d_{i,t} - z_{i,t}) \quad (7)$$

The extended index for safe asset demand is weighted by $w_{i,t}$, the level of over 64 old agents' financial wealth relative to the young, compared to the base year. Taking a log on each safe asset demand and supply index in Equation (4) gives more direct intuition when we solve the shortage in level ($e\_sas_{i,t}^{shortage}$) in Equation (6) and in yearly changes ($\Delta e\_sas_{i,t}^{shortage}$) in Equation (7). Then, the extended SAS index in difference is affected by a change in the relative share of old agents' financial wealth and by the central banks' asset purchase shock to the amount of safe assets available to the public.[28]

The variation in age-contingent financial wealth distribution over time is substantial. A comparison of the figures in the Republic of Korea and the US explains why the ratio of financial wealth could be important in safe asset debates. Financial wealth by age does not increase evenly. Figure 9.2 (a) depicts that the amount of financial wealth held by people aged over 63 grows faster than that of younger agents. Moreover, the growth rate of this ratio in the US is much steeper than in the Republic of Korea. The financial wealth share of agents over 63 accounts for 69% of the younger generation's in 2001 in the US. However, the figure records 131% in 2016, rising by 62 percentage points. In the Republic of Korea, the level of financial wealth of senior agents reaches only 13% of younger generations' in 2001, steadily increasing to 46% in 2016. During the same period, it only grows by 33 percentage points, approximately half of the US figure. This simple micro data analysis reveals that the demand for safe assets in the US may have been stronger than in the Republic of Korea, given that the relative asset share of senior agents in the US dominates that in the latter in scale and growth. In Figure 9.2 (c), younger household heads held more financial assets in per-head average term in the Republic of Korea in 2000. By contrast, Figure 9.2 (b) shows

28 It could be further extended and modified, as other determinants of the supply and demand of safe assets such as a series of uncertainty and regulations also need to be considered.

Figure 9.2: Total Financial Wealth Distribution: Republic of Korea vs. the United States



Notes: (a) summarizes the ratio of aggregate financial wealth between the group of household heads aged over 63 and the young aged below 64. The data for the Republic of Korea come from the Korean Labor & Income Panel Study of the Korea Labor Institute, adjusted to the 2015 price level, while the data for the US come from the Survey of Consumer Finances (SCF) of the Federal Reserve Board. (b) and (c) are the age profile of the households' average amounts of total financial assets for the US and the Republic of Korea in US dollars. Also refer to Figure A9.2.

Source: Author's calculation.

that already in 1995, the age profile of average total financial assets in the US saw a peak in agents over 60.

9.3.2 Demographics

The present and the following part describe the data from the sample of 18 countries used for the empirical analysis of Section 9.4[29] and stylized facts. The level of population aging is heterogenous over countries, but the trend of aging over time is a significant global phenomenon,

[29] See Appendix List A9.3 and Table A9.1.

with a secular fall in fertility and a surge in longevity.[30] It may imply a gradual increase in safe asset demand globally, or at least in developed economies[31] from the view of an investor's portfolio choice over the life cycle. According to data from the United Nations (UN) World Population Prospects, most sample countries belonged to the group of aging society[32] in 1950, except for the Republic of Korea (2000),[33] the Netherlands (2004), and Norway (1977). In 2015, most economies were classified in the aged society, while Germany (21.1%),[34] Italy (22.3%), and Japan (26%) entered the hyper-aged society. Besides the Republic of Korea (elderly population share, 13%), the US (14.6%) is the youngest country in the sample, followed by Australia (15%), Canada (16.1%), and Norway (16.3%). From 2000 to 2015, aging occurred fastest in Japan (average annual growth of 0.6 percentage points in elderly population share), with the Republic of Korea (0.4 percentage points), Finland (0.4 percentage points), and Germany (0.3 percentage points) behind.

Figure 9.3 depicts the time interval progress of old-age dependency ratio. The 5-year interval data also come from the UN World Population Prospects. For here and the following empirical study, I interpolate the data set to the annual data. The figure is little different from the evolution of the elderly share in the total population, owing to a stagnant birth rate and increasing longevity across countries. In 2017, Japan showed the highest record of 45, followed by Italy (36.3), Finland (34), and Germany (33). Relative to the level in the base year of 2000, the safe asset preference share of population (the old-age dependency ratio) grew most quickly in Japan (annually by 1.18 percentage points). Next was Finland (0.68 percentage points), followed by Italy (0.55 percentage points), the Republic of Korea (0.54 percentage points), Portugal (0.54 percentage points), and the Netherlands (0.53 percentage points), while Norway (0.12 percentage points) and Belgium (0.19 percentage points) showed rather slow progress in aging over 2000–2017.

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30 Refer to Amaglobeli et al. (2019) and Barany, Coeurdacier, and Guibaud (2019) for a broad description of the global and regional aging trend, including fertility and life expectancy rates.

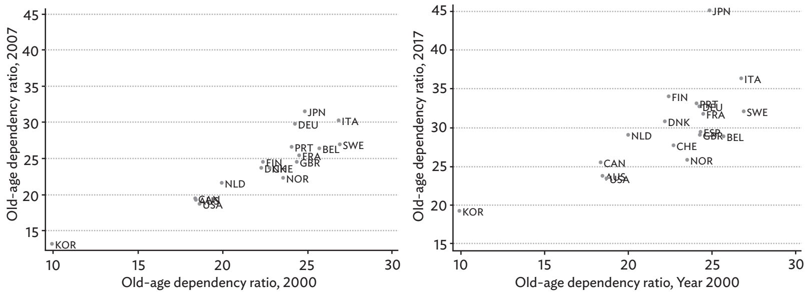
31 With substantially high financial assets held in the private sector.

32 According to the UN definition, when the elderly population (+65) in a country exceeds 7% of its total population, it is classified as an aging society. When it accounts for 14% (21%) or more, it is defined as an aged society (a hyper-aged or super-aged society).

33 The figure in parentheses refers to the year in which the countries became part of the aging society.

34 This refers to the percent share of elderly population (+65) in the total population.

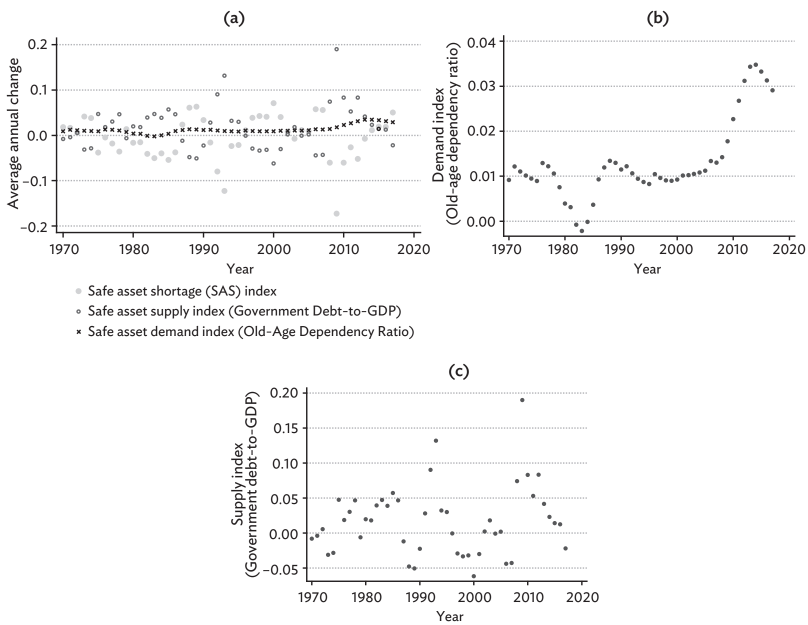
Figure 9.3: Demographics: Old-Age Dependency Ratio



Note: See Appendix List A9.1 List of Economies for abbreviations.

Source: UN World Population Prospects. Author's calculation.

Figure 9.4: Safe Asset Shortage Index in Difference (Average across Countries)



GDP = gross domestic product.

Note: The graphs (a)-(c) plot the sample average annual difference in (a) the safe asset shortage index across countries in 1970–2017, (b) demand index of old-age dependency, and (c) supply index of central government debt.

Source: Author's calculation.

In Figure 9.4(b), the sample average of annual changes in the old-age dependency ratio revealed a striking feature. Though it seemed stable in early 2000s, it was not constant at all in the long-run time series; rather, it exhibited big swings. The recent hike is dramatic, driving the SAS index after the global financial crisis. The average change in the ratio elevates in year 1986, 1991, 1996, 2006, 2010, and 2012. Some of the upturns came roughly before banking crises.

9.3.3 Government Debt

The CGD-to-GDP ratio is adopted as a proxy for annual safe asset supply in the study, and the data set comes from the Global Debt Database (2018) released by the IMF. The Global Debt Database provides the widest coverage in terms of time series of debt starting in 1950 and of sample countries (190 countries). It enables the study to overcome problems arising from data coverage and access to government debt issuance. The data set is unbalanced over the period 1950–2017. Among the 18 sample countries, the time series of debt for Canada (1990),[35] Germany (1961), the United Kingdom (UK) (1974), and the Republic of Korea (1960) are relatively short.

Figure 9.5 summarizes the evolution of the CGD across countries over time intervals. The countries that maintained a lower level of sovereign debt in 2017, compared to the level in 2000, were Belgium (98.2 [2000][36]→77.0 [2007]→88.1 [2017]), Canada (46.3→29.7→39.1), Switzerland (22.7→20.0→14.5), Denmark (53.6→27.1→30.0), Norway (19.0→11.3→15.8), and Sweden (65.5→39.6 (2008)→39.7). The group of countries that saw a big jump in debt by more than 50 percentage points after the crisis were Portugal (66.2 [2007] →131.3 [2016]), Japan (137.3 [2007]→196.7 [2016]), and Spain (29.5 [2007]→87.1 [2015]). By contrast, Switzerland shrunk liabilities by about 5 percentage points over the same period. The Republic of Korea expanded its debt-to-GDP from 17.1% in 2000 to 29.3% in 2006, reducing it slightly in 2007–2008 to 28.2%. After the global financial crisis, the level rose to 39.5% in 2017.

One stylized fact indicates that the government debt-to-GDP generally dropped in the year before the global financial crisis and dramatically inflated after the crisis, although the latter saw some variation by countries. In the case of the 2007–2008 global financial crisis, all 13 countries out of 18 dropped the debt ratio, that is, net government bond issuance relative to GDP, at the lowest point in 2007 or 2008 since

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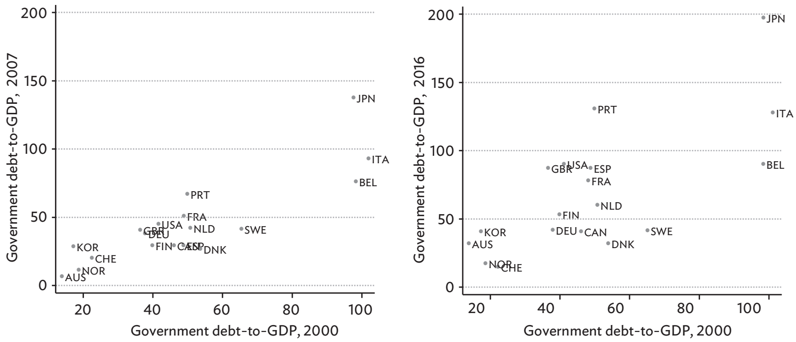
35 This denotes the year that the data run back to.

36 This indicates the year of the record.

Figure 9.5: Government Debt: CGD-to-GDP Ratio



CGD = central government debt, GDP = gross domestic product.

Note: See Appendix List A9.1 List of Economies for abbreviations.

Source: The Global Debt Database, IMF. Author's calculations.

year 2000.[37] Interestingly, a year before some banking crises, the sample average of annual changes in government debt declined, while the old-age dependency ratio jumped. In Figure 9.4(c), this decreased in 1987 (1986),[38] 1996 (1996), 2006 (2006), 2010 (2010), and 2013 (2012), except for a lift in the demand index (old-age dependency ratio) in 1991.

9.3.4 Index-Based Safe Asset Shortage across Countries, 1970–2017

Figure 9.6 provides an overview of the index-based SAS trend across countries over 1970–2017. Certain features emerge. First, out of all the sample countries except for the UK, the SAS index moved up consecutively for a couple of years just ahead of the 2007–2008 global financial crisis. The relatively sharp bounce during this period could be observed in the Scandinavian countries. The SAS index in Norway picked up by 28 percentage points in 2005–2007, Denmark

37 The US, Germany, France, and Japan reduced the level but not much by the scale compared to other countries. The UK did not curtail the level.

38 The year of local peak in the sample average change in the old-age dependency ratio.

by 26 percentage points, and Finland by 18 percentage points. The Netherlands, Switzerland, and Canada experienced a rise in the index by 16 percentage points, 10 percentage points, and 12 percentage points, respectively. The shortage grew modestly in the US by 4 percentage points. By contrast, the UK did not show such a trend. Rather, the index steadily fell over 2004–2015, rebounding only recently.

The second feature is the resurgence of the shortage after the culmination of the deep repercussion of the crisis. A strong upturn in the shortage could be observed in Switzerland, Denmark, Sweden, and the Netherlands. The SAS index of Switzerland revealed a dramatic surge from 2003, reaching the point of 0.58 in 2016, the deepest shortage since 1980. Denmark also recorded the greatest shortage of 0.83 in 2017 since 1980, rebounding from the level of 0.41 in 2011. Sweden and the Netherlands also experienced the most severe safe asset shortages in 2017 over the entire observation period of 1970–2017, with indexes of 0.58 and 0.25, respectively.

Another distinct case is Japan. During the observation period, Japan showed a relatively decreasing trend in the SAS after 1991. The anticipated strong demand pressure for safe assets, coming from steep aging in Japan, looks alleviated by the corresponding huge government debt. The index for the Republic of Korea headed downward from 1996.

A new, interesting finding is that the sample average of annual difference in the SAS index moved cyclically. The safety pressure tends to hike just before crises and dampen after them. I decompose the contribution of demand (aging) and supply (public debt) factors to the sample average change in the safe asset shortage. Figure A9.1 displays the dominant role played by government debt supply over the entire period, specifically up to year 2009, but a closer look also reveals that, at a time of a rise in SAS before crises, the portion of demand side contribution increased. Further, the post-global financial crisis role of aging has been escalating. This necessitates greater attention to demand-side factors in the shortage.

Using the data set from Jordà et al. (2019), I check the correlation among sample average changes in the SAS index and the sample average returns on risky (equities), safe (government bonds) and quasi-private-safe assets (housing). While Jordà et al. (2019) combined housing and equities in a risky asset basket, I split them, defining housing as quasi-private safe assets in terms of stores of values, and whose securities are alternative long-term assets for financial institutions. If SAS is driven by aging-contingent demand, the returns on both government bonds and equities would decrease, as the shift in demands toward safe assets negatively affects (spurs) the prices of equities (bonds). The housing returns increase in the process of interaction between financial institutions and real sectors to narrow the shortage. In the case of a supply shock to the shortage, the association between government bonds and equities returns is not clear-cut. However, the returns on alternative safe assets of housing would still appreciate in the shortage.

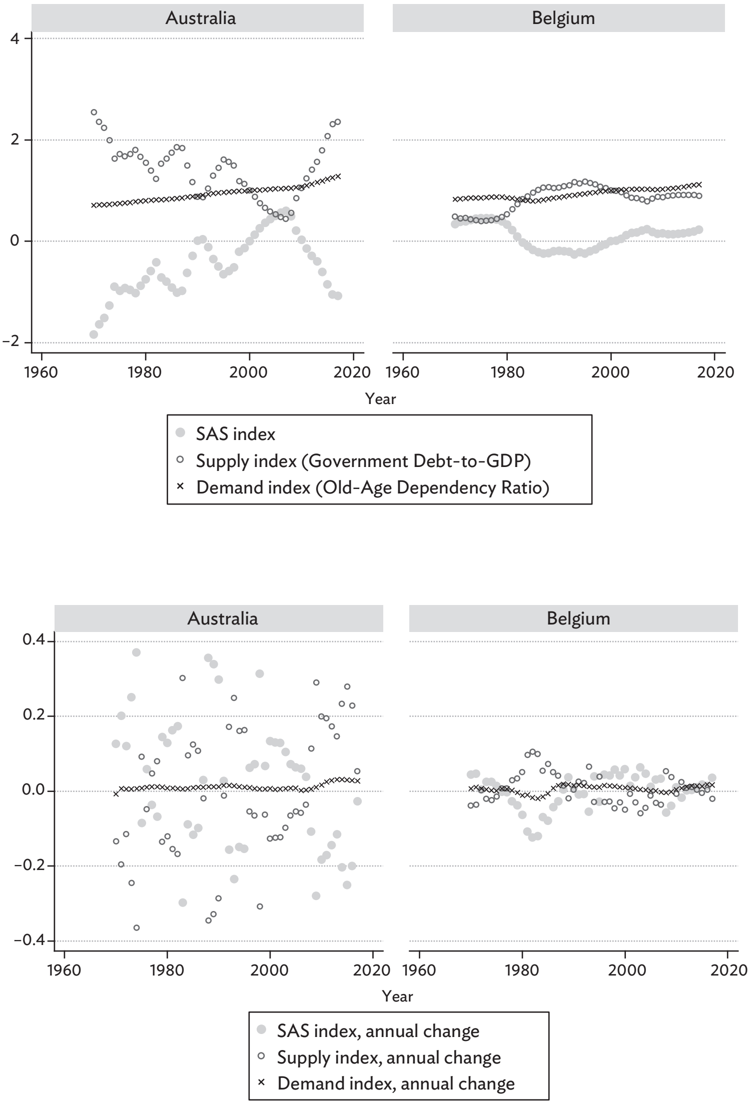
Table A9.2 documents the results for 16 countries[39] in 1970–2015. The sample average returns on bonds correlate positively with the equity returns, but negatively with the housing returns. As expected, the association of annual changes in the SAS index with the returns on bonds and equities is negative, while the shortage changes are positively related to housing returns. This implies that the risk premiums, that is, the spreads between the returns on equities and government bonds, would not get wider in a rise in the SAS since both returns tend to move in same direction to the shortage shock, but the spreads between the returns on housing and government bonds would increase in the shortage. The last three rows of Table A9.2 support this interpretation. The spreads between the returns on equities and bonds co-move negatively with the index in difference, although it is not statistically significant, while the changes in the index are positively and significantly related to risk premiums on housing.

Jordà et al. (2019) doubt the SAS argument based on recent risk premiums at the historical average. The risky assets in this seminal paper include equity and housing whose returns tend to move in opposite directions of the SAS in my exercise, canceling out the risk premiums[40] in 1970–2015. The definition of risky assets and the hypothesis on SASs would affect the debate on risk premiums.

[39] The sample countries are the same as in the List A9.3, excluding Canada and the Republic of Korea.

[40] In Table A9.2, the shortage change is positively correlated with the returns and the premiums on the risky assets, which are composed of both equity and housing, as in Jordà et al. (2019). However, the equity returns alone are negatively associated with the shortage change.

Figure 9.6: Safe Asset Shortage Index, Individual



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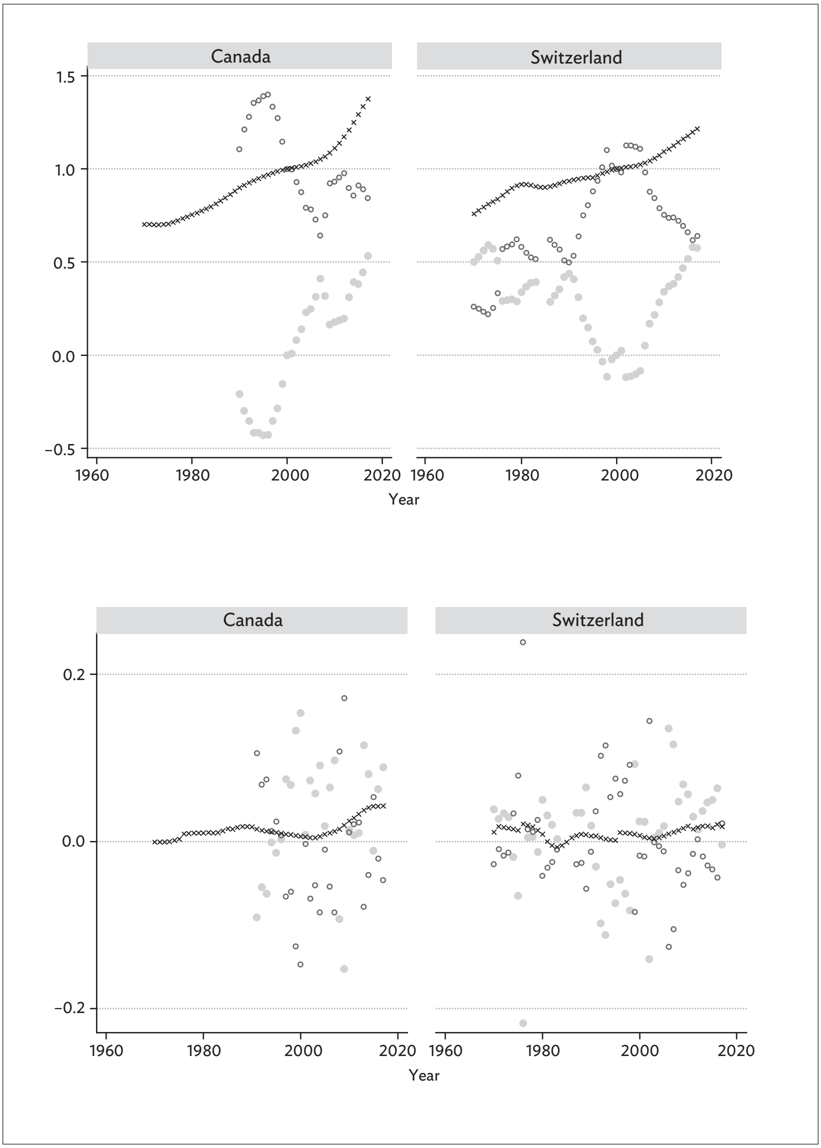

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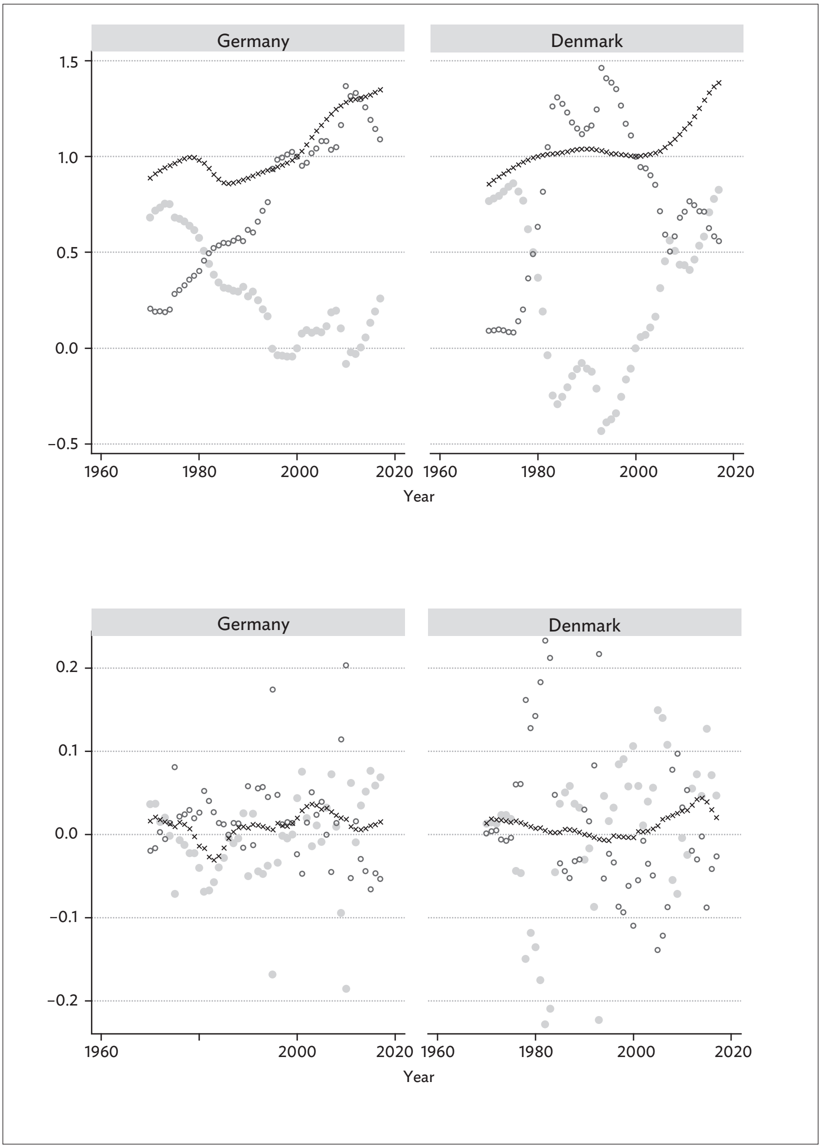

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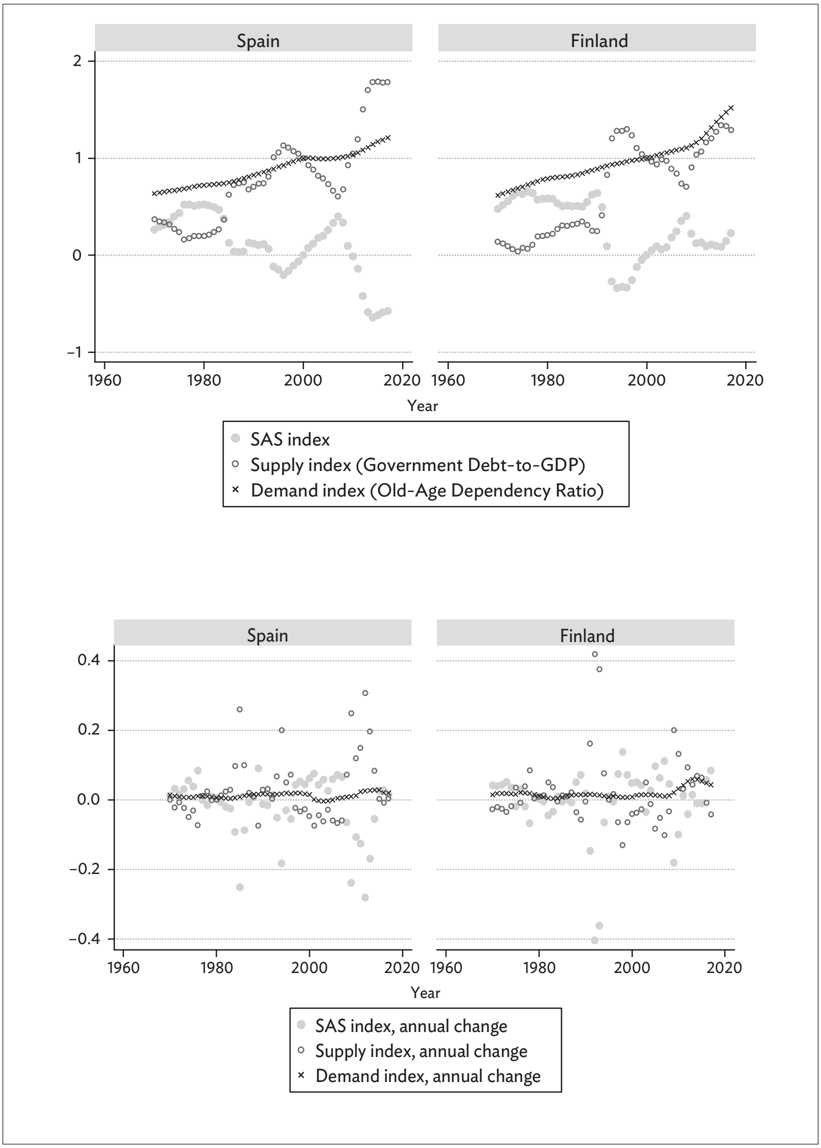

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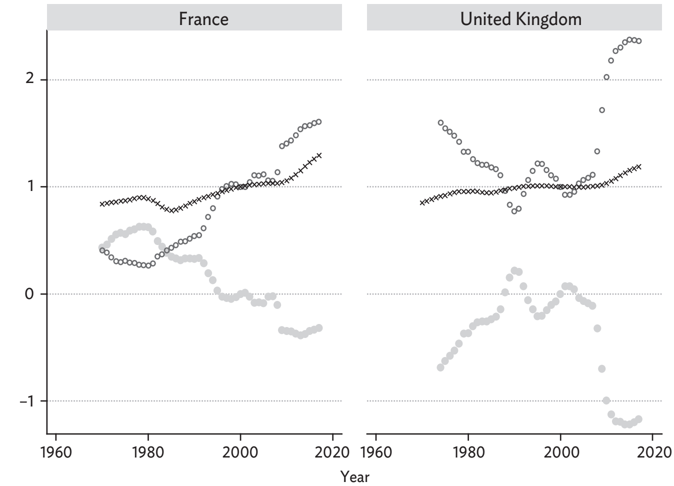

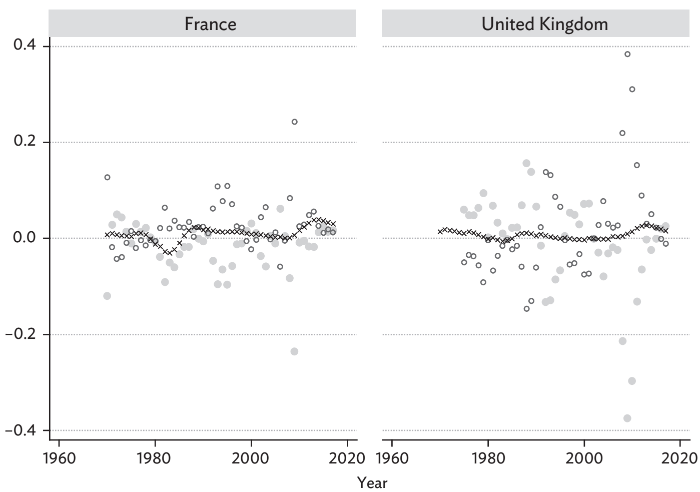

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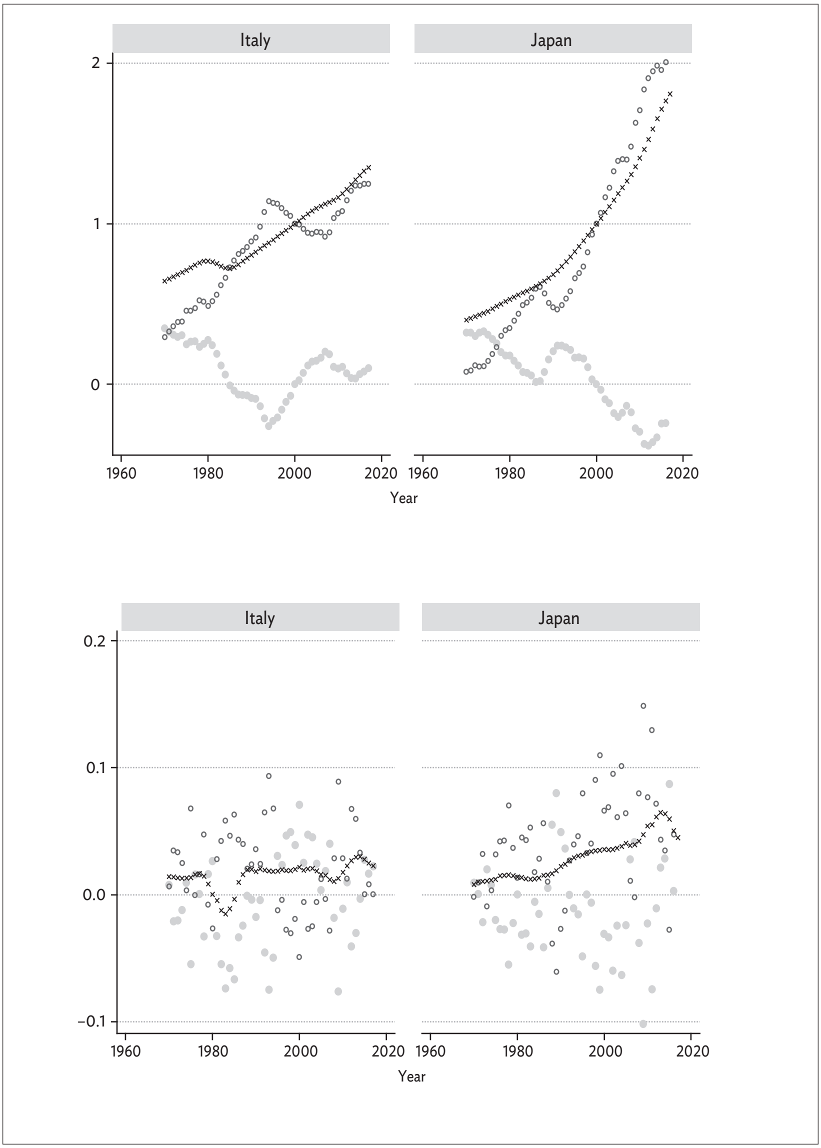

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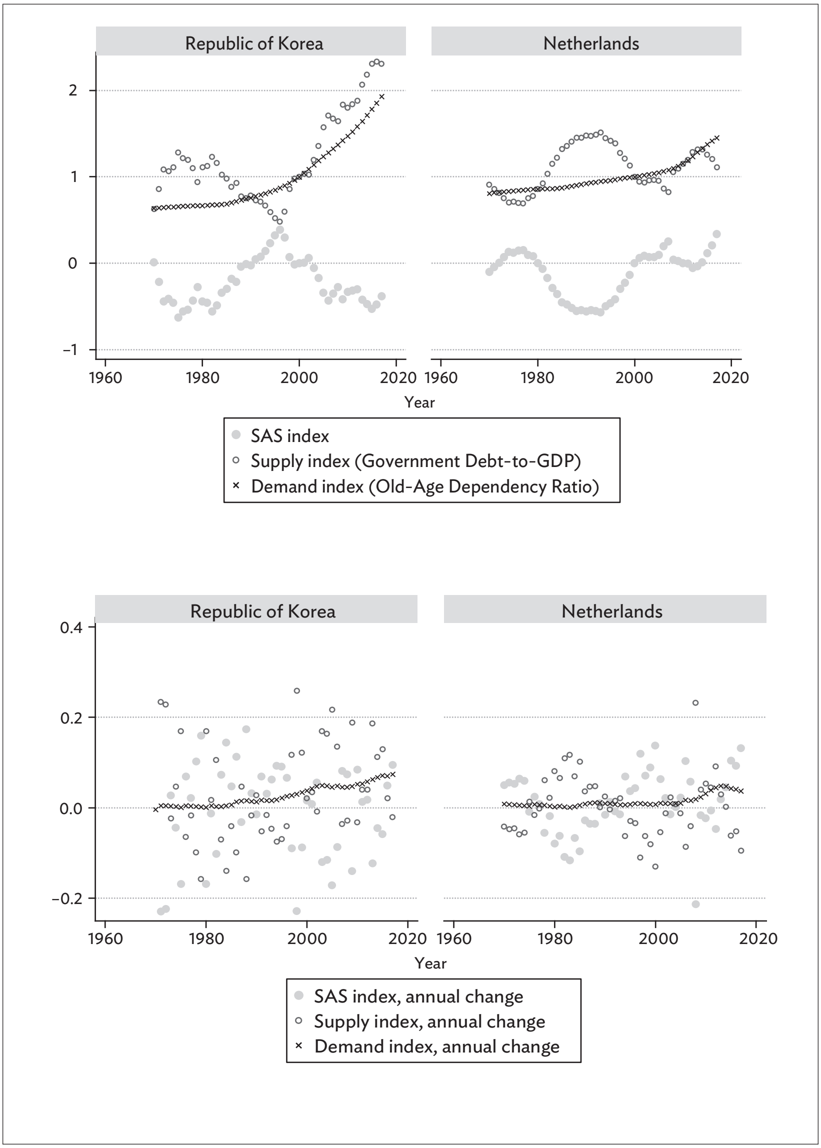

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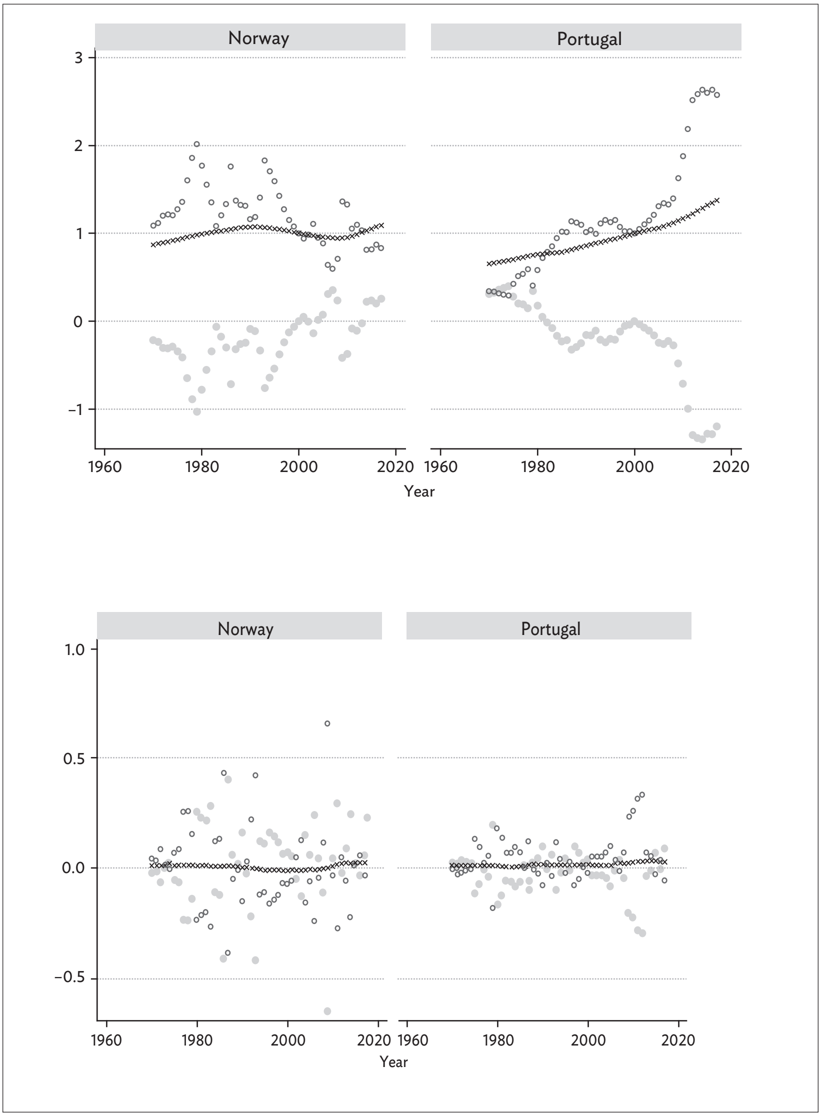

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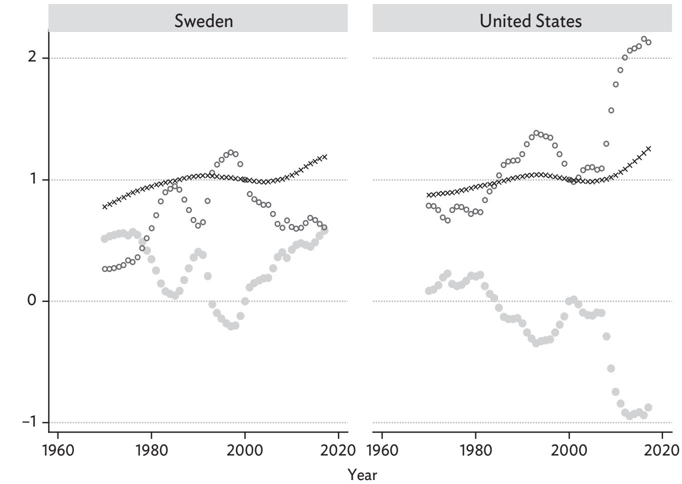

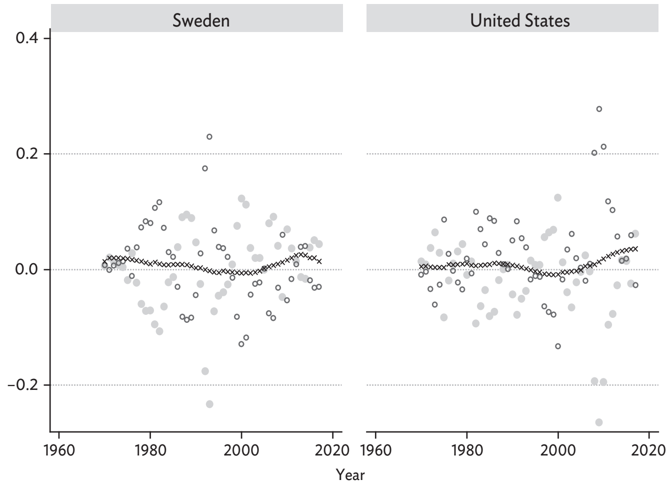

SAS = safe asset shortage, GDP = gross domestic product.

Note: The panel on the left-hand side of the Figure plots the evolution of indices in level (year 2000=1 for supply and demand indices, year 2000=0 for SAS index) while the panel on the right-hand side plots it in terms of yearly difference.

Source: Author's calculations.

9.3.5 Financial Crisis Classification Ability: Safe Asset Shortage Index (1960–2013)[41]

In this section, I assess the power of the SAS index as a crisis predictor in the same empirical model as in Section 9.2. Table 9.3 presents similar results as in Table 9.2. The change in private credit-to-GDP still has a significant impact on the possibility of crises as in Columns (2) and (3), while there is no role of change in the SAS used alone (see Column (1)). Nevertheless, the private credit growth loses power when the model facilitates an interaction between private debt and safe asset shortage.

Table 9.3: Financial Crisis Classification Ability: SAS Index

Classifier Logit Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Change in private credit/GDP (5-year moving average)		34.26*** (9.20)	34.03*** (9.26)	17.18 (13.72)			9.70 (11.36)
Change in SAS index (5-year moving average)	4.96 (3.99)	1.42 (4.12)			−6.83 (4.76)	−3.64 (5.40)	
Lagged level of private credit/GDP				2.11* (1.28)		4.21*** (1.46)	3.63** (1.62)
Lagged level of SAS Index			0.32 (0.77)		0.94 (0.94)		
Interaction term: $c_{i,t-1}^{priv} * sas_{i,t-1}$				0.36 (1.03)			
Interaction term: $c_{i,t-1}^{priv} * \Delta sas_{i,t-1}$					22.56*** (3.86)	18.06*** (3.46)	16.21*** (3.75)
Observations	938	938	950	950	935	935	935
AUROC	0.60 (0.06)	0.74 (0.05)	0.75 (0.05)	0.79 (0.05)	0.85 (0.03)	0.89 (0.03)	0.88 (0.03)

AUROC = area under the receiver operating characteristic curve, SAS = safe asset shortage, GDP = gross domestic product.

Note: Standard errors are in parentheses. *p<0.10, **p<0.05, ***p<0.01.

Source: Author's estimation.

41 I used the same time range of the SAS index from 1960–2013 despite some missing data points in government debt, for instance, for Canada, for a better comparison with the former exercises in Tables 9.1 and 9.2.

The AUROCs in Specifications (2) and (3) are clearly lower than in Columns (6) and (7), where the lagged private credit-to-GDP level and the interaction term of the lagged level of private credit as well as the lagged change in the SAS index are added. Specifications (6) and (7) show that in the presence of the two former terms, neither private credit growth nor the change in the SAS index provides any information on future financial turbulence. Instead, the (high) level of private credit associated with a (positive) change in the SAS index demonstrates significant power to detect a financial vulnerability. The coefficient estimates for the interaction term of lagged difference of the SAS index and the lagged level of private credit-to-GDP are statistically significant (see Columns (6) and (7)). The AUROC value for each specification is 0.89 (SE. 0.03) and 0.88 (SE. 0.03), respectively, exhibiting the strong crisis forecasting power of the models. Both are significantly different from the AUROC=0.54 (SE. 0.03) for the null reference model with only a country-fixed effect as a control variable.

The key finding in this exercise is two-fold. First, the test result offers empirical support for the interaction between the SAS and private credits as a useful financial risk predictor. Second, it is not the level of the shortage but its change that destabilizes the financial system via private credit channels.

9.4 Empirical Model and Analysis

9.4.1 Empirical Model

This section studies the causality effect of safe asset shortages on private credit expansion as part of an extended econometric model. In doing so, it focuses on the contribution of safe asset shortages to boosting the risky upturn of private credits. For this purpose, the chapter sets up the fixed-effects panel models of Equations (8) and (9) with unobserved country-specific (α_i) and time-fixed effects (τ_t). The securitization term ($secu_{i,t}$) explains the role of banks in producing quasi-private safe assets that foster private credit growth. The interaction term of lagged securitization growth and lagged yearly change in the SAS index measures the causality effect of an increase in securitization in the presence of a safe asset shortage, that is, the potential role of banks in filling the gap between supply and demand for safe assets.

Equation (8) is for the closed version of the economy that does not consider cross-country capital flows. All variables are in real terms, where subscripts (i) and (t) denote countries and years, respectively.

$$\Delta credit_{i,t} = \alpha_i + \tau_t + \beta_1 \Delta sas_{i,t-1} + \beta_2 \Delta secu_{i,t-1} + \beta_3 iy_{i,t-1} + \beta_4 \Delta gdp3_{i,t} + \beta_5 stir_{i,t-1} + \delta_1 \Delta secu_{i,t-1} \times \Delta sas_{i,t-1} + \beta_6 lgdppc_{i,t-1} + \varepsilon_{i,t} \quad (8)$$

$$\Delta credit_{i,t} = \alpha_i + \tau_t + \beta_1 \Delta sas_{i,t-1} + \beta_2 \Delta secu_{i,t-1} + \beta_3 iy_{i,t-1} + \beta_4 \Delta gdp3_{i,t} + \beta_5 stir_{i,t-1} + \delta_1 \Delta secu_{i,t-1} \times \Delta sas_{i,t-1} + \beta_6 lgdppc_{i,t-1} + \beta_7 \Delta niip^*_{i,t-1} + \delta_2 \Delta niip^*_{i,t-1} \times \Delta sas_{i,t-1} + \varepsilon_{i,t} \quad (9)$$

The dependent variable $\Delta credit_{i,t}$ is the annual growth rate of bank credit to private non-financial sectors, for which data come from the Bank for International Settlements database. The SAS index in difference, the main explanatory variable of interest, is introduced as a 1-year lagged term to measure the causality effect of the shortage on credit growth. In the same account, a variable for securitization growth is also employed in a lagged form. Adding an interaction term of the lagged change in the SAS index and securitization growth, the model examines if the SAS affects private credit growth via securitization. Other control variables include the lagged investment-to-GDP ($iy_{i,t-1}$) ratio, the 3-year moving average of GDP growth ($\Delta gdp3_{i,t}$), lagged short-term interest rates and lagged GDP per capita level in local currency, as generally employed in studies on credit growth.

Augmented by the term of net international investment position from the IMF database, Equation (9) measures the effect of an SAS on credit growth in the presence of cross-border investment. For this purpose, the lagged yearly difference in the net international investment position-to-GDP ratio ($\Delta niip^*_{i,t-1}$) is introduced. The positive net investment position in difference indicates a rise in net capital outflows, which I assume would subdue the risk of excessive credit boom in a domestic economy. Employing the interaction term of the lagged change in the net international investment position-to-GDP ratio and the lagged change in the SAS index ($\Delta niip^*_{i,t-1} \times \Delta sas_{i,t-1}$), the model evaluates the extent to which this effect determines the total effect of an SAS on domestic credit growth.

9.4.2 Estimation Results (1980–2016)

The data cover 18 developed economies[42] (see List A9.3) in annual observations from 1980 to 2016. Table 9.4 summarizes the main empirical

42 The Republic of Korea is added to the sample countries of 17 used for the previous estimations.

Table 9.4: Main Results

Bank credit growth ($\Delta credit_{i,t}$)	(1)	(2)	(3)	(4)	(5)	(6)
L(1) diff. safe asset shortage index ($\Delta sas_{i,t-1}$)	0.173*** (0.031)	0.108*** (0.030)	0.134*** (0.043)	0.152*** (0.043)	0.158*** (0.044)	0.160*** (0.044)
L(1) securitization growth ($\Delta secu_{i,t-1}$)			0.000 (0.005)	0.004 (0.005)	0.005 (0.005)	0.005 (0.005)
Interaction term: $\Delta secu_{i,t-1} \times \Delta sas_{i,t-1}$				0.090* (0.010)	0.087* (0.010)	0.122** (0.052)
L(1) investment/gdp ($iy_{i,t-1}$)		0.308** (0.134)	0.906*** (0.047)	0.914*** (0.211)	0.872*** (0.217)	0.863*** (0.215)
gdp growth ($\Delta gdp3_{i,t}$)		0.791*** (0.210)	0.573* (0.310)	0.620** (0.313)	0.646** (0.318)	0.590* (0.317)
L(1) short-term interest rates ($stir_{i,t-1}$)		−0.003 (0.003)	−0.006 (0.005)	−0.006 (0.005)	−0.006 (0.005)	−0.006 (0.005)
L(1)gdp per capita (log) ($gdppc_{i,t-1}$)		0.099 (0.061)	0.008 (0.072)	0.009 (0.070)	0.016 (0.071)	0.020 (0.070)
L(1)change in net int'l investment position/gdp ($\Delta niip^*_{i,t-1}$)					−0.016 (0.045)	−0.068 (0.053)
Interaction term: ($\Delta niip^*_{i,t-1} \times \Delta sas_{i,t-1}$)						−0.568* (0.320)
Nr. countries/observations	18/306	18/288	14/177	14/177	14/172	14/172
R-squared	0.369	0.390	0.486	0.496	0.511	0.524

Note: Standard errors are in parentheses. *p<0.10, **p<0.05, ***p<0.01. The dependent variable is the annual growth of bank credits to the private non-banking sector.

Source: Author.

outcomes. First, the SAS substantially drives the growth of bank credits. Across all variations of the model, the contribution of a SAS is robust and statistically significant.

Specification (4) in a closed economy framework indicates that a 1 percentage point lift in SAS growth stimulates a growth of bank credits by 0.15 percentage points in the following year. The securitization variable alone does not account for credit growth, but its role turns out to be substantial and statistically significant in an interaction with the lagged change in the SAS index. Once the SAS has intensified, the securitization expands credit volumes. A 1 percentage point increase in securitization growth, associated with an increasing asset shortage, raises credit growth by 0.09 percentage points. One caveat of this exercise is that the securitization issuance data set from the Association for Financial Markets in Europe database is short, available from 1999 and unbalanced across sample countries. This is why the number of countries and observations shrink in Columns (3) to (6).

As expected, physical investment and economic growth are strong predictors of credit expansion, with a 1 percentage point increase in each variable inflating the credit growth by 0.91 percentage points and 0.62 percentage points, respectively. A rise in short-term interest rates tends to subdue the credit volume but the coefficient is not statistically significant. The per capita GDP, a proxy for the level of economic advancement, is statistically irrelevant in the sample analysis.

The estimation outcome of Equation (9) with cross-border capital flows shows that the coefficient of the variable for the change in net capital outflows displays a negative sign. While the estimate would partially signal that increasing capital outflows reduces the domestic credit boom, it does not have a statistically significant meaning in Column (5). The interaction term, however, makes a surprising difference. Specification (6) reports that an increase in net capital outflows (1 percentage point) at an increasing SAS significantly restrains domestic credit expansion (by 0.57 percentage points), which is comparable to the magnitude of the GDP growth. Investment and GDP growth are still key drivers of credit growth in the open economy. A 1 percentage point rise in the growth of the shortage inflates domestic credit growth by 0.16 percentage points. The role of securitization has strengthened. A 1 percentage point rise in securitization growth in response to a rise in the shortage boosts credit growth by 0.12 percentage points.

The total effect of a SAS on private credit expansion depends on the interaction with securitization growth and capital outflows. The latter effect is considerably dominant. Net capital (in)outflows could significantly (intensify) mitigate the potential financial risk coming from the shortage-induced domestic credit expansion.

9.5 Conclusion and Policy Implications

An SAS contributes to a build-up of financial risks by driving private credit growth. Through employing the newly constructed SAS index, I have demonstrated that shortage-induced private credit expansion is the key crisis predictor. Neither the SAS index nor private credit growth provides better information when used alone in the crisis classification model. But, the study has found that when the two variables are combined in an interaction term, private credit booms that are in response to a surge in SAS reveal strong power to warn of financial crises in developed economies in the period 1960–2013. The chapter has also confirmed economically a significant, positive causal effect of an SAS on a domestic credit boom. The total effect of the shortage is positively associated with securitization growth and negatively with net capital outflows. An increase in net outflows at a time of rising shortage reduces domestic credit growth to the extent that it could make the total effect of the shortage on credit growth negative. From this result, we can infer that capital flows may have played a significant role in determining the (de)leverage position of the domestic financial system. However, this study has not examined the externality of net capital flows in the presence of the shortage at home and abroad. This remains an issue for further research.

The findings of the chapter have important policy implications. The timing of counter-cyclical fiscal policy and its magnitude matter for financial stability, specifically when policy causes a sudden drop in the net government bond issuance facing a high retirement wave. Such a deep shock to the shortage could evoke bubbly credit booms. From the view of SAS-financial instability, fiscal and macroprudential policies need to be coordinated, minimizing a fiscal shock to the financial market, and carefully monitoring the scale of new retirees or soon-to-be retirees, associated with its shock to a portfolio rebalance of an economy.

Second, a proper response to capital flows is crucial. A real challenge comes when the SAS is a global or a regional phenomenon. A couple of Asian economies have recently become exposed to an unprecedented deep aging shock (see Figure A9.3). As fiscal and monetary policies have gotten more synchronized across countries, most economies could face a negative mega-global or regional shock to safe asset supply at a time of a major influx of new retirees. In such cases, the solid macroprudential measures of one country might exacerbate a financial risk in others via capital flows. Under this condition, where should the shortage-induced capital flows go? International cooperation for financial stability may need to pay due attention to a new way of managing a safe asset supply and the externality of macroprudential policy, tracking the evolution of an individual SAS in either the global or the regional context. Central banks would find their role in more active, proper asset management via their balance sheets.

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Appendix 9.1

List A9.1 List of Economies

Argentina (ARG); Australia (AUS); Austria (AUT); Belgium (BEL); Brazil (BRA); Canada (CAN); Czech Republic (CZE); Denmark (DNK); Finland (FIN); France (FRA); Germany (DEU); Greece (GRC); Hong Kong, China (HKG); Hungary (HUN); India (IND); Indonesia (IDN); Ireland (IRL); Italy (ITA); Japan (JPN); Luxembourg (LUX); Malaysia (MYS); Mexico (MEX); Netherlands (NLD); Norway (NOR); People's Republic of China (PRC); Poland (POL); Portugal (PRT); Republic of Korea (KOR); Russian Federation (RUS); Singapore (SIN); South Africa (ZAF); Spain (ESP); Sweden (SWE); Switzerland (CHE); Thailand (THA); Turkey (TUR); United Kingdom (GBR); and United States (USA)

List A9.2 Country List (17) and Systemic Banking Crises, 1960–2013

AUS: 1989; BEL: 2008; CAN; CHE: 1991, 2008; DEU: 2008; DNK: 1987, 2008; ESP: 1977, 2008; FIN: 1991; FRA: 2008; GBR: 1974, 1991, 2007; ITA: 1990, 2008; JPN: 1997; NLD: 2008; NOR: 1988; PRT: 2008; SWE: 1991, 2008; USA: 1984, 2007

Note: Systemic Banking Crises Classification and Records from http://www.macrohistory.net/data/.

List A9.3 Country List (18)

AUS, BEL, CAN, CHE, DEU, DNK, ESP, FIN, FRA, GBR, ITA, JPN, KOR*, NLD, NOR, PRT, SWE, USA

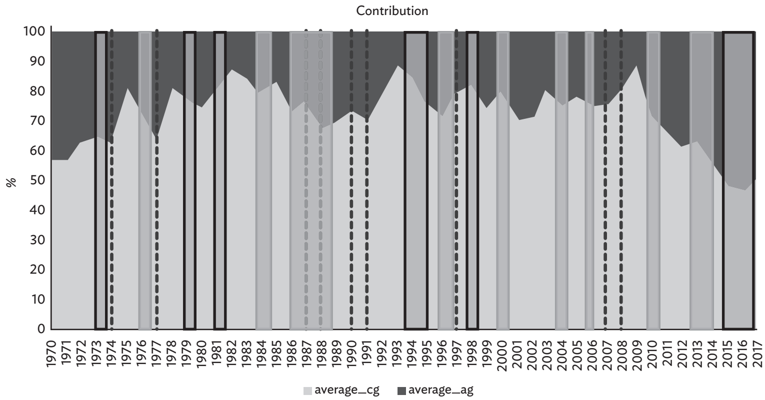
Note: *The fixed-effects panel analysis includes the Republic of Korea.

Table A9.1: Data Source

Variable		Source
(Crisis Probabilistic Model)	Data for Tables 1, 2, and 3 (1960–2013)	
Central government debt	Global Debt Database	IMF
Old-age dependency ratio	UN World Population Prospects	UN World Population Prospects
Other variables	Jordà, Schularick, and Taylor (2017)	www.marohistory.net/data#DownloadDate
(Fixed-Effects Panel Model)	Data for Table 4 (1980–2016)	
Dependent Variable		
Private credit growth: ($\Delta credit_{i,t}$) annual growth of bank credit to private nonfinancial sector	Bank credit to private non-financial sector, local currency	BIS
Explanatory Variables		
Change in SAS index: ($\Delta sas_{i,t}$)		Autor's calculation
Securitization growth: ($\Delta secu_{i,t}$)	Unbalanced. Converted into local currency, using year-end average US exchange rates from the BIS.	Association for Financial Markets in Europe
NIIP-to-GDP change: ($\Delta niip^{*}_{i,t}$)	Unbalanced. Net International Investment Position, converted into local currency, using year-end average US-exchange rates from the BIS. GDP in local currency.	International Financial Statistics, IMF
Other Control Variables		
GDP growth (previous 3-year moving average), Investment-to-GDP ratio, Short-term interest rates, Per capita GDP (in log), CPI	For sample countries (excl. Republic of Korea): Jordà, Schularick, and Taylor (2017)	www.marohistory.net/data#DownloadDate
	For the Republic of Korea, all corresponding data compiled.	IMF

CPI = consumer price index, GDP = gross domestic product, IMF = International Monetary Fund, BIS = Bank for International Settlements, NIIP = net international investment position, UN = United Nations.

Figure A9.1: Contribution of Demand and Supply Factors to Annual Change in the SAS

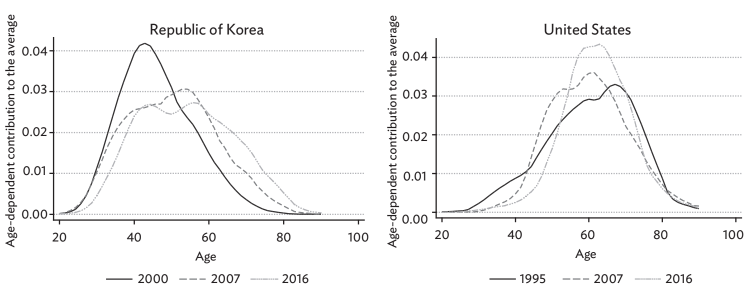


SAS = safe asset shortage.

Note: The black (light gray) shaded area represents the contribution of sample average change in demand (supply) side to the sample average change in the SAS index. Dotted lines denote the year of banking crises of 18 countries. The boxes show the years in which safe asset shortages deepened. Among them, the black-bordered boxes indicate the year for a dual drop in demand and supply sides, where a drop in government debt dominated. The gray-bordered boxes boxes mark the year the safe asset shortages deepened, but in such cases the demand side of the sample average ratio of the retiree population increased while the supply of the net government securities declined.

Source: Author's calculation.

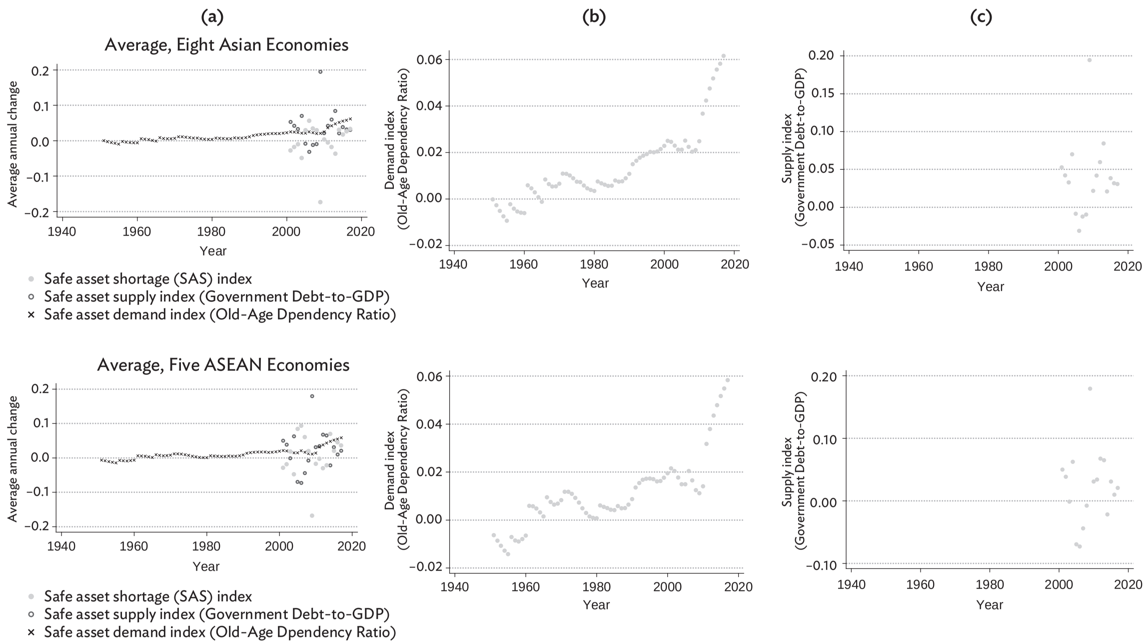
Figure A9.2: Age-Dependent Contribution to the Weighted Average of Total Financial Wealth



Note: The distribution is normalized by the weighted average of total financial wealth.

Source: Author's calculation.

Figure A9.3: Safe Asset Shortage Index in Difference (Average across Countries)



GDP = gross domestic product.

Note: The graphs in the first row summarize the analysis of eight Asian economies (Hong Kong, China; Indonesia; Japan; Malaysia; the People's Republic of China; the Republic of Korea; Singapore; and Thailand; see Appendix List A9.1 List of Economies for abbreviations), while the graphs in the second row present that of the subgroup of five Association of Southeast Asian Nations (ASEAN) countries (excluding Japan, the People's Republic of China, and the Republic of Korea). Panel (a) is the sample average annual difference of the SAS index in 2000–2017. Panel (b) is the sample average annual change of the old-age dependency index in 1950–2017, while Panel (c) that of central government debt index in 2000–2017. General government debt data are used for the People's Republic of China.

Source: Author's calculation.

Figure A9.4: Safe Asset Shortage Index, Individual (Asian Economies)

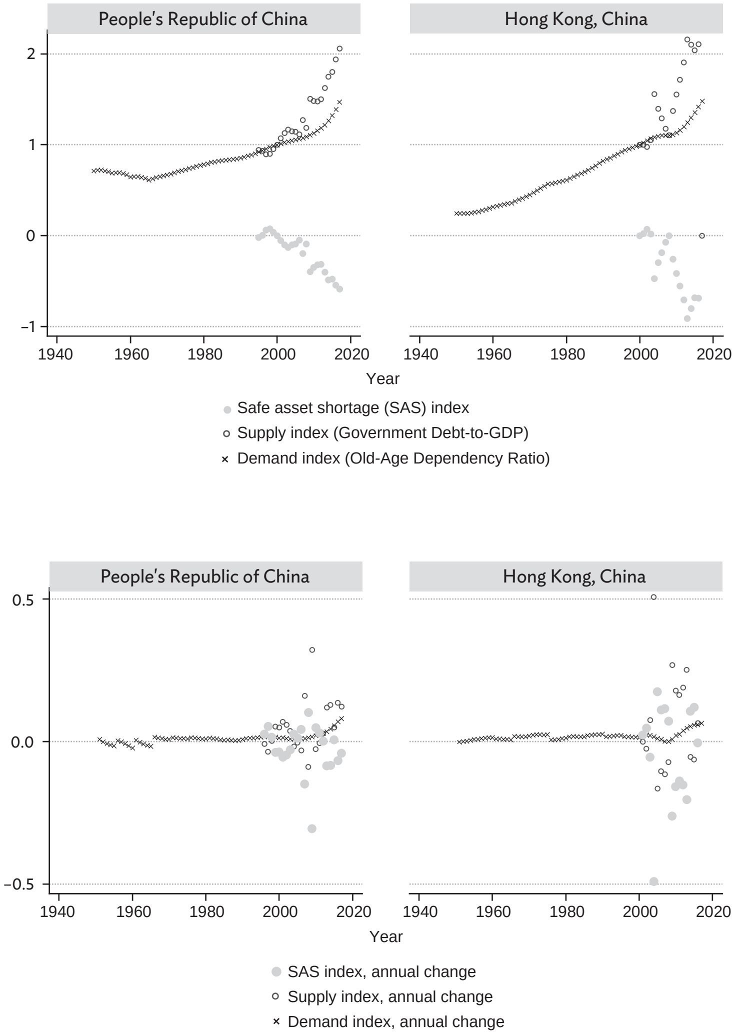


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Figure A9.4 *continued*

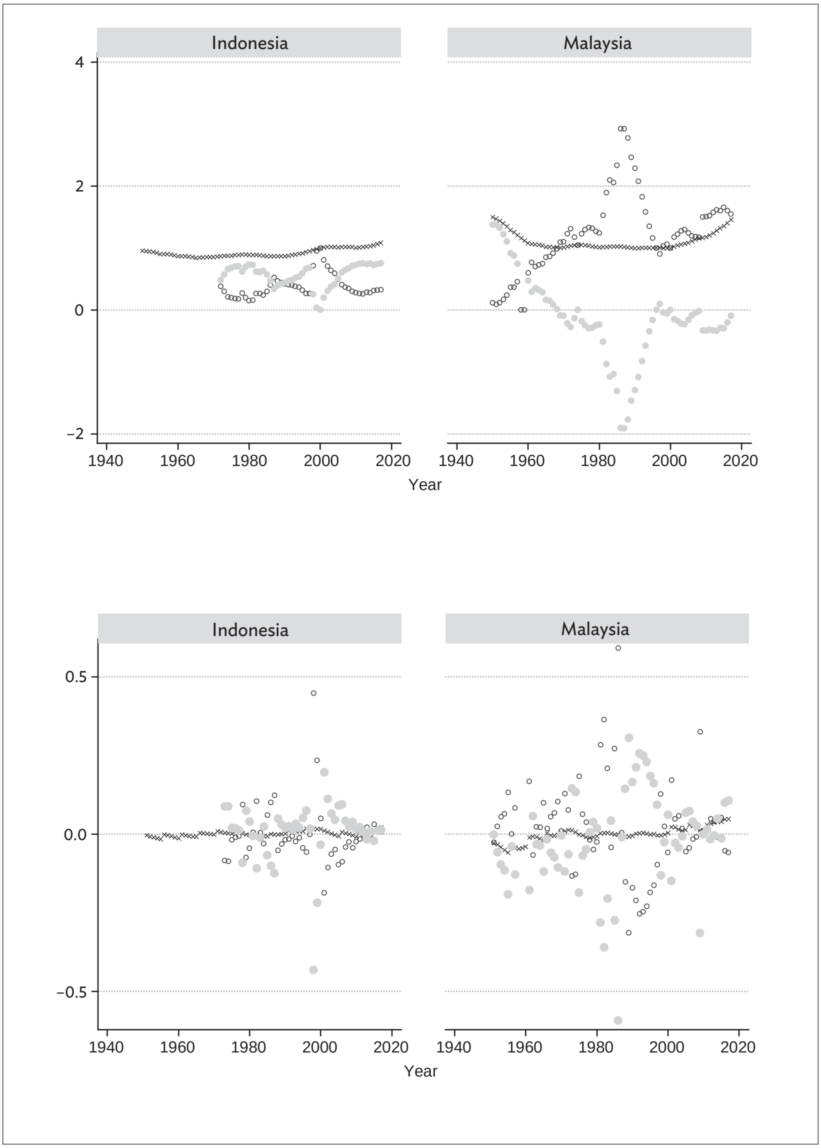

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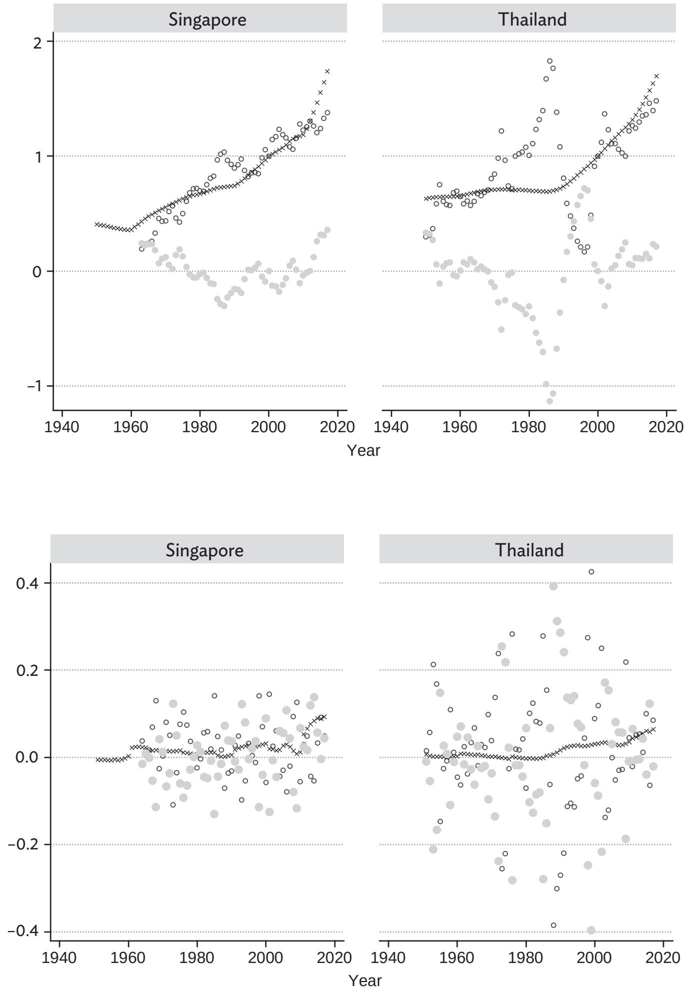
Figure A9.4 *continued*



SAS = safe asset shortage, GDP = gross domestic product.

Note: The graphs on the first row show the evolution of indices in level, while the graphs on the second row plot it in terms of yearly difference. As for the range of time series of each index, refer to the note in Figure A9.3.

Source: Author's calculation.

Table A9.2: Sample Average Return Correlation (16 Countries, 1970–2015)

	Bond	Equity	Housing	Risky Asset	Safe Asset	SAS Index
Bond	1					
Equity	0.230* (0.0000)	1				
Housing	−0.154* (0.0000)	0.174* (0.000)	1			
Risky Asset	0.004 (0.9076)	0.812* (0.0000)	0.622* (0.0000)	1		
Safe Asset	0.967* (0.0000)	0.270* (0.0001)	−0.078* (0.0296)	0.063 (0.078)	1	
SAS index	−0.286* (0.0000)	−0.141* (0.0001)	0.698* (0.0000)	0.289* (0.0000)	−0.253* (0.0000)	1
R.P. Equity (the spreads between returns on equity and bond)						−0.024 (0.5174)
R.P. Housing (the spreads between returns on housing and bond)						0.521* (0.0000)
R.P. Risky (the spreads between returns on risky assets and safe assets, defined in Jordà et al. [2019])						0.397* (0.0000)

SAS = safe asset shortage.

Note: * Indicates significance at 5% level. Data, except for SAS index, from JSTdatasetR4 (Release 4 May, 2019) and Jordà et al. (2019). All variables are real terms. R.P. denotes risk premium, and bonds in the analysis are government bonds. The SAS index is used in annual difference. The sample countries are the same as in List A9.3, excluding Canada and the Republic of Korea.

Source: Author's calculation.

10

Rationales for the Use of Capital Flow Management Measures since the Global Financial Crisis

Mitali Das and Evgenia Pugacheva[1]

10.1 Introduction

This chapter presents an initial set of stylized facts and empirical evidence on the incidence of capital controls (now increasingly referred to as "capital flow management measures" or CFMs) and the factors that motivate their use.[2] Our study is focused on the experience of 11 developed and emerging markets in the Asia and Pacific region. This study is facilitated by a new dataset that records high-frequency changes to capital account policies (Binici, Das, and Pugacheva 2020). The underlying data for Binici, Das, and Pugacheva come from the International Monetary Fund's (IMF) new *Taxonomy of Capital Flow Management Measures* (henceforth Taxonomy), which is a textual repository of all changes since 2008 to capital account restrictions that the IMF classifies as a CFM.

The years since the global financial crisis have seen a significant use of CFMs. Between 2008 and 2019, over 40 countries adjusted restrictions on

1 The views expressed in this chapter are purely those of the authors and do not necessarily represent those of the International Monetary Fund (IMF), its Executive Board, IMF management, or IMF policy.

2 As defined by the International Monetary Fund, capital flow management measures include capital controls and any other capital account restrictions on cross-border financial transactions that discriminate by residency, as well as prudential measures that do not discriminate by residency but nevertheless limit capital flows (IMF 2012).

their capital account policies in the face of the inflow or outflow of foreign capital. The rationales offered for the use of CFMs during these episodes ranged from domestic overheating, to the loss of competitiveness and threats to their export sector, financial stability risks, balance of payment pressures, and a desire to curtail hot money flows. In parallel with these developments, there has been a renewed debate on the benefits and costs of the free flow of cross-border capital. The question of whether CFMs have a role in policymakers' toolkits to address the scale or volatility of capital flows has become a central issue in international fora, as well as the subject of numerous Group of 20 communiques since 2011. There are three potentially interrelated reasons for the renewed interest.

First, in the years immediately following the global financial crisis there was a tremendous surge of foreign capital from developed to emerging markets. The causes of these flows have been discussed extensively,[3] and were linked to a multitude of factors including the relatively advanced cyclical positions of emerging markets, the improved risk-return tradeoffs amid a decisive re-rating of emerging markets' fundamentals and policy frameworks, and favorable interest rate differentials due to the unconventional monetary policies in developed economies. These factors prompted large flows of capital to emerging market equity and bond markets and their banking sectors. Capital flows were also spurred by the ongoing and rapid improvements in fintech, which facilitated cheaper, faster, and more decentralized means of transmitting capital across borders (Adrian and Mancini-Griffoli 2019).

Official statements of policy makers during these episodes clearly highlight their concerns about the scale and volatility of these capital flows. Guido Mantega, then Minister of Finance in Brazil, stated in September 2010: "We are in the midst of an international currency war. This threatens us because it takes away our competitiveness." (Financial Times 2020). Echoing these sentiments, then President of Brazil Dilma Rousseff noted in March 2012 that richer nations of the world were unleashing a "tsunami" of capital flows that forced countries such as Brazil to limit their impact on local industries (Soto and Pariz 2012). Raghuram Rajan, then Governor of the Reserve Bank of India, warned in August 2014 of the risk of "a global market crash" when investors began to pull out of risky assets created by the monetary policies of developed economies (Times of India 2014).

Second, faced with questions about managing capital flows in the aftermath of the global financial crisis from countries in its membership,

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3 See, e.g., IMF (2010, 2012), Eichengreen and Rose (2014), Alfaro, Chari, and Manczuk (2017), Forbes, Fratzscher, and Straub (2015), Fratzscher (2014).

the IMF softened its decades-old position on the benefits of free capital mobility. In 2012, the IMF declared that, "for countries that have to manage the risks associated with inflow surges or disruptive outflows, a key role needs to be played by macroeconomic policies, as well as by sound financial supervision and regulation, and strong institutions. In certain circumstances, CFMs can be useful. They should not, however, substitute for warranted macroeconomic adjustment" (IMF 2012). The change in the IMF's position, viewed by some as a qualified endorsement of the use of capital controls, was a significant impetus in bringing the discussion of them back into the spotlight.

Third, in parallel with the IMF's work, a new body of academic research began to assess the role of CFMs—as well as broader prudential measures that were domestically oriented but, by their design, could limit capital flows—as a potential policy response to the surge or flight of capital when conventional macroeconomic or financial stabilization policies are unavailable.[4] This body of work advanced CFMs as a second-best welfare improving policy option when distortions in the economy made conventional first-best policies unavailable. Such distortions could reflect price inertia and downward nominal wage rigidity that result in large gains in real wages during the upswing of capital flows but result in employment losses when foreign capital recedes (see, e.g., Schmitt-Grohe and Uribe 2012; Farhi and Werning 2012); imperfect cross-border risk-sharing that results in large output fluctuations and large swings in terms of trade (e.g., de Paoli and Lipinska 2013); and inadequate financial sector regulation (e.g., Bianchi and Mendoza 2010; Korinek 2018). This influential body of academic work may have at least indirectly lent support to their use among emerging market policy makers (Eichengreen and Rose 2014).

The interest from policy makers, international institutions, and academics alike suggests that continued examination of CFMs and the factors that motivate their use remains a worthwhile endeavor. In this context, the Asia and Pacific region is an interesting region to consider because it consists of a large number of both developed and emerging markets, which have recalibrated their capital account policies—although with significant variation across countries—since the global financial crisis.

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[4] See Eichengreen and Rose (2014) for a summary of using CFMs as a second-best alternative to monetary, fiscal, and financial policies (e.g., Bianchi and Mendoza 2010; Jeanne and Korinek 2010; Schmitt-Grohe and Uribe 2012; Farhi and Werning 2012; Forbes, Fratzscher, and Straub 2015; Korinek 2018).

Moreover, the nature of capital account restrictions in these countries, with regard to whether they are focused on capital inflows or outflows, whether they are targeted to the equity market, bond market, or housing sector, and the duration of time for which the measures are kept in place provide for a rich differentiation across countries and over time in empirical analysis. Countries in this region differ significantly in their historical usage of capital controls and the overall openness of their economies. In some, the use of CFMs has been significant as an active tool of stabilization policies, while in others their use has been more episodic.

Our work complements an earlier literature that has analyzed the factors that determine the probability of implementing a CFM. Alesina, Grilli, and Milesi-Ferretti (1993), Berger, Sturm, and de Haan (2001) and Hagen and Zhou (2005) find that capital controls are more likely to be imposed when the exchange rate is either a peg or managed. Grilli and Milesi-Ferretti (1995) find a positive association between capital controls and countries with large governments, i.e., those where the central bank is less independent. Capital controls are also found to be more likely used by governments that repress the financial sector, as well as those that are facing balance-of-payment crises (Leblang 1997) and those at intermediate development levels (Alfaro 2004). In discriminating between various objectives of CFMs, Aizenman and Pasricha (2013) find that overheating and foreign exchange valuation concerns lead to tightening capital controls. Fratzscher (2014) finds evidence indicating that they are driven primarily by appreciation of the real exchange rate.

The main innovation of our chapter from the earlier research is the use of a unique and high-frequency dataset on CFMs rather than annual measures of capital account openness, which can remain static even when there are significant within-year changes in CFMs (see Binici et al. 2020). Furthermore, we cover nearly 10 years after the global financial crisis, extending the time period of analysis several years beyond that in other recent papers, thus capturing many changes in the global financial cycle. Using data on CFMs at monthly frequency permits us to relate economic and financial developments at business cycle frequency to the recalibration of CFMs.

The rest of the chapter is organized as follows. In Section 10.2, we describe the data used in the study along with stylized facts about the incidence of CFMs in our sample. Section 10.3 presents the different motivations for using CFMs that have been discussed in the literature. In Section 10.4, we describe our empirical strategy and discuss the quantitative evidence. Section 10.5 concludes.

10.2 Data and Stylized Facts

This section describes the data used in the study and provides a detailed set of stylized facts about the incidence of CFMs in the countries analyzed.

10.2.1 Data on CFMs

The primary dataset on CFMs used in this study is Binici, Das, and Pugacheva (2020). This database draws primarily from the Taxonomy, which is a *textual* repository of the changes to capital account policies undertaken by the IMF member countries since 2008. Binici et al. compile a quantitative database from the Taxonomy, recording the introduction of new measures, the removal of existing measures, the tightening or loosening of existing measures, as well as changes to the enforcement of any measures. The country coverage in their database is 44 economies that have recalibrated their CFMs between the first quarter of 2008 and the third quarter of 2019. Our analysis is based on the 11 economies in the Asia and Pacific region in their data, which includes six developed economies and five emerging and developing markets. The list of economies is given in Appendix Table A10.1.

Table 10.1: Types of CFMs

	Inflows	Outflows
Approval requirement	New Zealand (+)	
Ban		Malaysia (+)
Fees	Australia (+)	
Loan-to-value requirement	Macau, China (+)	
Limit	Australia (+), PRC (-/+), India (-/+), Indonesia (+), Rep. of Korea (-/+), Malaysia (+), Sri Lanka (-/+)	PRC (-/+), India (-/+), Malaysia (-/+)
Limit / Approval requirement	India (-)	
Reserve requirement		PRC (-/+)

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Table 10.1 *continued*

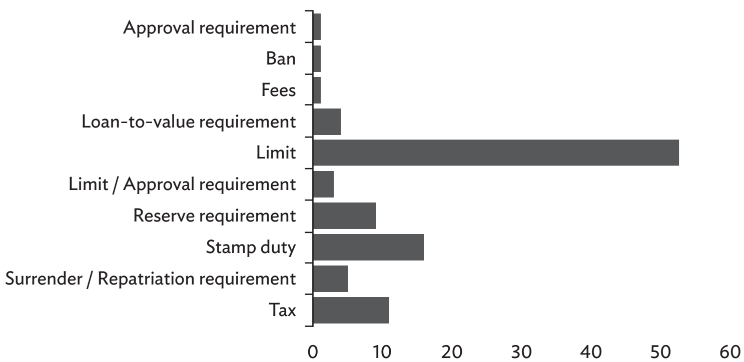
	Inflows	Outflows
Stamp duty	Australia (+), Hong Kong, China (+), Singapore (+)	
Surrender / Repatriation requirement		Malaysia (-/+), Sri Lanka (+)
Tax	Australia (+), Rep. of Korea (+), Malaysia (+)	

CFM = capital flow management measure, PRC = People's Republic of China.

Note: The table lists countries that have introduced/tightened (+), removed/eased (-), or both removed/eased and introduced/tightened (-/+) CFM measures of each type since 2008.

Sources: Binici, Das and Pugacheva (2020); IMF (2019).

Figure 10.1: CFMs Undertaken Economies in the Asia and Pacific Region



CFM = capital flow management measure.

Source: Binici, Das and Pugacheva (2020); IMF (2019).

Table 10.1 and Figure 10.1 summarize the CFMs deployed by these 11 economies, with Table 10.1 showing that economies used a wide range of capital account restrictions. "Limits"—which represent a broad range of quantitative restrictions on the notional value or currency of denomination in specific asset classes or on individuals or institutions—on the cross-border flow of capital were used by several countries. “Bans”, which could be viewed as an extreme case of a limit, were used just in one. “Reserve Requirements”, which require foreign investors to deposit a percentage of their capital for a given duration in either a non-interest or low-interest bearing account and are typically levied on banks, depositary institutions, and financial corporates, were imposed exclusively by emerging markets. Price-based controls, such as taxes and fees, had a high incidence among developed economies. Among these price-based CFMs, “stamp duties” (taxes on cross-border real estate transactions) have a particularly high incidence in the developed economies of the region. Their use was motivated by prudential and affordability concerns due to a price boom in their domestic residential real estate sectors. These are also macroprudential measures, but because they can affect capital flows, regardless of their intent, the Taxonomy classifies them to be both a macroprudential measure and a CFM.

Table 10.2: CFMs by Exchange Rate Regime, Monetary Policy Regime, and Income Level

	All Measures	Tightening	Easing	Inflow Tightening	Inflow Easing	Outflow Tightening	Outflow Easing	Net Inflow Measures	Net Outflow Measures
Exchange rate									
Flexible	25	22	3	19	1	3	2	21	4
Fixed	82	48	34	34	25	15	9	43	40
Monetary policy									
IT	51	33	18	33	18	0	0	33	18
Non-IT	56	37	19	20	8	18	11	31	26
Economy Group									
Developed	38	36	2	36	2	0	0	36	2
Emerging	69	34	35	17	24	18	11	28	42
Total	107	70	37	53	26	18	11	64	44

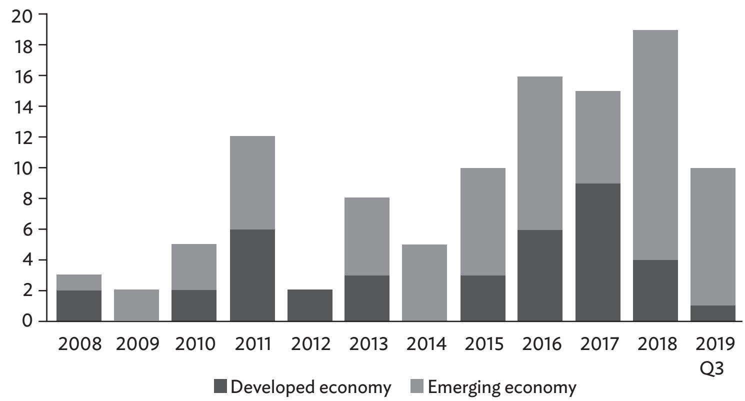
CFM = capital flow management measure, IT = inflation targeting..

Notes: Net inflow measures = inflow tightening + outflow easing. Net outflow measures = outflow tightening + inflow easing. Flexible exchange rate regime is defined based on Ilzhetzki et al. (2019). Inflation targeting (IT) countries (time varying): Australia, India, Indonesia, Rep. of Korea, and New Zealand. For a list of developed and emerging economies see Appendix Table A10.1.

Sources: Binici, Das and Pugacheva (2020); IMF (2019).

In Table 10.2, based on monthly data, we further break down these CFMs by exchange rate regime and monetary policy regime and income level. We use the fine classification from Ilzetzki, Reinhart, and Rogoff (2019) to determine exchange rate regimes, and data from the IMF to classify countries by inflation-targeting status and income level.[5] The incidence of CFMs presents stylized evidence of the links between the exchange and monetary policy regime and the use of capital controls. In countries with fixed or managed exchange rates, the use of CFMs in general facilitates maintaining the level, consistent with the higher number of CFMs observed in fixed rather than flexible rate regimes. Non-inflation targeting regimes are more likely to use CFMs, as monetary policy is not constrained by an explicit inflation target consistent with their higher incidence in these countries. Developed economies, which are in general more open (as measured, for example, by the Chinn-Ito index), had a much lower number of CFMs in this period (Figure 10.2). In general, since 2008 there were more tightening CFMs than easing CFMs (Figure 10.3).

Figure 10.2: CFMs: Advanced versus Emerging Economies in the Asia and Pacific Region

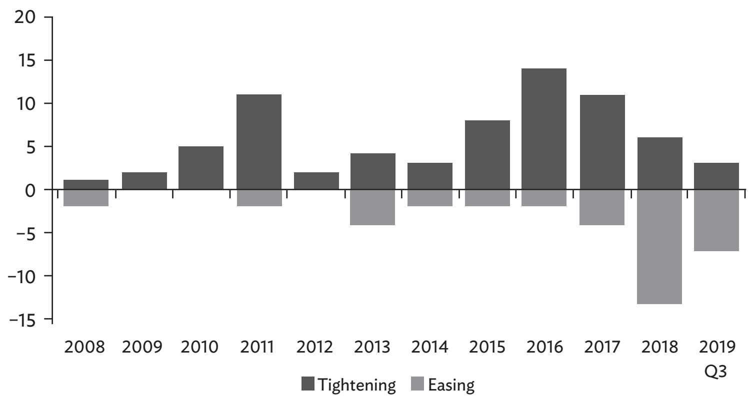


CFM = capital flow management measure.

Sources: Binici, Das and Pugacheva (2020); IMF (2019).

5 Some economies changed their inflation-targeting status during the 2008–19 period. Table 10.2 shows their latest status.

Figure 10.3: Tightening versus Easing Measures (Economies in the Asia and Pacific Region)



CFM = capital flow management measure.

Sources: Binici, Das and Pugacheva (2020); IMF (2019).

10.3 Motivations for the Recalibration of CFMs

The literature has offered many motivations for the recalibration of CFMs. Erten, Korinek, and Ocampo (2019) provide an overview of the current debates on their role in macroeconomic management and a review of recent advances in the literature on CFMs. Drawing on this literature, we broadly divide the objectives behind CFMs into four (possibly overlapping) categories: (1) macroeconomic stabilization motives; (2) capital flow management motives; (3) financial stability goals; and (4) exchange rate motives.

10.3.1 Macroeconomic Stabilization

A longstanding explanation for the use of CFMs is macroeconomic stabilization. This includes recalibrating CFMs to limit the impact of capital flows on overheating or the domestic business cycle. Indicators of overheating used in previous research include output growth, output volatility, terms of trade volatility, inflation, and the growth of nominal exports or imports. The motive for macroeconomic stabilization encompasses the broader objective of achieving monetary or exchange rate autonomy when faced with inconsistent objectives under trilemma considerations (see, e.g., Calvo, Liederman, and Reinhart 1996; de Gregorio, Edwards, and Valdes 2000). For example, inflow controls can be used to limit exchange rate appreciation pressures while retaining some control over domestic monetary policy. This is because limiting the volume of capital flows gives policy makers room to raise the policy rate without concomitant (or, at the least, a proportional) loss of external competitiveness. In a capital flight episode, capital controls on outflows give authorities some ability to avoid disorderly exchange rate depreciation without raising interest rates that could otherwise choke investment and output objectives.

Macroeconomic stabilization motives could also include “financial repression” (Laban and Larrain 1997). Capital controls on outflows lower the cost of government borrowing—and determine its allocation across sectors—by retaining domestic saving within the country. This argument has been presented in terms of lowering debt-service costs by using capital controls on outflows to keep domestic interest rates low (Drazen 1989). In general, CFMs for financial repression are accompanied by a wide range of restrictions on interest rates, credit ceilings, limited product market competition, and high reserve requirements for banks.

10.3.2 Capital Flow Management

A second rationale for the use of CFMs is to manage one or more features of foreign capital flow. The objective can range from targeting the volume of foreign capital flows, to its composition (e.g., recalibrating CFMs to engineer a shift from equity to debt flows), or its maturity structure.

In some cases, capital account restrictions may be implemented to reflect the shallowness of the domestic financial sector and the inability to absorb the foreign capital without creating significant financial imbalances. These concerns may be amplified when the exchange rate is not freely floating and when monetary policy is not pinned to an explicit inflation target. This use of CFMs in such cases is sometimes justified by asymmetric information problems that give rise to herding among foreign investors (see, e.g., Eichengreen and Mussa 1998) that necessitate their use to limit the volatility of capital flows and exchange rates.

CFMs could be targeted to specific asset classes, such as the price- or quantity-based controls on hot money flows that were used by Brazil in the years after the global financial crisis to limit flows to their equity markets (see, e.g., Alfaro, Chari, and Manczuk 2017). By imposing administrative controls on short-term portfolio flows, CFMs can also alter the relative risk-return profile of longer-term flows, such as foreign direct investment, and thus also affect the maturity structure of foreign capital flows.

10.3.3 Financial Stability Concerns

A third objective is the use of CFMs to limit the buildup of risks to the financial sector from large and/or volatile capital flows, particularly those targeted to the banking and financial sector (see, e.g., Jeanne 2012; Korinek 2018). Examples of financial stability risks include an excessive increase in the foreign-currency denomination of domestic banking sector liabilities, financial sector volatility, a rapid growth of foreign credit to the private sector intermediated by the domestic financial system, as well as localized sectoral risks, such as a boom in residential real estate or construction financed by foreign capital.

The overarching concern is that the build-up of such financial stability risks can lead to boom-bust cycles, which have historically been followed by financial crises and large output losses (Laeven and Valencia 2018). Moreover, due to the significant growth in inter-linkages between sovereigns, the nonfinancial sector, and the banking sector, the rise in foreign-currency exposure in any one sector can rapidly escalate to a domestic financial crisis. Such concerns may be amplified in financially fragile economies, e.g., those with limited financial market depth and weaker institutions for the regulation and resolution of financial distress (Fratzscher 2014).

10.3.4 Exchange Rate Rationale

A fourth objective may be an explicit exchange rate goal. While the previously noted rationales may have the consequence of limiting exchange rate movements, an explicit exchange rate goal is one that is carried out even in the absence of domestic overheating, financial stability risks, or concerns about the volume or composition of capital flows. In particular, policy makers target the level of the exchange rate to maintain competitiveness, prevent the exchange rate from being away from its fundamental level, or, in the case of capital outflows, prevent disorderly depreciation in the case of capital outflows.

Such motives of “competitive devaluations” are often the target of criticisms of CFMs because of their zero-sum nature. That is, depreciation in one country necessitates a nominal appreciation and potentially lower competitiveness in trading partners. A related externality is that restrictions on capital inflows in one country distort international capital flows to other countries, including those which may have weaker policy frameworks and shallower financial markets to effectively absorb them (Giordani et al. 2017).

However, it has also been recognized (see, e.g., Baldwin 1988; Baldwin and Krugman 1989) that transitory capital inflow surges that lead to temporary exchange rate appreciation cause lasting damage on the export sector through hysteresis effects. In its re-examination of the role of inflow controls, the IMF noted that such permanent effects from transitory capital flows could be one circumstance under which temporary controls on capital inflows may be warranted (IMF 2010).

10.3.5 Other

In addition to the motives described above, there are other structural, long-standing, or institutional features that may influence the use of CFMs. For instance, fixed or managed exchange rate regimes may in general be helped by the use of controls on capital flows in maintaining their exchange rate levels. By contrast, in inflation-targeteting countries, particularly those with flexible exchange rates, the emphasis on price stability as the primary goal of monetary policy is likely to subordinate the use of capital controls in trying to attain domestic policy objectives.

The openness of the economy—measured by the Chinn-Ito index, for example—may also influence the probability of implementing CFMs, although it is not a priori clear in which direction. On the one hand, more open economies are more exposed to external shocks and may use CFMs to minimize the impacts of these shocks. On the other hand, more open economies in general—and also in our sample—have a greater commitment to free capital mobility and in general have flexible exchange rate regimes and oftentimes an inflation-targeting framework. We control for such structural characteristics in our empirical analysis.

10.4 Empirical Strategy and Evidence

Consistent with the different objectives discussed above, we empirically link proxies for each of these objectives to the probability of implementing a CFM as discussed below.

10.4.1 Empirical Strategy

We begin by outlining the empirical framework within which we test among the different motives described above for recalibrating capital controls. Given the richness of our data, we present results by grouping

CFMs in several interesting ways. Our baseline regression is a binary choice probit model that takes the form:

$$\Pr\left(CFM_{it}^{j} = 1\right) = f(MS_{it}'\beta_{ms} + FS_{it}'\beta_{fs} + CF_{it}'\beta_{cf} + ER_{it}'\beta_{er} + O_{it}'\beta_{ot} + e_{it}) \quad (1)$$

$$(j=1,\ldots,6); \ (i=1,\ldots,11); \ (t=1,\ldots,T)$$

where *f*(.) represents the cumulative distribution function of the standard normal distribution, *MS* are the covariates that capture the macroeconomic stabilization motive, *FS* are the proxies for financial stability objectives, *CF* are variables that capture capital flow management motives, and *ER* proxies exchange rate concerns. We use *O* to denote the other variables, such as exchange rate regime and capital account openness. The proxies for each of these objectives are described below. In terms of the sample size, we have 11 economies observed over varying subsets of the period between the first quarter of 2008 and the third quarter of 2019.[6] Altogether, this gives us a quarterly panel data with 268 observations.

The dependent variable, denoted CFM_{it}^{j}, is one of six possible indicators of CFMs that we describe below. In each case, the dependent variable takes the value 1 when the particular measure is taken and 0 otherwise. The six possible indicators CFM_{it}^{j} are:

(1) *All measures*. This includes all 107 CFMs, with no distinction between inflow and outflow measures, tightening and easing measures, or measures designed to restrict either net capital inflows or net capital outflows. This measure is closest to the one considered in most of the existing literature.

(2) *Tightening measures*. We extract from *All measures* only those 70 that are classified as tightening measures, including the introduction of those to limit capital flows, as well as any changes designed to tighten enforcement, either on inflows or outflows or both inflows and outflows.

(3) *Easing measures*. We extract from *All measures* only those 37 that are classified as easing measures, including the removal of measures to limit capital flows, as well as any changes designed to ease enforcement, either on inflows or outflows or both inflows and outflows.

[6] Countries enter into the Taxonomy with the first CFM that they implement in the 2008:q1–2019:q3 period. For several, this is a quarter in some year after 2015.

(4) *Net inflow measures*. We use the Taxonomy to construct *net inflow* CFMs, defined as measures designed to limit capital inflows and encourage capital outflows.[7] This includes all CFMs classified as tightening measures on inflows as well as all CFMs classified as easing measures on outflows. As shown in Table 10.2, column (8), there were 64 net inflow measures.

(5) *Net outflow measures*. We use the Taxonomy to construct *net outflow* CFMs, defined as measures designed to limit capital outflows and encourage capital inflows. This includes all CFMs classified as tightening measures on outflows as well as all CFMs classified as easing measures on inflows. Column (9) in Table 10.2 indicates there were 44 such measures.

(6) *Inflow measures*. This includes 79 distinct measures targeted to inflows (including the introduction, removal, tightening or easing, targeted to inflows).[8]

We use several proxies to empirically capture the different objectives of recalibrating CFMs. With regard to the macroeconomic stabilization motive, we consider the growth rate of real GDP, the volatility of GDP (measured as the standard deviation of real GDP over the previous six quarters) along with one period lagged import growth rates, export growth rates and consumer price index inflation (Aizenman and Pasricha 2013, Fratzscher 2014).

With regard to financial stability objectives, a key concern of policy makers is that large inflows fuel domestic credit booms and asset market bubbles (see, e.g., Jeanne 2012; Korinek and Sandri 2016). To capture these developments, we consider the growth rate of private sector credit (the change in credit issued to the private sector in ratio to GDP), the volatility of stock market (measured as the standard deviation of equity market total returns over the last 52 weeks, using weekly information on stock price indices), and the annualized change in total returns on the stock market.

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7 The terminology of net inflow and net outflow measures originates in Pasricha (2012) and Aizenman and Pasricha (2013). Our definition of net inflow (net outflow) measures is equivalent to "NKI" reducing (increasing) measures in these papers. Using this terminology, a tightening of net inflow measures can imply either a tightening of CFMs on inflows, a loosening of CFMs on outflows or both. Analogously, tightening net outflow measures can reflect either the tightening of CFMs on outflows, a loosening on inflows, or both.

8 We do not include the corresponding outflow measures in our results because there are too few measures, leading to a fully determined discrete choice regression.

Regarding capital flow management goals of CFMs, our proxies include the change in net portfolio flows in ratio to GDP over the past two quarters, the volatility of net portfolio flows (measured as the standard deviation of net portfolio flows over the last six quarters), and the annual change in gross capital outflows and gross capital inflows both in percent of GDP, to determine whether CFMs are deployed with a capital flow motive (see, e.g., Forbes et al. 2015).

Finally, for the exchange rate motive, our proxies are: the change in the real effective exchange rate (REER) over the past two quarters; the volatility of the REER (measured as the standard deviation of the REER over the past six quarters); and the percent change in official reserves over the past two quarters scaled by GDP. Following Aizenman and Binici (2016), we add an index of quarterly exchange market pressure, defined as the standardized difference between the exchange rate, short-term interest rate, and changes in foreign reserves. The measure is defined so that an increase in exchange market pressure implies greater depreciation pressure.

Our regressions also include policy variables. When faced with a capital flow episode, policy makers may first consider countercyclical macroeconomic policies if there is space to implement them (IMF 2012). We use the short-term interest differential vis-à-vis the Group of Four economies to capture monetary policy space and the primary fiscal balance for fiscal space (Aizenman and Pasricha 2013). Additional controls include the current account balance in percent of GDP, an indicator for a floating exchange rate, an indicator for inflation targeters, and a measure of capital account openness. The complete list and sources of the variables used are given in Appendix Table A10.2.

As our sample size is relatively small and there are several proxies for each of the considered objectives of CFMs, a preliminary step is a stepwise regression where we estimate the six binary choice models for each of the four objectives to test the empirical support of the various proxies. Drawing on the results of these individual regressions, we then narrow down the set of covariates to use in joint tests of all the objectives. Following Binici and Das (2021), our approach is to select all covariates that are within a 20% error level in at least four of the six distinct regressions. An additional practical benefit of this approach is that it lowers the dimensionality of the regression given the high correlation among variables which are proxying for closely related developments. Eliminating country-quarter pairs for which we do not have data on certain variables, our sample size consists of a panel of 227 country-quarter observations.

10.4.2 Evidence

Tables 10.3–10.6 present the estimated results. We begin with presenting results for the entire sample in Table 10.3. Overall, the models of tightening measures and net outflow measures have the best fit, while the model of easing measures has the weakest fit. Nevertheless, the Wald test comfortably rejects the null hypothesis of the joint insignificance of the covariates in all the six regressions.

Table 10.3: Determinants of CFMs: Full Sample

	All measures	Tightening measures	Easing measures	Net inflow measures	Net outflow measures	Inflow measures
	(1)	(2)	(3)	(4)	(5)	(6)
Output growth	0.20	0.34*	0.15	0.21	0.15	0.14
	(0.15)	(0.18)	(0.16)	(0.16)	(0.30)	(0.17)
Inflation	0.37	0.84*	0.31	0.82**	0.28	0.29
	(0.23)	(0.44)	(0.24)	(0.36)	(0.30)	(0.25)
Private Credit Growth	0.00*	0.00	0.00*	0.00	0.00	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Stock Market Volatility	−0.23	−0.05	−0.19	−0.16	−0.33	0.03
	(0.29)	(0.32)	(0.33)	(0.37)	(0.39)	(0.30)
Net Portfolio Flows	−0.78	1.24	−0.14	2.02	−25.93*	−0.17
	(4.92)	(4.37)	(4.18)	(3.65)	(14.20)	(4.06)
Capital Flow Volatility	0.24**	0.36***	0.24**	0.28**	0.66**	0.27**
	(0.11)	(0.13)	(0.11)	(0.12)	(0.27)	(0.12)
REER % Change	0.09**	0.05	0.08**	0.06	0.13	0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.08)	(0.04)
REER Volatility	0.45**	0.48*	0.37*	0.48**	0.72*	0.26
	(0.21)	(0.28)	(0.21)	(0.24)	(0.38)	(0.23)
EMP Index	0.02	0.17	0.03	0.09	−0.23	0.04
	(0.18)	(0.26)	(0.18)	(0.23)	(0.33)	(0.20)
Current Account Balance	0.09	0.11	0.07	0.10	−0.11	0.02
	(0.06)	(0.07)	(0.06)	(0.07)	(0.18)	(0.07)
Capital Account Openness	0.29	0.62	0.37	0.51	−1.26	0.45
	(0.28)	(0.43)	(0.28)	(0.37)	(0.78)	(0.30)

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Table 10.3 *continued*

	All measures	Tightening measures	Easing measures	Net inflow measures	Net outflow measures	Inflow measures
	(1)	(2)	(3)	(4)	(5)	(6)
Floating Exchange Rate	−0.48	−2.01	−0.43	−1.97	5.19**	−0.01
	(1.22)	(1.88)	(1.20)	(1.76)	(2.27)	(1.21)
Inflation Targeter	0.45	1.74*	0.29	1.43*	0.27	0.08
	(0.73)	(0.89)	(0.78)	(0.83)	(1.06)	(0.88)
Interest rate differential	0.40***	0.32**	0.44***	0.26*	0.39**	0.52***
	(0.12)	(0.15)	(0.13)	(0.13)	(0.16)	(0.14)
Primary Balance	0.24	0.54*	0.30	0.31	0.08	0.58**
	(0.19)	(0.28)	(0.22)	(0.26)	(0.27)	(0.27)
Constant	−11.41**	−14.05**	−9.86**	−12.98**	−17.58*	−8.36
	(4.88)	(6.13)	(4.96)	(5.46)	(9.01)	(5.36)
Observations	227	227	227	227	227	227
Pseudo R^2	0.158	0.187	0.154	0.149	0.288	0.181
Wald χ^2	37.20	23.84	33.11	30.21	42.41	29.54

REER = real effective exchange rate, CFM = capital flow management measure, EMP = exchange market pressure.

Note: Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Source: Authors' calculations.

Table 10.4: Determinants of CFMs: Emerging Markets

	All measures	Tightening measures	Easing measures	Net inflow measures	Net outflow measures	Inflow measures
	(1)	(2)	(3)	(4)	(5)	(6)
Output growth	0.28	0.47*	0.18	0.02	0.31	0.26
	(0.21)	(0.28)	(0.22)	(0.23)	(0.36)	(0.28)
Inflation	0.53*	0.90**	0.47	1.10**	0.34	0.43
	(0.28)	(0.45)	(0.30)	(0.47)	(0.33)	(0.32)
Private Credit Growth	0.00	0.00	0.00	0.00	−0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Stock Market Volatility	−0.32	−0.09	−0.30	−0.45	−0.30	0.00
	(0.37)	(0.43)	(0.45)	(0.59)	(0.45)	(0.42)
Net Portfolio Flows	−11.06	−7.57	−5.98	9.32	−25.49	−6.99
	(11.94)	(20.06)	(11.49)	(13.57)	(16.49)	(11.37)

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Table 10.4 *continued*

	All measures	Tightening measures	Easing measures	Net inflow measures	Net outflow measures	Inflow measures
	(1)	(2)	(3)	(4)	(5)	(6)
Capital Flow Volatility	0.52**	0.98	0.46**	1.18*	0.53*	0.43**
	(0.22)	(0.66)	(0.19)	(0.70)	(0.31)	(0.18)
REER % Change	0.18***	0.17*	0.18***	0.11	0.18*	0.17**
	(0.07)	(0.10)	(0.07)	(0.09)	(0.09)	(0.07)
REER Volatility	0.99***	0.95*	0.98***	1.04*	0.97*	0.93**
	(0.36)	(0.57)	(0.37)	(0.62)	(0.52)	(0.39)
EMP Index	−0.27	−0.12	−0.25	−0.31	−0.27	−0.19
	(0.28)	(0.44)	(0.30)	(0.41)	(0.40)	(0.33)
Current Account Balance	−0.13	0.01	−0.17	−0.01	−0.28	−0.27
	(0.13)	(0.13)	(0.15)	(0.18)	(0.24)	(0.17)
Capital Account Openness	−1.66**	−0.83	−1.67**	−1.38	−2.87**	−1.64**
	(0.68)	(0.99)	(0.74)	(1.02)	(1.30)	(0.80)
Floating Exchange Rate	–	–	–	–	–	–
Inflation Targeter	2.15*	3.72*	2.03	3.51*	1.02	1.90
	(1.19)	(2.06)	(1.28)	(1.91)	(1.45)	(1.36)
Interest rate differential	0.46***	0.44**	0.52***	0.33*	0.41**	0.63***
	(0.16)	(0.22)	(0.17)	(0.20)	(0.17)	(0.19)
Primary Balance	0.19	0.35	0.24	0.01	0.18	0.60*
	(0.25)	(0.45)	(0.27)	(0.37)	(0.32)	(0.35)
Constant	−24.06***	−25.11*	−23.62***	−23.57*	−25.51**	−23.97***
	(8.47)	(13.50)	(8.68)	(14.29)	(12.35)	(9.30)
Observations	156	156	156	156	156	156
Pseudo R^2	0.252	0.246	0.243	0.255	0.276	0.256
Wald χ^2	42.96	31.13	45.44	33.23	39.09	39.59

REER = real effective exchange rate, CFM = capital flow management measure, EMP = exchange market pressure.

Note: Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Source: Authors' calculations.

Table 10.5: Determinants of CFMs: Non-Floating Exchange Rates

	All measures	Tightening measures	Easing measures	Net inflow measures	Net outflow measures	Inflow measures
	(1)	(2)	(3)	(4)	(5)	(6)
Output growth	0.22	0.36*	0.17	0.22	0.32	0.16
	(0.15)	(0.19)	(0.16)	(0.17)	(0.36)	(0.18)
Inflation	0.41*	0.97*	0.35	0.92**	0.34	0.34
	(0.24)	(0.50)	(0.25)	(0.39)	(0.33)	(0.26)
Private Credit Growth	0.00*	0.00	0.00*	0.00	−0.00*	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Stock Market Volatility	−0.25	−0.05	−0.21	−0.17	−0.31	0.03
	(0.30)	(0.33)	(0.35)	(0.39)	(0.44)	(0.32)
Net Portfolio Flows	0.12	2.48	0.73	3.21	−25.77	0.71
	(4.33)	(4.00)	(3.71)	(3.25)	(16.57)	(3.65)
Capital Flow Volatility	0.26**	0.42***	0.26**	0.34***	0.54*	0.29**
	(0.11)	(0.14)	(0.11)	(0.12)	(0.31)	(0.12)
REER % Change	0.09**	0.05	0.09**	0.05	0.18*	0.07
	(0.04)	(0.04)	(0.04)	(0.04)	(0.09)	(0.04)
REER Volatility	0.47**	0.55**	0.39*	0.53**	0.97*	0.29
	(0.22)	(0.28)	(0.22)	(0.25)	(0.51)	(0.25)
EMP Index	0.00	0.16	0.00	0.07	−0.26	0.01
	(0.18)	(0.28)	(0.18)	(0.24)	(0.39)	(0.20)
Current Account Balance	0.09	0.11	0.07	0.11	−0.29	0.01
	(0.06)	(0.08)	(0.07)	(0.07)	(0.24)	(0.08)
Capital Account Openness	0.36	0.81*	0.45	0.65*	−2.95**	0.54*
	(0.28)	(0.47)	(0.29)	(0.39)	(1.33)	(0.31)
Floating Exchange Rate	–	–	–	–	–	–
Inflation Targeter	0.46	1.80*	0.29	1.45*	0.99	0.06
	(0.74)	(0.93)	(0.79)	(0.85)	(1.46)	(0.89)
Interest rate differential	0.41***	0.35**	0.45***	0.28**	0.41**	0.54***
	(0.13)	(0.16)	(0.13)	(0.14)	(0.17)	(0.15)
Primary Balance	0.26	0.62**	0.33	0.37	0.18	0.62**
	(0.19)	(0.30)	(0.22)	(0.27)	(0.32)	(0.29)
Constant	−11.91**	−15.35**	−10.32**	−13.89**	−25.48**	−8.89
	(5.11)	(6.29)	(5.21)	(5.61)	(12.34)	(5.65)

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Table 10.5 *continued*

	All measures (1)	Tightening measures (2)	Easing measures (3)	Net inflow measures (4)	Net outflow measures (5)	Inflow measures (6)
Observations	208	208	208	208	208	208
Pseudo R^2	0.170	0.218	0.167	0.172	0.335	0.198
Wald χ^2	35.61	25.40	31.27	34.70	44.01	27.74

REER = real effective exchange rate, CFM = capital flow management measure, EMP = exchange market pressure.

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' calculations.

Table 10.6: Determinants of CFMs: Non-Inflation Targeting

	All measures (1)	Tightening measures (2)	Easing measures (3)	Net inflow measures (4)	Net outflow measures (5)	Inflow measures (6)
Output growth	0.26	0.03	0.15	−0.47	0.65	0.20
	(0.23)	(0.42)	(0.22)	(0.41)	(0.50)	(0.25)
Inflation	0.62**	1.26**	0.54*	1.32**	0.64*	0.47
	(0.29)	(0.61)	(0.30)	(0.62)	(0.33)	(0.31)
Private Credit Growth	0.05	0.27	0.05	0.37**	−0.01	0.05
	(0.04)	(0.18)	(0.05)	(0.17)	(0.17)	(0.08)
Stock Market Volatility	−0.33	−0.02	−0.34	−0.46	−0.40	−0.01
	(0.43)	(0.51)	(0.53)	(0.65)	(0.58)	(0.48)
Net Portfolio Flows	2.75	3.41	3.15	3.66*	−22.28	2.72
	(2.65)	(2.84)	(2.42)	(2.03)	(15.90)	(2.60)
Capital Flow Volatility	0.17	0.12	0.19	0.17	0.47	0.16
	(0.13)	(0.15)	(0.14)	(0.14)	(0.50)	(0.13)
REER % Change	0.19**	0.11	0.18**	0.03	0.30**	0.16*
	(0.08)	(0.07)	(0.09)	(0.10)	(0.15)	(0.09)
REER Volatility	1.03***	0.59*	0.96***	0.60	1.69***	0.85**
	(0.34)	(0.30)	(0.36)	(0.41)	(0.60)	(0.38)
EMP Index	−0.25	0.31	−0.22	0.09	−0.67	−0.12
	(0.29)	(0.38)	(0.31)	(0.40)	(0.45)	(0.35)
Current Account Balance	−0.15	−0.01	−0.20	−0.20	−0.48*	−0.26
	(0.16)	(0.23)	(0.19)	(0.31)	(0.28)	(0.21)

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Table 10.6 *continued*

	All measures	Tightening measures	Easing measures	Net inflow measures	Net outflow measures	Inflow measures
	(1)	(2)	(3)	(4)	(5)	(6)
Capital Account Openness	1.08	−0.73	1.41	0.13	–	1.29
	(0.84)	(0.93)	(1.08)	(1.16)		(1.17)
Floating Exchange Rate	–	–	–	–	–	–
Inflation Targeter	–	–	–	–	–	–
Interest rate differential	0.37**	−0.03	0.41**	−0.30	0.57**	0.50**
	(0.19)	(0.54)	(0.20)	(0.51)	(0.26)	(0.22)
Primary Balance	0.27	0.63*	0.29	0.34	0.45	0.57**
	(0.20)	(0.38)	(0.22)	(0.32)	(0.33)	(0.28)
Constant	−21.22***	−14.21	−19.04**	−7.97	−37.92***	−18.18**
	(7.96)	(9.01)	(8.29)	(10.63)	(14.31)	(8.34)
Observations	120	120	120	120	83	120
Pseudo R^2	0.243	0.280	0.233	0.285	0.228	0.234
Wald χ^2	20.73	29.02	17.90	23.24	20.56	16.78

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: Authors' calculations.

While there are some differences across columns (1)–(6), the overall finding is that policy makers had multiple objectives in recalibrating CFMs. The estimated coefficients of capital flow volatility and exchange rate volatility, in particular, are statistically significant in all regression, pointing to the importance of a capital flow management and exchange rate rationales. Furthermore, the magnitude and significance of inflation in the tightening measures and net inflow measures suggest that policy makers responded to overheating and stabilization concerns as well.

While exchange rate and capital flow volatility mattered for recalibrating CFMs, we do not find evidence that their levels mattered as much, supporting the arguments presented in Eichengreen and Mussa (1998). We also do not find much evidence in support of financial stability objectives, as evidenced by the estimated coefficients on stock market volatility and private credit growth. Furthermore, while the coefficients of flexible exchange rates are negative in accordance with our priors in all but one regression, they are not statistically significant.

With regard to policies, our prior is that, for capital outflows, the larger the interest differential, the lower the scope to further raise interest rates (due to concerns about choking domestic demand), and thus the greater the probability of tightening controls on outflows or easing controls on inflows. Conversely, our prior is that, for capital inflows, the larger the differential, the greater the scope to lower interest rates and discourage flows, and thus the lower the probability of tightening controls on inflows or easing them on outflows. While the estimated coefficients of interest rate differential in the regression on tightening measures, easing measures, and net outflow measures are consistent with this hypothesis, the positive coefficient on net inflow measures is unexpected. With reference to fiscal policy, our results do not find a statistically significant relation with any of the measures.

To explore the robustness of the results from the overall sample, we next partition the sample into three groups: emerging markets, non-flexible exchange rates, and non-inflation targeting regimes. For instance, developed economies which are generally more open, have deeper financial markets and effective adjustment policy frameworks, and are committed to free capital mobility, may resort to CFMs much less frequently. Policy makers in fixed exchange rate regimes may rely more on capital controls to manage capital flow episodes as the exchange rate does not act as a shock absorber. In countries where monetary policy does not target inflation or price stability, officials may be more likely to use CFMs to achieve their policy objectives than otherwise.

The results for emerging markets are given in Table 10.4. The results are qualitatively consistent with the overall sample. The estimated coefficients on capital flow volatility and exchange rate volatility are substantively larger than in the overall sample, suggesting that volatile conditions in exchange markets and capital flows more often led emerging markets, rather than developed economy policy makers, to use CFMs. This is consistent with our prior, as all emerging markets in our sample had non-flexible exchange rate regimes,[9] which would naturally lead to more responsiveness to volatile exchange rate and capital flow developments to manage their exchange rates.

The results for non-flexible exchange rate and non-inflation targeting regimes are given in Tables 10.5 and 10.6, respectively.[10] The estimated impact of inflation is stronger in the non-flexible exchange rate sample than in the overall sample, consistent with the notion that

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9 For this reason, the flexible exchange rate regime indicator drops out from Table 10.4.

10 While all emerging markets in the sample are non-flexible exchange rate countries, some developed economies also have non-flexible exchange rate regimes. Thus, the samples are different in Tables 10.4 and 10.5.

officials were more likely to recalibrate CFMs to achieve domestic policy objectives when the exchange rate was not an effective shock absorber. For the non-inflation targeting sample, the estimated coefficient on inflation is even higher than in the non-flexible exchange rate sample and substantially larger than in the overall sample. Furthermore, the estimated coefficients on exchange rate volatility is nearly three times the magnitude than in the overall sample. This finding is consistent with our prior that officials will rely more on CFMs to manage their domestic policy objectives when monetary policy is not pinned to maintaining price stability.

10.5 Conclusion

This chapter presents the incidence of CFMs in the 11 developed and emerging economies of the Asia and Pacific region that recalibrated them between 2008 and 2019. Using a new high-frequency dataset on CFMs, we then empirically analyze the factors that motivate their use in these economies, discriminating between macroeconomic stabilization, financial stability, capital flow, and exchange rate objectives.

Our results indicate that the relevance of these objectives differ across measures of CFMs. Capital flow management and exchange rate objectives appear to be strong predictors of net inflow, easing and tightening measures, while macroeconomic stabilization additionally is another driver of tightening measures. These results are qualitatively similar, but quantitatively stronger, for emerging markets, non-flexible exchange rates, and particularly non-inflation targeting countries. Thus, an overall conclusion is that the probability of using CFMs was higher in countries where financial markets were shallow or undeveloped, the exchange rate could not act as an effective shock absorber, and policy frameworks did not provide an adequate adjustment mechanism.

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Appendix Table A10.1: Economy Sample

Developed Economies	Emerging Market and Developing Economies
Australia	People's Republic of China
Hong Kong, China	India
Rep. of Korea	Indonesia
Macau, China	Malaysia
New Zealand	Sri Lanka
Singapore	

Source: Authors' compilation based on IMF (2019).

Appendix Table A10.2: Variables Descriptions and Sources

Variable	Description and Original frequency	Source
CFMs	Capital flows management measures based on the 2019 CFM taxonomy; monthly	IMF (https://www.imf.org/~/media/Files/Data/2019/imf-2019-taxonomy-of-capital-flow-management-measures.ashx, accessed 5 October 2020)
Net inflow measures	Tightening measures (including introduction) on inflows of capital and easing measures (including removal) on outflows of capital	Binici, Das and Pugacheva (2020)
Net outflow measures	Tightening measures (including introduction) on outflows of capital and easing measures (including removal) on inflows of capital	Binici, Das and Pugacheva (2020)
Output growth, lagged 1 quarter	Real GDP growth year-over-year; quarterly	IMF, International Financial Statistics
Inflation, lagged 1 quarter	Consumer price index inflation, year-over-year change; quarterly	IMF, International Financial Statistics

continued on next page

Table A10.2 *continued*

Variable	Description and Original frequency	Source
Private credit growth	Annual change in quarterly credit to the non-financial private sector normalized by quarterly nominal US dollar GDP; quarterly	BIS, ECB, IMF International Financial Statistics
Stock market volatility	Standard deviation of equity market total returns over the last 52 weeks using weekly information on stock price indices, weekly	Haver, national stock market websites
Net portfolio flows, lagged 1 quarter	Net inflows (gross asset flows less gross liability flows) in percent of quarterly nominal GDP; quarterly	IMF, International Financial Statistics, authorities
Capital flow volatility	Standard deviation of net portfolio flows over the last six quarter	IMF, International Financial Statistics, authorities
REER % change, lagged 1 quarter	Change in CPI-based real effective exchange rate over previous quarter; monthly. Increase is appreciation.	BIS, IMF International Financial Statistics
REER volatility	Standard deviation of the REER over the past six quarters	BIS, IMF International Financial Statistics
EMP Index	Calculated as the standardized difference between the exchange rate, short-term interest rate and changes in foreign reserves; annual. Higher values indicate higher depreciation pressure. See Aizenman and Binici (2016).	All series from IMF International Financial Statistics
Capital account openness	Normalized index that lies between 0 (fully closed capital account) and 1 (fully open capital account), annual. See Chinn and Ito (2006).	Updated Chinn-Ito (http://web.pdx.edu/~ito/Chinn-Ito_website.htm; accessed 5 October 2020)
Floating exchange rate	An indicator variable for a floating exchange rate regime using fine classification (if rank = 12, 13); monthly	Ilzetzki, Reinhart and Rogoff (2019)
Inflation targeting	An indicator variable for an inflation-targeting monetary policy; monthly	IMF World Economic Outlook

continued on next page

Table A10.2 *continued*

Variable	Description and Original frequency	Source
Current account balance, lagged 1 quarter	Current account balance as a share of GDP; quarterly	IMF, International Financial Statistics
Primary fiscal balance (% of GDP)	General government primary net lending/borrowing as share of GDP; annual	IMF World Economic Outlook Database

CFM = capital flow management measure, ECB = European Central Bank, BIS = Bank for International Settlements, CPI = consumer price index, GDP = gross domestic product, IMF = International Monetary Fund, REER = real effective exchange rate, CFM = capital flow management measure, EMP = exchange market pressure.

Source: Authors' compilation.

PART III

Macroeconomic Uncertainty and New Challenges for Central Banks

11

Assessing Macroeconomic Uncertainties for an Emerging Economy

Motilal Bicchal and S. Raja Sethu Durai

11.1 Introduction

The importance of economic uncertainty in policy making is well documented in the literature (see, for example, Issing 2002; Aikman et al. 2010). Recent studies on the business cycle identified macroeconomic uncertainty as one of the key drivers in frequent business cycle fluctuation (Stock and Watson 2012; Bloom et al. 2018). As observed by Bloom (2014), uncertainty rose during the financial crisis period of 2008, and its likely role in shaping the subsequent global recession focused policy attention on this topic, as evidenced by the introduction of Fan chart[1] forecasts of output and inflation across central banks. Also, reading the minutes of the central banks' monetary policy committees reveals that policy makers dwell on macroeconomic uncertainty a good deal before changing policy instruments. However, measuring true uncertainty is a difficult task as it is neither directly observable nor quantifiable. The literature on uncertainty, therefore, developed proxy measures and incorporated the Knightian notion of risk in a broader definition of the term. Many proxy measures have been proposed, mostly since the 2008 financial crisis, and research on uncertainty is still evolving.

The proxies are broadly classified as finance-based measures, news-based measures, forecast-based measures, and measures of dispersion

[1] Fan charts, first introduced by the Bank of England, depict the probability distribution of forecasts, with information on the risk factors affecting them and the surrounding uncertainties.

among forecasters. Bloom (2009) first suggested realized stock market volatility and the Chicago Board Options Exchange's implied volatility index (VIX) as proxy measures for the United States (US). VIX is derived from call and options prices, so it is said to be a forward-looking indicator of market uncertainty. The idea is that markets are more volatile during a period of increased macroeconomic uncertainty, and several studies have used the stock market volatility measures to assess uncertainty shocks. However, VIX is useful for capturing uncertainty originating from the financial sector rather than the real economy. In their study, Bekaert, Hoerova, and Lo Duca (2013) decomposed the Standard & Poor's 500 stock index VIX into a risk aversion component and an uncertainty component and examined the effect of monetary policy on both.

Baker, Bloom, and Davis (2016) developed a news-based economic policy uncertainty (EPU) index for the US that searches keywords associated with uncertainty in relevant media articles. Following their methodology, many studies have attempted to develop similar indices for countries such as India (Bhagat, Ghosh, and Rangan 2016). At first glance, such a measure looks practical for capturing major economic events of uncertainty, even though it is after the fact and does not disentangle the effect of purely economic uncertainty from that of more general uncertainty news. Particularly in developing countries' media, sociopolitical uncertainty-related events are seen as a more dominant discourse, and often may die off without any economic consequence. Some studies consider the cross-sectional variance of forecasts given by forecasters to be an indicator of ex ante uncertainty (Bachmann, Elstner, and Sims 2013; Banerjee, Kearns, and Lombardi 2015). However, one major drawback of such a measure is that it reflects differences of opinion rather than an economic uncertainty, so it potentially presents a misleading picture.

More recently, an econometric approach has been developed, focusing on the variance of the forecast errors. In this line, Scotti (2013), using Bloomberg forecast data, built an index based on the surprise component of the data releases relative to the forecasts. Jurado, Ludvigson, and Ng (2015) derived macroeconomic uncertainty measures using the common volatility of forecasts of several economic series, arguing that it is the predictability that matters for economic decision making and, therefore, the variance of forecast errors and not the dispersion that would provide better statistics for uncertainty measures. Rossi and Sekhposyan (2015) extended this notion of uncertainty in a more general way and proposed a measure using the US Federal Reserve Bank's survey data of professional forecasters. This index, which has several advantages, is based on relating the realized forecast error to the historical distribution of a variable. It uses the unconditional likelihood of the observed outcome and is not dependent on any parametric model, which is very useful for emerging economies, where the dearth of large sample data is a major problem.

Several studies provide evidence on the macroeconomic effect of uncertainty for advanced countries. Among others, Bloom (2014) shows that uncertainty is highly countercyclical, and developing countries exhibit more uncertainty than developed countries. Indeed, the burgeoning literature on uncertainty has identified real option, precautionary savings, and risk premia channels, among others, through which uncertainty affects the economy.

The prime focus of this chapter is to construct measures of macroeconomic uncertainty using Rossi and Sekhposyan's 2015 methodology and compare them with other measures for India in terms of tracing the transmission channels and mapping with business cycles. The main contributions of this study are twofold. First, it identifies different propagation channels of uncertainty by estimating a series of vector autoregression models with suitable proxy variables. Second, it assesses the uncertainty measures and relates them to the business cycles in India. The study evaluates holistically the effect of macroeconomic uncertainty from an emerging economy perspective.

The study is organized as follows. Section 11.2 describes the data and method used for the uncertainty indices and also provides a criterion for choosing a data set for constructing a forecast-based macroeconomic uncertainty index. Section 11.3 analyzes the macroeconomic effect of uncertainty, and the final section concludes with policy implications.

11.2 Measuring Macroeconomic Uncertainty

11.2.1 Data

The availability of the data drives the choice of sample period and frequency. The uncertainty indices are computed using quarterly data for the period 2008Q1 to 2018Q2, and are built upon forecast errors. The data are compiled from the Reserve Bank of India's various issues from a survey of professional forecasters (SPF). The median forecast of gross domestic product (GDP) growth, inflation rate, and exchange rate over one-quarter and four-quarter horizons are used. The corresponding actual data for the variables are then used to generate forecast errors and uncertainty indices. The study uses survey data on the Business Expectations Index, which are collected from various issues of the

Reserve Bank of India's Survey quarterly Industrial Outlook Survey.[2] The details on other variables used in the study are given in Appendix Table A11.1.1.

11.2.2 Uncertainty Indices

We outline below various uncertainty measures used in the analysis.

Uncertainty Index based on Forecast Error Distributions

The forecast-based uncertainty is based on the notion that the large forecast errors in the economic predictions are an indication of macrocosmic uncertainty. Along the same lines, the uncertainty index proposed by Rossi and Sekhposyan (2015) suggests that if the probability of observing a forecast error of $\theta\%$ is very unlikely, for example, in the 99th quantile of the historical distribution of forecast errors, and the actual observed forecast error value is indeed $\theta\%$, then it is indicative of substantial uncertainty. Following the Rossi and Sekhposyan (2015) methodology, the overall uncertainty index (U^*_{t+h}) is derived as follows: Let us define the forecast error made over the h-step-ahead at time t as: $e_{t+h} = y_{t+h} - E_t(y_{t+h}), t = 1, 2, \dots, T - h$, with T standing for total sample size. Further, let $f(e)$ denote the probability distribution function of the forecast errors, e_{t+h}. Given e_{t+h} and $f(e)$, U_{t+h} is calculated as:

$$U_{t+h} = \int_{-\infty}^{e_{t+h}} f(e)\mathrm{d}e$$

The value of U_{t+h} by construction lies between zero and one. To obtain information about upside uncertainty (U^U_{t+h}) and downside uncertainty (U^D_{t+h}) the normalized version of U_{t+h} is computed as follows:[3]

$$U^U_{t+h} = \frac{1}{2} + max\left\{U_{t+h} - \frac{1}{2}, 0\right\} \text{ and } U^D_{t+h} = \frac{1}{2} + max\left\{\frac{1}{2} - U_{t+h}, 0\right\}$$

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[2] The Business Expectations Index is a weighted average index derived from the quarterly net responses of businesspeople on the situation of nine indicators related to the manufacturing sector. These indicators are as follows: overall business situation, production, order books, inventory of raw material, inventory of finished goods, profit margin, employment, exports, and capacity utilization.

[3] Since at any given time either positive or negative forecast errors are observed, the normalized version of the U_{t+h} provides the information on the upside (positive) and downside (negative) uncertainty.

The upside uncertainty, $U_{t+h}^{U} > 0.5$, will be observed only when the realized value exceeds the expected value, and the downside uncertainty, $U_{t+h}^{D} > 0.5$, only when the realized value goes below the expected.[4] Lastly, the overall uncertainty index is defined as:

$$U_{t+h}^{*} = \frac{1}{2} + \left| U_{t+h} - \frac{1}{2} \right|.$$

The uncertainty values for all normalized indices thus lie between 0.5 and 1. Using this methodology, we derive two economic uncertainty indices as follows:

(i) *Domestic macroeconomic uncertainty index (SPFGDP_U)*: The literature broadly defines fluctuations in the business cycle in terms of changes in GDP. We derive the uncertainty index using the SPF error of GDP variable and consider it to be an indicator of domestic macroeconomic uncertainty.

(ii) *Open economy uncertainty index (SPFMACRO_U)*: Additionally, we derive a wider open macroeconomic uncertainty index using the SPF forecast information from other macro variables. It is obtained by computing Rossi and Sekhposyan (2015) uncertainty indices of GDP, exchange rate, and inflation rate separately, and then the average of the derived indices is defined as an open economy uncertainty index that captures both domestic and external sources.

The Implied Volatility Index

Bloom (2009) proposed VIX as a measure of uncertainty and it is widely used as a proxy in the literature. This measure is considered an expectation indicator of market volatility and is computed using data from the call and options prices of stock indexes such as S&P 500 options contracts for the US or Nifty options for India. We derived a quarterly average of VIX uncertainty for India using the average of daily data compiled from the National Stock Exchange of India website and called it "AVIX_U."

News-based Economic Policy Uncertainty Index

The EPU index was developed by Baker, Bloom, and Davis (2016) to capture the frequency of US media articles referring to terms related to economic and policy uncertainty. This idea of a news-based uncertainty

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4 The definitions of positive and negative shocks depend on the variable under study. In the case of GDP, upside uncertainty implies positive shocks.

index is subsequently expanded to calculate category-based uncertainty indices like monetary policy uncertainty, fiscal policy, and trade policy indices. We obtained India's news-based economic policy uncertainty (IPU) index from the website given in Appendix 11.1 and used the quarter end as well as a three-month average of data in the analysis.

11.2.3 Assessing the Data Set for an Uncertainty Index

The uncertainty-based business cycle theory postulates that common variations across many data series is required for measures of macroeconomic uncertainty (Jurado, Ludvigson, and Ng 2015). We use the bias, variance, and covariance decomposition of the mean square error[5] to assess whether a professional forecast of a variable under inquiry is useful for constructing a macroeconomic uncertainty index. Table 11.1 presents the decomposition for one-quarter-ahead forecast error data.[6]

Table 11.1: Mean Square Error Decompositions

	Bias Proportion	Variance Proportion	Covariance Proportion
SPFGDP	0.02	0.01	0.97
SPFINF	0.03	0.00	0.97
SPFEXC	0.12	0.03	0.85

Note: SPFGDP denotes a survey of professional forecast series gross domestic product, SPFINF denotes a survey of professional forecasts on inflation, and SPFEXC denotes a survey of professional forecast series on rupee–US dollar nominal exchange rate.

Source: Authors' calculations.

The results show that the bias and variance proportions are very insignificant for SPF-based forecasts, suggesting that the model of

5 The mean square error of forecasts is decomposed into three sources: the bias proportion, which measures how far the mean of the forecast is from the mean of the actual series; the variance proportion, which measures how far the variation of the forecast is from the variation of the actual series; and the covariance proportion, which measures unsystematic error, the error remaining after taking into account bias and variance proportion. For further details on computation, see Sharma and Bicchal (2018).

6 Similar results are found for the four-quarter-ahead forecast data.

Table 11.2: Cross-Correlations of Uncertainty Measures

	SPFGDP_U	SPFINF_U	SPFEXC_U	SPFMACRO_U	AVIX_U
SPFINF_U	0.48				
	(0.00)				
SPFEXC_U	0.27	0.20			
	(0.08)	(0.22)			
SPFMACRO_U	0.77	0.73	0.70		
	(0.00)	(0.00)	(0.00)		
AVIX_U	0.35	0.47	0.20	0.46	
	(0.02)	(0.00)	(0.18)	(0.00)	
IPU	0.28	0.06	0.09	0.20	0.27
	(0.06)	(0.67)	(0.56)	(0.20)	(0.08)

SPF = survey of professional forecasters, IPU = India policy uncertainty.

Note: SPF uncertainty measures are based on one-quarter-ahead forecast error. P-values of cross-correlations are in parenthesis.

Source: Authors' calculations.

professional forecasters provides a good estimate of the underlying data-generating process. They further reveal that there is neither systematic bias nor any variance (uncertainty) about the forecast of individual series, but all the errors are due to the covariance proportions. These covariance proportions must be associated with the common variations of uncertainty fluctuation that exist across the many macroeconomic data series affecting them at the same time. The SPF-based forecast errors can thus be considered reliable data for generating macro uncertainty indices.

The inferences from the mean square error results can be corroborated by findings of cross-correlation of uncertainty measures. The results in Table 11.2 show that SPF-based uncertainty measures have a significant positive correlation among them and with AVIX_U, suggesting that the forecast error of professional data includes the common variations of cyclical fluctuations. Further, it appears that SPF-based uncertainty indices are correlated more closely with AVIX_U than IPU, indicating the existence of common underlying uncertainty between them. Overall, the forecast error of SPF can be considered useful data for generating macroeconomic uncertainty indices.

11.3 Analyzing Macroeconomic Uncertainty

The following sections assess uncertainty proxies, described in the previous section, mapping with the business cycles in India.

11.3.1 Recession and Uncertainty

One of the stylized facts about uncertainty is countercyclical behavior, which is high during recessions and low in normal times. However, in India, like the US, where the National Bureau of Economic Research officially defines recession dates, there is no agency that formally announces the dates of a recession. We, therefore, use recession dates identified for India in a study by Pandey, Patnaik, and Shah (2017)[7] and track some stylized behaviors of various uncertainty measures against them (see Figures 11.1 to 11.5).

Figure 11.1 shows that the domestic macroeconomic uncertainty closely captures two recession episodes as the SPFGDP_U values are persistently above their average during the recession periods. It also spikes above the average on two other occasions—notably, the upside uncertainty spike during the time of demonetization, indicating that forecasters are uncertain about the actual growth rate resulting in an underestimation, while on another occasion, the downside uncertainty spikes around goods and services tax implementation, suggesting that forecasters overestimated the growth rate. On both occasions, however, the uncertainty does not persist in subsequent periods, thereby ruling out recessions. The open economic uncertainty (SPFMACRO_U) in Figure 11.2 shows some variability with a higher mean value than the SPFGDP_U, reflecting additional uncertainty stemming from the forecast bias of the exchange rate.

The AVIX_U in Figure 11.3 illustrates that the financial crisis of 2008 was picked up a priori and observed as starker and more persistent. In contrast, the IPU index in Figure 11.4 exhibits substantial uncertainty during the second recession period but very low uncertainty during the financial crisis period. Thus, this finding underlines that the two measures may capture two different types of uncertainty: AVIX_U could be a better proxy for the uncertainty that originates from the financial market, whereas India's IPU measure may be better at capturing a

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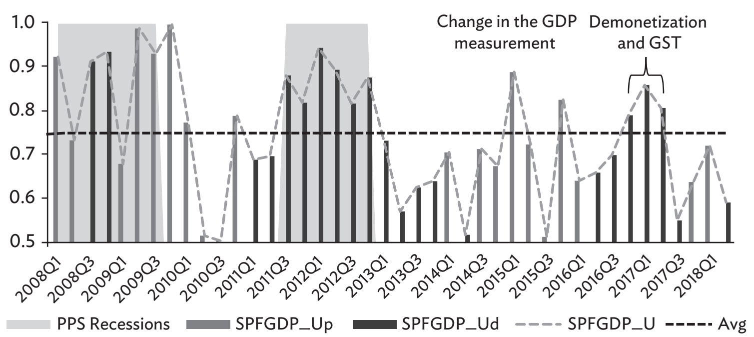
[7] The authors show that their identified recession dates are robust to the methods used and to the choice of the business cycle indicator. We, therefore, consider the recession dates identified by this study for the analysis. For further details, refer to Pandey, Patnaik, and Shah (2017).

broader policy uncertainty. Looking at the IPU spike in Figure 11.4 and related events in India suggests that non-economic events broadly drive it. For instance, in the second recession period between 2011Q3 and 2012Q1, there was a series of political events and scams, such as the coal scam and the 2G spectrum scam, which, along with a nationwide anti-corruption protest, were the primary reasons for the rise in the IPU index and were further amplified by global economic events such as the Fed tantrum policy and the Greek sovereign debt crisis. Thus, when compared with two popular measures, namely the finance-based VIX and news-based IPU, the SPF-based index, as shown in Figure 11.5, provides a good proxy indicator of macroeconomic uncertainty. It not only meaningfully enfolds both the recession periods, but it also rises in other specific economic events such as government switching the GDP measurement from the factor cost to gross value-added methodology,[8] demonetization, and goods and services tax.

Figure 11.1: Plot of SPFGDP_U Uncertainty with PPS Recession Dates



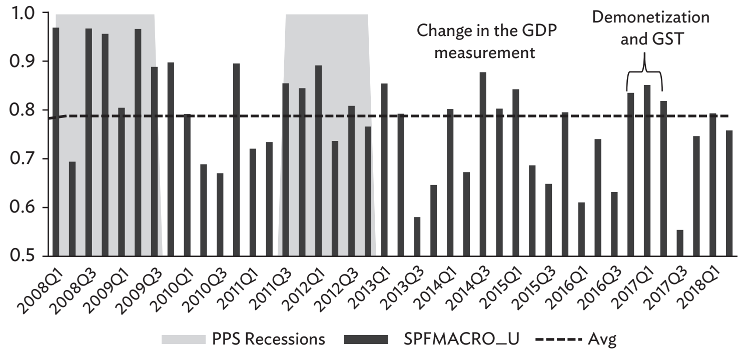
GDP = gross domestic product, GST = goods and services tax, PPS = Index based on Pandey, Patnaik, and Shah (2017).

Note: The shaded area denotes the PPS recession dates, and the horizontal dotted line is the mean value of SPFGDP_U.

Source: Authors' calculations.

8 From January 2015 onward, India's official statistical agency, the Central Statistics Office, started measuring India's GDP growth by gross value-added at basic prices, replacing the previously followed factor cost method of measuring it.

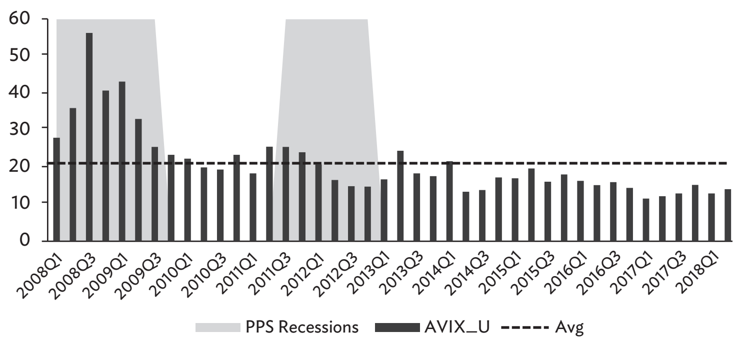
Figure 11.2: Plot of SPFMACRO_U Uncertainty with PPS Recession Dates



GDP = gross domestic product, GST = goods and services tax, PPS = Index based on Pandey, Patnaik, and Shah (2017).

Source: Authors' calculations.

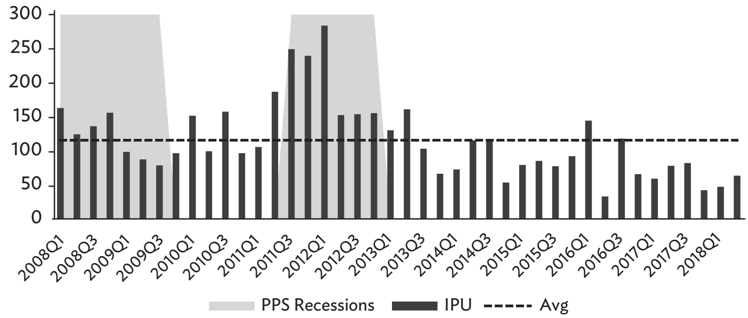
Figure 11.3: Plot of AVIX_U Uncertainty with PPS Recession Dates



PPS = Index based on Pandey, Patnaik, and Shah (2017).

Source: Authors' calculations.

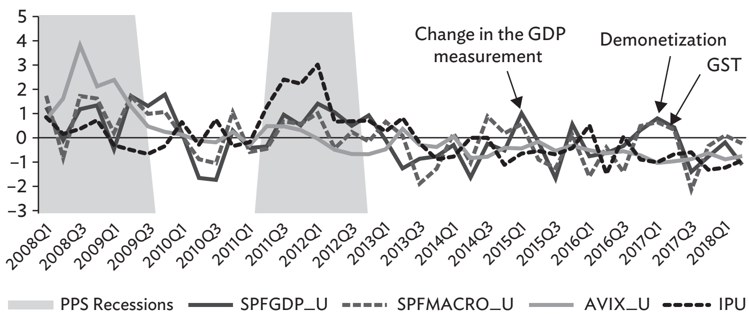
Figure 11.4: Plot of IPU Uncertainty with PPS Recession Dates



IPU = India policy uncertainty, PPS = Index based on Pandey, Patnaik, and Shah (2017).

Source: Authors' calculations.

Figure 11.5: Plot of Measures of Uncertainty with PPS Recession Dates



GDP = gross domestic product, GST = goods and services tax, IPU = India policy uncertainty, PPS = Index based on Pandey, Patnaik, and Shah (2017).

Note: The left axis measures standardized uncertainty series.

Source: Authors' calculations.

11.3.2 Transmission Channels of Uncertainty Shocks

Uncertainty shocks affect both aggregate demand and supply side of the economy through different propagation channel. The "real options" channel predicts that heightened uncertainty affects both the demand and the supply sides of the economy. In a period of uncertainty, firms postpone costly decisions about hiring and investment; once the uncertainty subsides, investment will catch up (Dixit and Pindyck 1994). Thus, the initial fall in investment witnesses a sharp decline in output, and the subsequent rise in investment sees a rebound in the real output (Bloom 2009). Such a horizontal "S" shape-type impulse response of output is known as "uncertainty overshoot". The precautionary savings channel predicts that a rise in uncertainty reduces discretionary consumption, which increases household saving (Carroll 1997). Last, the risk premia channel envisages that uncertainty will adversely affect the demand and supply of a flow of funds in the financial market and predicts increased risk premia and credit speeds, which could negatively influence the real output through low investment. Additionally, heightened uncertainty also discourages banks from supplying funds, which creates tightening credit conditions and eventually results in a decline in the real output (Haddow et al. 2013).[9] To identify various transmission channels of uncertainty, we use the standard vector autoregressive (VAR) models with impulse response and variance decomposition. The standard VAR (p) model is described as follows:

$$X_t = A_0 + B(L)X_{t-1} + e_t$$

where X_t is the vector of endogenous variables, $B(L)$ is a matrix lag polynomial of coefficients, and $e_t \sim N(0, \sum)$. One problem in the VAR analysis of uncertainty is the choice of appropriate identifications and proxy variables. To address this problem, we rely on recursive ordering through Cholesky decomposition of $\hat{\sum}$ to identify structural shocks with alternative ordering and with suitable proxy variables, as described in the following sections. Another problem in VAR modeling is the appearance of nonstationarity in some variables. To this end, the uncertainty literature seems to be oblivious to the stationarity of variables in analyzing the effect of uncertainty shocks. This inattention is partly because the VAR model in levels to some extent affects only the estimators' efficiency but not consistency. Furthermore, Bjørnland

9 With the lack of appropriate data on credit spreads, we do not explicitly assess the risk premia channel. However, its effects can eventually be observed in the reduced investment and industrial output.

(2000) pointed out that time series is not just a random walk process; it may still display transitory fluctuations around a determinist trend. So here we estimated all VAR models in logarithmic level variables except rate variables and uncertainty indicators and included a constant and deterministic trend in the estimation with two lags identified by the Schwarz Bayesian Information Criterion.

11.3.3 Examining the Supply Side of the Real Option Channel of Uncertainty Shocks

A recursively ordered two-variable VAR with log of the index of industrial production (IIP) and an uncertainty measure is used one at a time to examine whether impulse responses of output to shocks to an alternative measure of uncertainty are on expected lines. Figure 11.6 shows the impact of uncertainty measures on industrial production, and the results show that all uncertainty measures except Baker, Bloom, and Davis's 2016 IPU index show an adverse effect on future output. These findings are robust to alternative orderings and including other variables in the model. Given that the impulse response is conditional on information used in the model, we expanded the basic 2-VAR by including business expectations and inflation deviation with the following recursive ordering of the vector of the endogenous variable X' as:

$$X' = [\textit{IIP, Inflation deviation, Business expectations, Uncertainty}] \quad (1)$$

In the above specification, the inflation deviation is the difference between actual inflation and the professional forecasters' expectations. The business expectations are a weighted composite index of an average net response of expectations on nine determinate variables of output. Shock to business expectations, therefore, could be interpreted as shock to first-moment (mean) determinants of output and that uncertainty in the model can be considered as shock to the second movement of output. The equation of IIP in the VAR estimation thus stands for a representative aggregate supply curve.[10] The IIP output in the model is determined by its lags, inflation deviation, business expectations, and uncertainty shocks.[11]

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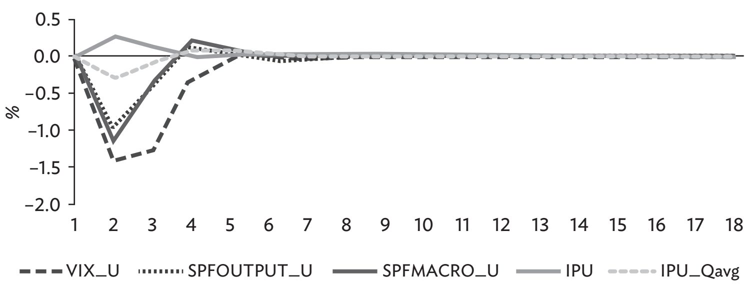
10 The standard aggregate supply curve is determined by the potential output, deviations of the price level from the expected level, and shocks. Specification (1) could be viewed as a representative form of a typical aggregate supply curve.

11 The uncertainty shocks here imply the common variations that exist across macro variables.

The recursive ordering of the specification means that shocks to uncertainty only affect other variables with lags.[12] The relationship between expectations[13] and uncertainty is considered to be closely linked to variables (Baker, Bloom, and Davis 2016; Perić and Sorić 2017). The changes in confidence and uncertainty are unlikely to occur independently (Haddow et al. 2013).[14] Baker, Bloom, and Davis (2016) and Redl (2018) included the confidence variable in their benchmark VAR model to disentangle uncertainty (volatility) from unexpected bad news (a change in mean). The above specification allows changes in the confidence in the form of the expectations variable.[15] The results of the estimation from specification (1) are shown in Figure 11.7. It can be seen that these impulses are similar to the two-variable VAR estimation.

Figure 11.6: Responses of IIP to Alternative Uncertainty Shocks



IIP = index of industrial production, IPU = India policy uncertainty.
Source: Authors' calculations.

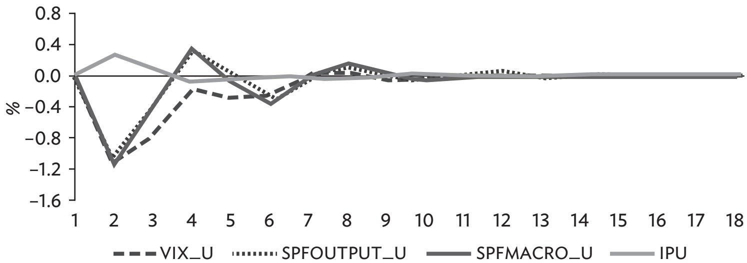
12 This assumes an important policy implication that policy makers will have time to respond to the heightened uncertainty.

13 In the uncertainty literature, confidence and expectations are used as interchangeable terms.

14 Particularly during a crisis period, most often changes in confidence are seen as being driven by shocks to uncertainty.

15 The confidence channel is empirically traced using a survey of expectations; refer to Kamber et al. (2016).

Figure 11.7: Responses of IIP to Alternative Uncertainty Shocks (Specification 1)



IIP = index of industrial production, IPU = India policy uncertainty.

Source: Authors' calculations.

We check the robustness of the impulse response of the IIP in alternative VAR specifications.[16] In particular, we estimate a VAR with the following recursive ordering: uncertainty, inflation deviation, and IIP gap. We also consider a VAR specification (3) that includes Nifty and Call rate, and they are ordered from fast to slow as in Baker, Bloom, and Davis (2016), i.e., placing uncertainty first assuming uncertainty shocks contemporaneously affect all variables. We also estimate VAR specification (2), which considers ordering variables from slow- to fast-moving as in Jurado, Ludvigson, and Ng (2015) and Rossi and Sekhposyan (2015), i.e., putting uncertainty last, assuming it responds to other variables contemporaneously. Specification (2) is taken as the baseline model.

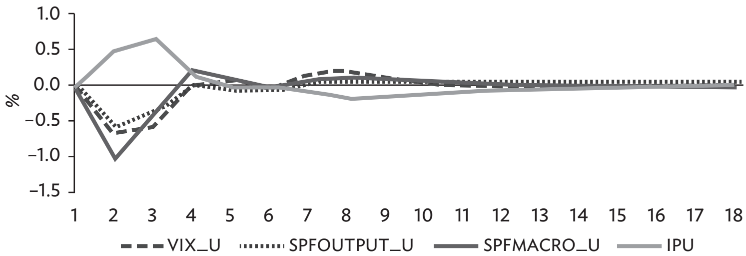
$$X' = [IIP, Call\ rate, Business\ expectations, Nifty, Uncertainty] \quad (2)$$

$$X' = [Uncertainty, Nifty, Business\ expectations, Call\ rate, IIP] \quad (3)$$

A rationale for the above specifications is that all the variables in the level are trend stationary. Table A11.1.2 reports the results of the unit root test. It indicates that all variables are trend stationary while interest rate

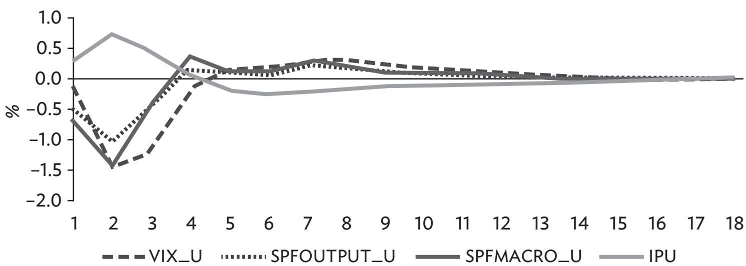
16 Bjørnland (2000) argued that the robustness of the impulse responses will be established if the extended model is consistent and is invariant to an extension of the information used.

Figure 11.8: Responses of IIP to Alternative Uncertainty Shocks (Specification 2)



IIP = index of industrial production, IPU = India policy uncertainty.
Source: Authors' calculations.

Figure 11.9: Responses of IIP to Alternative Uncertainty Shocks (Specification 3)



IIP = index of industrial production, IPU = India policy uncertainty.
Source: Authors' calculations.

variables in the literature are considered stationary variables. Hence, as mentioned above, all VARs are estimated with constant and trend.

The impulse responses of macro variables to each uncertainty measure from the baseline estimation are reported in Appendix 11.2. The results show that barring the IPU, the effects of a shock to AVIX_U and SPF uncertainty measures on all the variables are consistent with the predictions of the effects of uncertainty.[17] Figures 11.8 and 11.9 show the key results from specifications (2) and (3), respectively, that, except for IPU uncertainty, all measures are consistent with the predictions of the supply-side channel of uncertainty. Particularly given that the quarterly growth rate of IIP averaged around 3.15% over the sample period, it is observed that the immediate fall in the production of around 1.40 percentage points is a noticeable effect. Further, the results confirm Bloom's 2009 overshoot prediction of an initial fall in output following an uncertainty shock and subsequent rise over the baseline and then falling back to the baseline. Overall, the results of the supply-side channel show consistency in terms of alternative ordering and also alternative variable sets.

11.3.4 Examining the Demand-side Transmission Channels of Uncertainty Shocks

To identify demand-side transmission channels of uncertainty shocks, we expand the VAR model with variables relevant to the component of aggregate demand.

Real Options Channel of Investment

The investment channel functions on both the demand side and the supply side of an economy. It affects not only aggregate demand today but also the future productive capacity of an economy. To capture this transmission channel of uncertainty, we consider gross domestic expenditure at constant prices (GDE) [18] and gross fixed capital formation (GFCF) with the following recursive ordering of endogenous X' variables as:

$$X' = [GDE, GFCF, Project\ stalling\ rate, \\ Business\ expectations, Call\ rate, Uncertainty] \qquad (4)$$

The project stalling rate is calculated as the total number of stalled projects as a percentage of the overall projects under implementation.[19] The above specification after accounting for aggregate expenditure

[17] Impulse responses of macro variables from specification (3) show similar results. Further, these results do not change, regardless of the quarter end (IPU_Qend) or 3-month average of the IPU index (IPU_Avg) used, as shown in Appendices 2 and 3.

[18] GDE is reported in the ordinal data source as gross domestic product at constant prices measured by the expenditure method with the base year 2011–2012.

[19] We consider the project stalling rate so that it can be comparable across time.

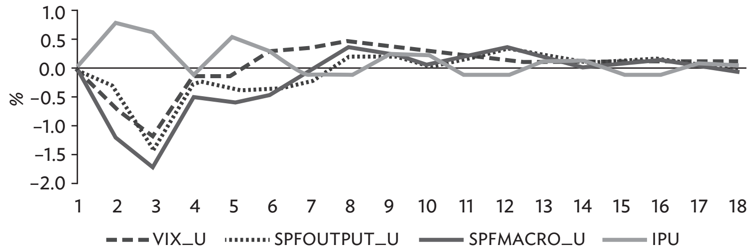
and other first-movement information allows us to assess the impulse responses of investment and project stalling rate to shocks to an alternative measure of uncertainty. We further propose the use of the number of projects announced in place of GFCF as it is directly linked with the wait-and-see decision effect of investment (Bernanke 1983).

$$X' = [\textit{GDE, Number of private investment projects announced, Project stalling rate, Business expectations, Call rate, Uncertainty}] \quad (5)$$

The impulse responses of all variables from estimation 4 to each uncertainty measure are reported in Appendix 3.[20] Again barring the IPU, the impact of AVIX_U and SPF uncertainty is broadly consistent with the theoretical effects of uncertainty. Figure 11.10 shows that, except for the IPU, a rise in the uncertainty is associated with a decline in GFCF. The stalled project rate is an additional indicator of investment slowdown. It is expected that during a period of uncertain environment, firms often hold off on many financial decisions associated with the project. As a result, the stalled project rate may rise. The response of the project stalling rate to uncertainty shocks except for the IPU in Figure 11.11 supports the investment channel. For the robustness of these results, a VAR specification (5) is estimated by replacing GFCF in specification (4) with the number of private projects announced. A similar negative effect of uncertainty shocks on the project's announcement decisions is observed in Figure 11.12. The SPFMACRO_U measure has a maximum uncertainty effect on GFCF, with a peak fall noticed around 1.75% as against the average quarterly rate of GFCF of about 2% over the sample period. The result from specification (4) is robust to a VAR that includes Nifty and also robust to one with the uncertainty measure ordered first and replaces GFCF with the number of projects announced.

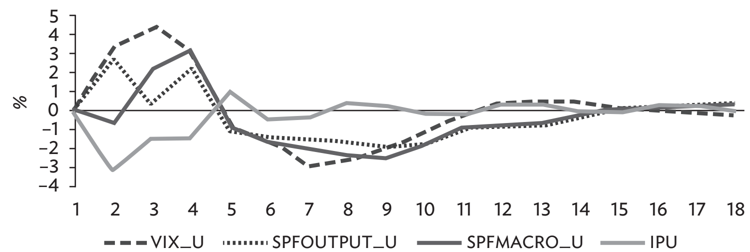
20 It should be noted here that the impulse response results of all specifications from (1) to (8) for all the variables to each uncertainty measure are found to be qualitatively the same as those reported in Appendices 11.2 and 11.3 from specifications (2) and (4).

Figure 11.10: Responses of GFCF to Alternative Uncertainty Shocks



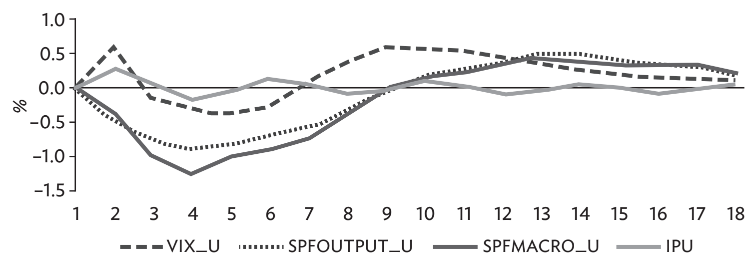
GFCF = gross fixed capital formation, IPU = India policy uncertainty.
Source: Authors' calculations.

Figure 11.11: Responses of Project Stalling Rate to Alternative Uncertainty Shocks



IPU = India policy uncertainty.
Source: Authors' calculations.

Figure 11.12: Responses of Number of Private Investment Projects Announced



IPU = India policy uncertainty.
Source: Authors' calculations.

The Precautionary Channel of Private Consumption and Government Consumption

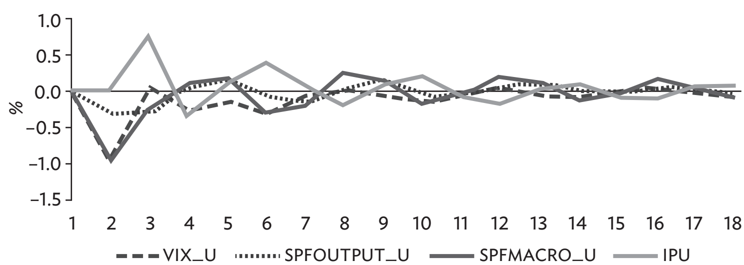
The precautionary saving channel of uncertainty postulates that a rise in uncertainty leads to an increase in household saving and a decrease in discretionary consumption. The consumption effect of uncertainty is expected to have two different effects: on the one hand that heightened uncertainty can induce households to postpone consumption, particularly a discretionary one, analogous to private investment channels; on the other hand, the government may increase its fiscal activity as it responds aggressively to uncertainty with increased spending to stimulate the economy. These two effects are captured using private final personal expenditure (PFPE) and final government expenditure (GFE) with the following recursive ordering of X':

$$X' = [GDE, PFPE, Business\ expectations, Callrate, Nifty, Uncertainty] \quad (6)$$

$$X' = [GDE, GE, Business\ expectations, Callrate, Nifty, Uncertainty] \quad (7)$$

In the case of PFPE response, as shown in Figure 11.13, it appears that its initial response to SPF and VIX uncertainty innovations is supportive of the precautionary savings channel, but it shows a relatively short-lived response—fluctuating around the baseline. This transient reaction is because the PFPE is a poor measure of discretionary expenditure, which

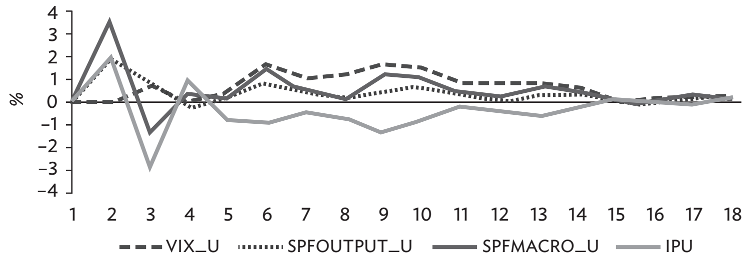
Figure 11.13: Responses of PFPE to Alternative Uncertainty Shocks



PFPE = private final personal expenditure, IPU = India policy uncertainty.

Source: Authors' calculations.

Figure 11.14: Responses of Government Expenditure to Alternative Uncertainty Shocks



IPU = India policy uncertainty.
Source: Authors' calculations.

is expected to be affected most. Therefore, we consider below a small saving as a more suitable variable to trace the precautionary savings channel. The response of government expenditure in Figure 11.14 is consistent with the economic prediction. However, note that the delayed response of government expenditure to AVIX_U shock is indicative of inside fiscal policy lag, but its response is persistent. This finding implies that the government does not respond instantly to uncertainty arising from the stock market until it becomes widespread and persistent.

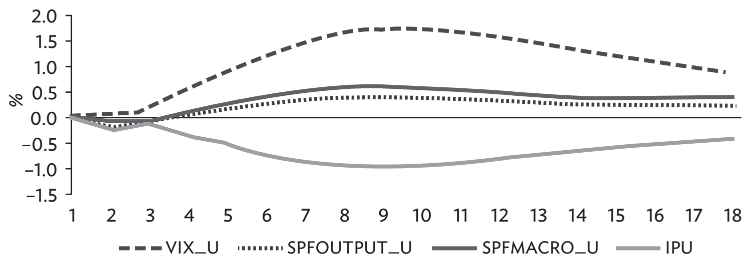
The Precautionary Channel of Saving

The flip side of consumption effect is an increase in precautionary savings following a rise in uncertainty. We trace this effect by replacing private final consumption effect in specification (6) with small saving as:

$$X' = [GDE, \textit{Small saving}, \textit{Callrate}, \\ \textit{Business expectations}, \textit{Nifty}, \textit{Uncertainty}] \qquad (8)$$

The saving response in Figure 11.15 provides evidence of the relative effectiveness of alternative measures of uncertainty. Its response to VIX- and SPF-based measures supports the precautionary savings channel prediction that the small saving rises following uncertainty shock and stays persistently at an elevated level. The highest peak impact is about a 1.75% increase for AVIX_U, followed by about 0.60% for SPFMACRO_U and 0.40% for SPFOUTPUT_U. AVIX_U uncertainty roughly triples the positive impact of uncertainty shocks on small savings. This uncertainty

Figure 11.15: Responses of Small Saving to Alternative Uncertainty Shocks



IPU = India policy uncertainty.

Source: Authors' calculations.

effect on saving is notable as the actual quarterly growth of small savings during the sample period is around 0.90%, and year-on-year growth is about 3.40%. On the other hand, the response of saving to IPU shocks shows an adverse effect, which is inconsistent with a precautionary saving channel.

International Spillovers Channel of Uncertainty

Bloom (2017) postulated that uncertainty shocks in a domestic economy might sometimes originate from a foreign country. We test this proposition by using US VIX uncertainty to assess the international spillover effect of uncertainty using the following ordering of X':

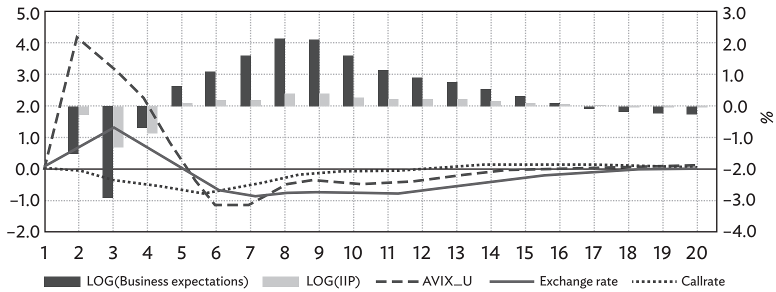
$$X' = [\textit{Foreign uncertainty, domestic uncertainty, Dollar-rupee exchange rate, Business expectations, Caltrate, IIP}] \quad (9)$$

In the above recursive VAR estimation, the foreign/US uncertainty is placed first, and then its response is restricted such that it does not respond to domestic variables, but domestic variables can respond to shocks to the US uncertainty.[21]

Figure 11.16 shows a substantial positive impact of US VIX uncertainty on the domestic VIX uncertainty and exchange rate, and exerts a negative effect on the level of business expectations, IIP, and

21 Specification (9) is similar to that of baseline VAR estimation (2), but it includes the exchange rate to account for uncertainty arising from the external sector.

Figure 11.16: Responses of Domestic Variables to US VIX Uncertainty Shocks



US = United States, VIX = implied volatility index.

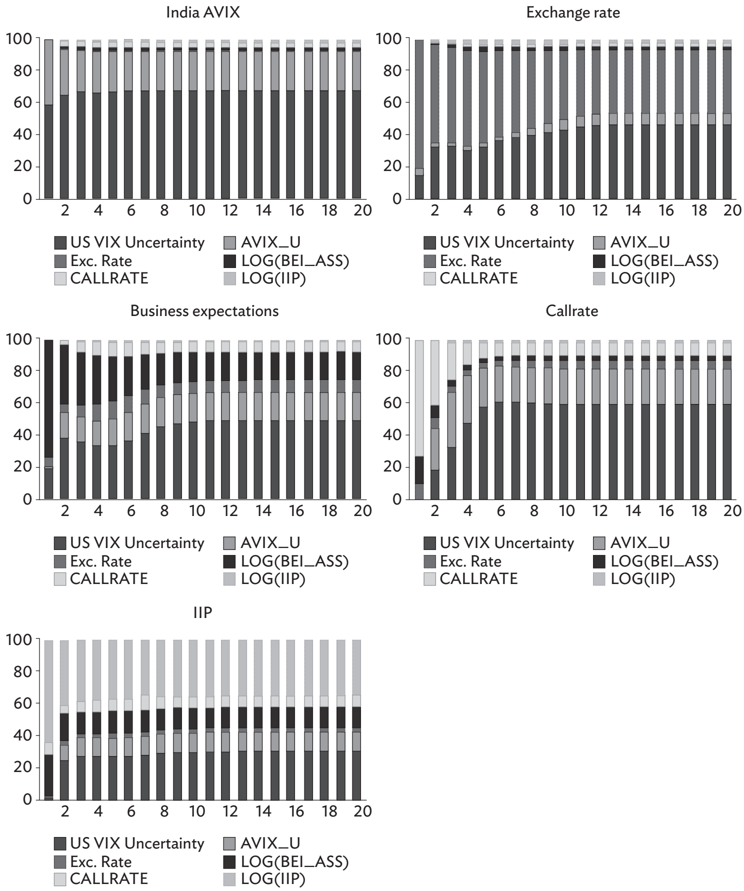
Note: The left axis measures the rate variables, exchange rate and call rate and India's VIX uncertainty index, and the right-hand axis measures the log variables in the percentage.

Source: Authors' calculations.

call rate. These responses are similar to a VAR that uses domestic uncertainty; therefore, they are perfectly consistent with the expected theoretical channels. Further, the results are qualitatively not different to the use of US EPU or world EPU, suggesting that the overall story is intact. We use the variance decompositions of estimation (9) to quantify the actual role of foreign-originated uncertainty shocks in explaining the fluctuation of domestic variables, shown in Figure 11.17. These findings clearly demonstrate that US VIX uncertainty shocks are much more significant than India's VIX uncertainty in explaining the movements of domestic variables.

Overall, the VAR analysis of the uncertainty effect suggests that forward-looking variables are more responsive to uncertainty shocks than variables of current perceptions. The response of fiscal policy shows a considerable inside lag in recognizing the state of the economy and is found to be less effective in terms of size, although along expected lines. On the other hand, the monetary policy decisions are based on the forward-looking framework; hence, call rate responses are seen to be swift and substantial. Similarly, the reaction of business expectations appears to be more profound and substantial vis-à-vis all other responses. However, it also rebounds quickly, signifying that the expectations are data driven and so more rational. Likewise, the investment responses appear to be data driven as responses are more immediate and persistent than their counterpart consumption expenditure.

Figure 11.17: Variance Decompositions of Variables



IIP = Index of industrial production.

Source: Authors' calculations.

11.4 Conclusion

This study constructs the macroeconomic uncertainty indices of Rossi and Sekhposyan (2015) for an emerging economy, India, and considers various other macroeconomic uncertainty indices to validate their suitability in tracing the business cycles and their consistency in shock transmission channels defined by different theoretical channels. Using quarterly data from 2008Q1 to 2018Q2, this study estimates a series of VAR models to identify different uncertainty channels of aggregate demand and supply. The derived measures of uncertainty are at a higher level around recessions and other structural changes like demonetization and GST implementation in India. Further, the empirical results also suggest that uncertainty shocks reduce industrial output, in line with the supply side of the real-option channel and correspondingly reduces the gross fixed capital formation and the number of private investment projects announced as well as raising the project stalling rate, in line with the demand-side channel of investment. Similarly, uncertainty raises household savings while reducing consumption and increasing government expenditure, which is consistent with the precautionary channel.

Finally, this study also examines the international spillover of uncertainty by measuring the effects of US uncertainty measures on the domestic variables. The results show that US uncertainty has a substantial effect in explaining movements of domestic variables, much more than domestic uncertainty, suggesting a significant international spillover effect in the Indian economy. The empirical results also suggest that, among alternative measures, the forecast-based measure of Rossi and Sekhposyan (2015) and the market-based implied volatility measure of Bloom (2009) are found to be suitable proxies for uncertainty, while the news-based economic policy uncertainty of Baker, Bloom, and Davis (2016), which is widely used in developed countries, has not properly captured the state of economic uncertainty in India. This finding may suggest that news-based economic uncertainty indices may not be useful for developing countries since related local sociopolitical events are seen to be a more dominant discourse in the media, and often such uncertainty may die off without any economic recession.

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Appendix 11.1

Table A11.1.1: Data and Sources

Variables	Source
1. US economic policy index (EPU) 2. World policy uncertainty index 3. India's economic policy index (IPU)	http://www.policyuncertainty.com/
4. India's implied volatility index (VIX) data	https://www.nseindia.com/
5. US VIX data	http://www.cboe.com/
6. Business expectations index data	Reserve Bank of India quarterly survey of industrial outlook: https://www.rbi.org.in/
7. Survey of professional forecasters (SPF) data	Reserve Bank of India quarterly survey of professional forecasters (SPF): https://www.rbi.org.in/
8. Gross domestic product (GDP) 9. Gross fixed capital formation (GFCF) 10. Government expenditure (GE) 11. Final private consumption expenditure (PFPE) 12. Index of industrial production (IIP) 13. Number of private investment projects announced 14. Total number of stalled projects 15. The overall number of projects under implementation	CMIE economic outlook database: https://economicoutlook.cmie.com/

Note: All links accessed 26 September 2020.
Source: Authors' compilation.

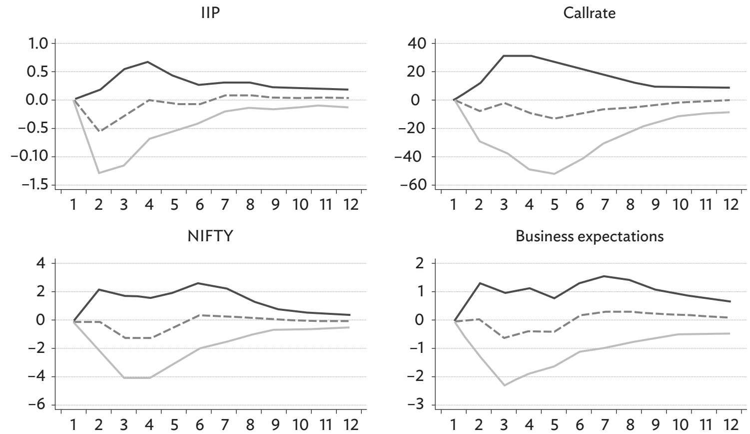
Table A11.1.2: Augmented Dickey-Fuller (ADF) Test Results

Variables	p-Values of Intercept	p-Values of Trend and Intercept
SPFGDP_U	0.00	0.00
SPFMACRO_U	0.00	0.00
AVIX_U	0.29	0.00
IPU	0.05	0.07
log(IIP)	0.39	0.01
log(Nifty)	0.82	0.05
log(Business expectations)	0.03	0.00

Source: Authors' calculations.

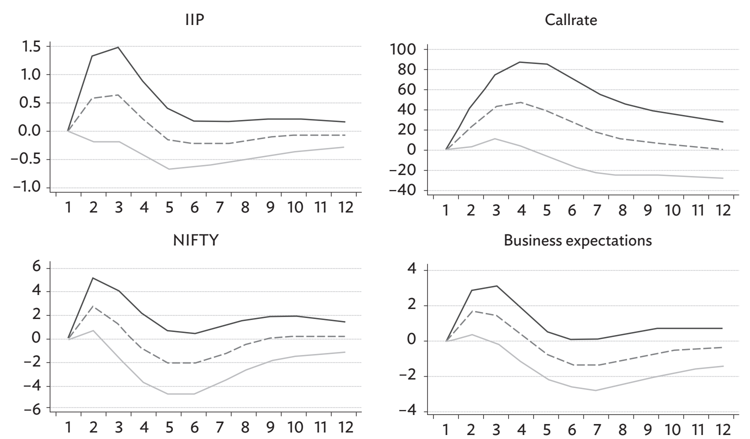
Appendix 11.2:
Impulse Responses of Baseline Specification (2): The Supply Side of the Real Option Channel

Figure A11.2.1: Responses to SPFGDP_U Uncertainty Shocks



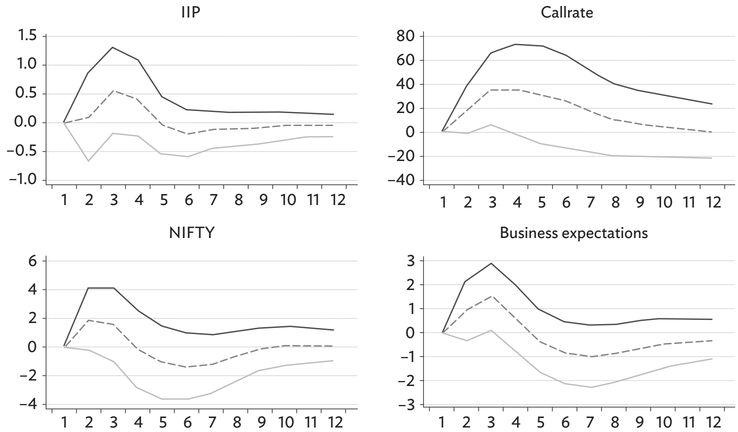
Source: Authors' calculations.

Figure A11.2.2: Responses to IPU_Qend Uncertainty Shocks



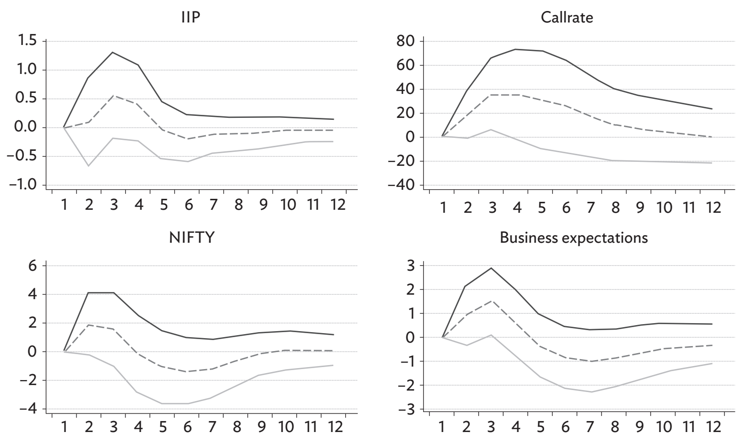
Source: Authors' calculations.

Figure A11.2.3: Responses to IPU_Qavg Uncertainty Shocks



Source: Authors' calculations.

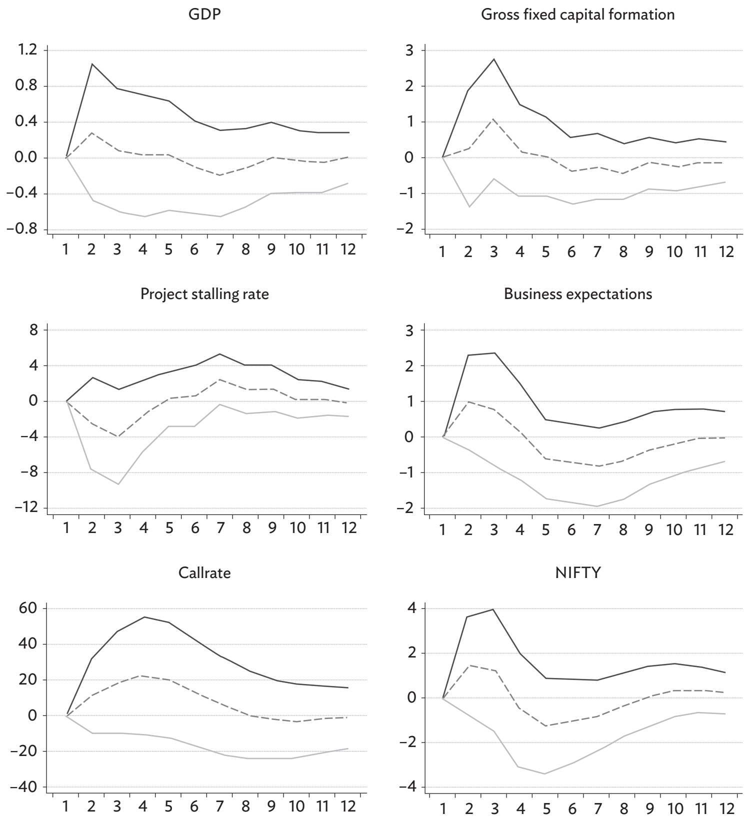
Figure A11.2.4: Responses to AVIX_U Uncertainty Shocks



Source: Authors' calculations.

Appendix 11.3: Impulse Responses from the Specification (4): The Demand-Side Real Option Channel of Investment

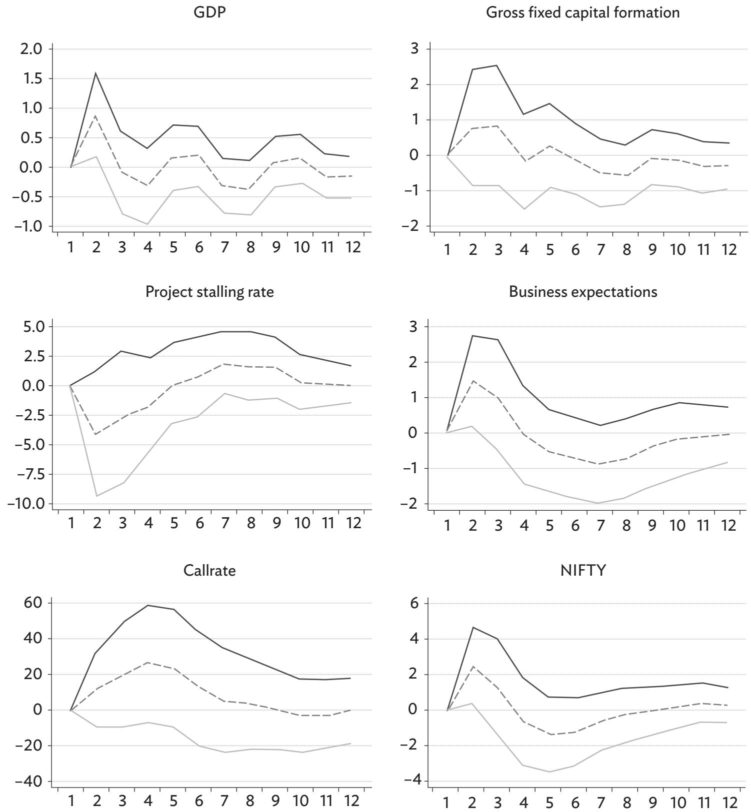
Figure A11.3.1: Responses to IPU_Qavg Uncertainty Shocks



GDP = gross domestic product.

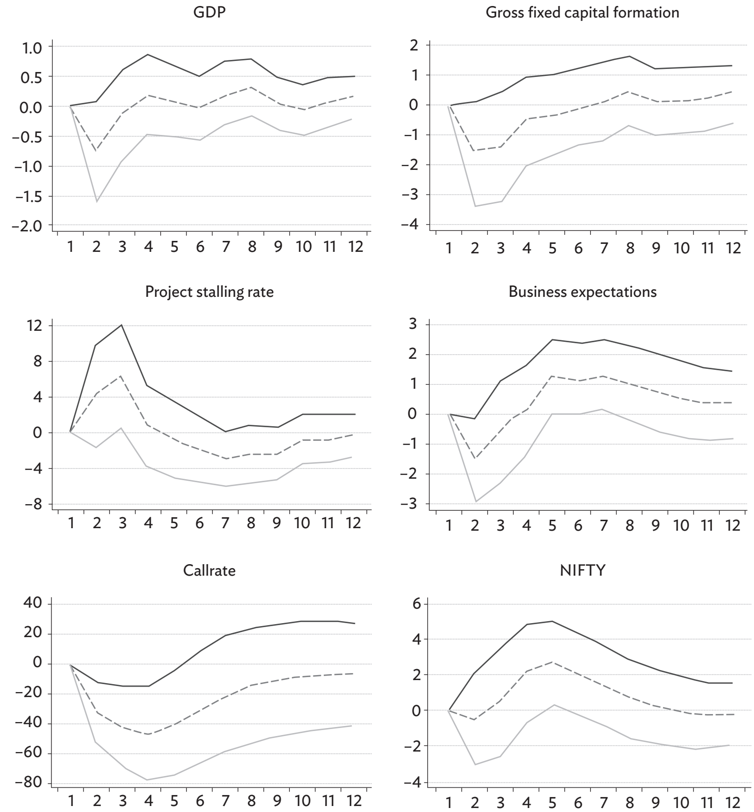
Source: Authors' calculations.

Figure A11.3.2: Responses to IPU_Qend Uncertainty Shocks



GDP = gross domestic product.
Source: Authors' calculations.

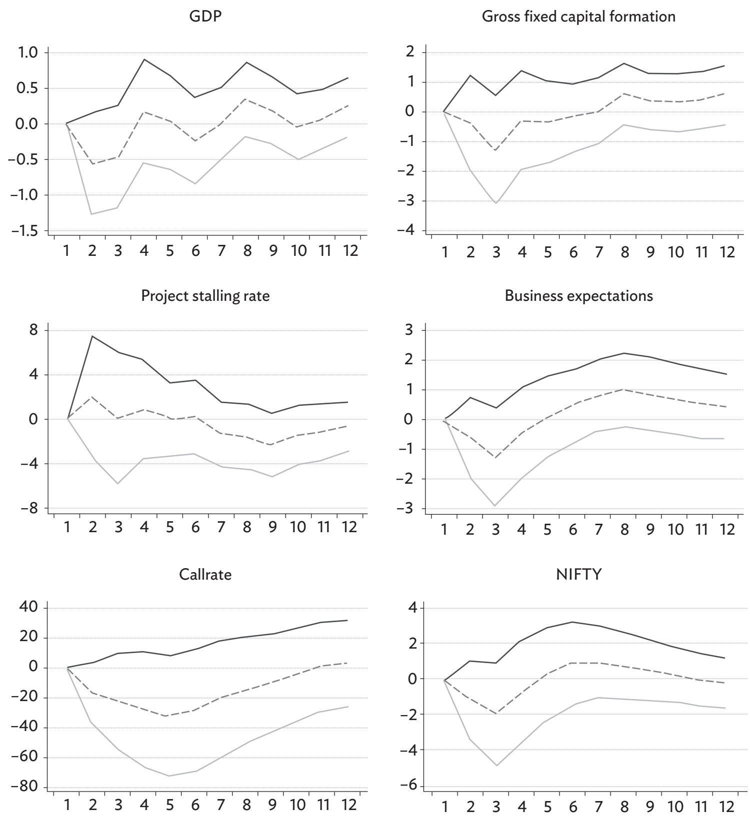
Figure A11.3.3: Responses to AVIX_U Uncertainty Shocks



GDP = gross domestic product.

Source: Authors' calculations.

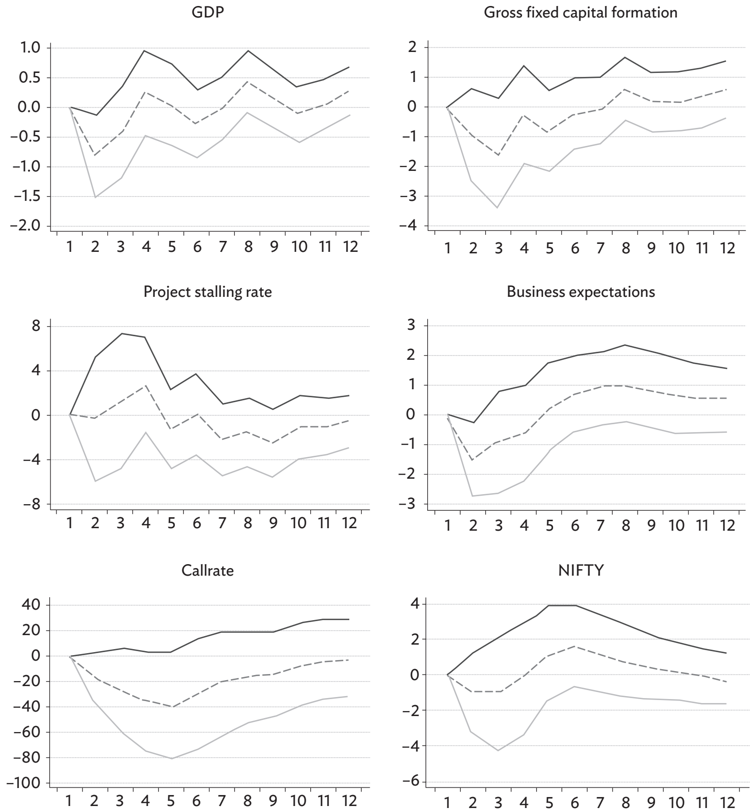
Figure A11.3.4: Responses to SPFGDP_U Uncertainty Shocks



GDP = gross domestic product.

Source: Authors' calculations.

Figure A11.3.5: Responses to SPFMACRO_U Uncertainty Shocks



GDP = gross domestic product.

Source: Authors' calculations.

12

Do Fintech Activities Affect Monetary Policy?

Muhammad Zubair Mumtaz, Zachary A. Smith, and Zafar Mahmood

12.1 Introduction

Over the last decade, the emergence of new financial technologies (fintech) has posed serious threats and challenges to the structure of the financial sector. The evolution of electronic money, digital banking, crowdfunding platforms, and distributed ledger technology raises various concerns for the banking industry and macroeconomic policy (Paternoster and Dessimirova 2017). The innovation in fintech has tremendously changed the accessibility of financial services. For instance, peer-to-peer lending permits customers to get funds in the absence of a banking channel, new modes of payments (e.g., mobile software) allow people to transact through a smartphone, and distributed ledger technology (e.g., blockchain) facilitates new means of reporting and executing transactions. These developments have started to influence the ability of central banks to conduct monetary policy effectively with a goal of financial stability.

In a Global Fintech Summit, Jun Zhu, director-general of the International Department at the People's Bank of China claimed that, "the growth of fintech will have an impact on the formulation and implementation of monetary policy" (CBN 2018). He emphasized that the growth of fintech will generate competition in the financial sector and cause the market to become more responsive to interest rates. This implies that technological innovation increases the sphere of intangible assets that are likely to affect the transmission mechanism of monetary policy. Zhu also argued that fintech could affect price changes based on targets set under monetary policy, and this aspect becomes more prevalent through real-time changes in goods and services via algorithmic technology that may have a significant effect on inflation (CBN 2018).

On another front, International Monetary Fund Managing Director Lagarde (2017) claimed that virtual currencies pose little to no threat to fiat currencies and central banks because they are too volatile, cost too much to maintain, and are not scalable; however, she envisages a future in which countries with weak central banks move to this type of digital currency as the technology evolves. She refers to this as dollarization 2.0, a time in which countries with weak institutions rely on something other than the dollar or a foreign government's currency to provide the necessary functions of money that its citizens demand. She continues to provide an example of Seychelles from 2006 to 2008 and indicates that the dollarization of its currency rose from 20% to 60% during this time. Further, she claims that this movement from current forms of money could improve payment systems by reducing costs for transfers of funds for simple transactions.

Tule and Oduh (2017) examined the impact of financial innovations on the monetary policy in Nigeria during the period from January 2009 to February 2015. They argued that, "the constant substitution of e-money for cash among other things, will enhance the efficiency of production, strengthen the interest rate channel of monetary policy transmission and reduce the effects of price on money demand" (p. 472). Alternatively, it is challenging for the central bank to control the money supply through its influence on the operating goal, surges in the velocity of money, interest rate elasticity of the demand for money, and the cost of monetary policy arising from the trade-off between inflation and output.

The emergence of technological innovations in the financial sector affected the dynamics of businesses as well as the banking system. Digital currencies are used as a model of modern technology to transact business, which may affect the demand for and the supply of money. To raise this concern, it is important to analyze how markets are reacting to fintech instruments. The purpose of this study is to examine the impact of fintech on the monetary policy in developed countries. We consider 25 developed economies and identify the income velocity and money multiplier before and after the initiation of fintech. The results report no change in income velocity and the money multiplier after the era of fintech. The other objective of the study is to investigate the money demand using the generalized method of moments (GMM) estimator. We identify that gross domestic product (GDP), real interest rates, inflation, and wealth are significant determinates. When fintech instruments are included, the results indicate that mobile technology, internet technology, and Bitcoin are the robust predictors of money demand. We also examine the product market equation and cost function and determine that after the start of fintech activities, monetary policy, as proxied for through interest rates, may have an insignificant effect. Moreover, we report that Bitcoin, Ethereum, and Ripple are robust determinants of the output gap. Further, we interact fintech instruments with interest rates, and report that the transmission mechanism of monetary policy may influence the mobile and internet technology, Ethereum, and Ripple. Finally, we investigate the innovations of fintech instruments and find that GDP, real interest rates, inflation, and financial development indexes are the significant factors.

The remainder of this chapter is structured as follows. Section 12.2 provides an overview of the channel of money demand and supply in terms of fintech. Section 12.3 describes the overview of financial technology. Section 12.4 discusses the research methodology and data, Section 12.5 examines the empirical results, and Section 12.6 concludes the study.

12.2 What is Fintech and How Does It Affect the Monetary Policy?

Fintech is generally referred to as "a portmanteau of financial technologies," which is characterized by the financial services of the 21st century. Initially, the innovation process supported and recognized consumer and trade financial institutions, which eventually turned into a full-fledged process by creating digital currencies like Bitcoin and altcoin. Though there are various negative concerns associated with the cryptocurrencies, fintech products affect the sales of banking products, and speed up innovation. Prior studies (Bernanke and Blinder 1988; Arize 1990) explored the influence of financial innovation on the monetary policymaking and the role of central banks. Due to the emergence of the innovation process, central banks are supposed to have a pivotal role in conducting monetary policy after the collapse of the Bretton Woods system (Arize 1990). It seems as though there is a complicated relationship between the central bank and its ability to implement monetary policy, which greatly influences the supply of money or credit throughout the financial system.

12.2.1 The Supply Side

In line with this general idea that central banks had some control over the money supply, Werner (2016) sought to answer the following question: do banks lend existing money or create money? This led to a more nuanced understanding of what the central bank's role is as a supplier of credit and how much influence it might have over the money supply. Werner (2016) indicates that over the last century, there have been three dominant theories about banking's role in the economy. The first is that they act as intermediaries and collect deposits, then lend them out to consumers. The second is that banks on their own are not able to create money, but do so collectively through the fractional reserve system and the multiplier effect. The third suggests that banks do not act collectively, but each individual bank creates credit and money when they make loans. Based on an empirical test and case studies, Werner (2016) indicates that the first two theories are rejected and found empirical evidence supporting the third (similar to Werner 2014).

Traditionally, the suppliers of credit have been banking institutions, not the central bank. Brunnermeier and Sannikov (2016) provide a good overall summary of the role that banks play in terms of monetary policy and the creation of money. According to them, their role is to, "take stakes in the households' risky projects, absorbing and diversifying some of the households' risk. They are active in maturity and liquidity transformation, as they issue liquid, at notice redeemable, (inside) money and invest in illiquid long-term investments." By creating money, the banks take on risks associated with the mismatch between assets and liabilities. When the economy is functioning properly, this process of banks creating inside money for individuals to allow them to make investments in projects that they would otherwise be unable to afford is effective; however, when the economy contracts, banks shrink their balance sheets, the availability of inside money decreases, and the demand for money increases. This is when outside money becomes valuable (i.e., provided by a central authority). They highlight two cases: (i) one in which the banks have sufficient capital and are able to provide households with that capital to invest in projects; and (ii) one in which the banks do not have sufficient capital (either because they choose not to lend or their access to capital is somehow restricted) to provide to the markets.

To understand the issues that are created from the supply side, this chapter uses the convention provided in Braun (2016), which illustrates the differences between inside and outside money and indicates that "legally" only outside money is legal tender. Further, he attempts to discredit the myth that banks use deposits to create loans and suggests that banks make loans, which creates a deposit by expanding its balance sheet through making two offsetting entries, i.e., a loan on the asset side and a deposit on the liability side. Moreover, he contends that banks loan funds and then borrow the necessary reserves to satisfy the United States Federal Reserve (the Fed) requirements for making that loan. So, the creation of inside money is not dependent on the amount of outside money available in the system, but it is dependent on the market's demand for loanable funds. Similarly, he contends that external money is not an exogenous variable under the control of the central authority. Concisely, he explains that "both inside and outside money are endogenous to the interaction of loan demand and lending behaviour in the economy." Finally, he explained that the monetization of "private loans by making them exchangeable with sovereign promises to pay is the hallmark of capitalist credit money, which finds its contemporary expression in central banks' collateralized open market operations. In this public-private partnership, demand deposits created through bank loans make up the largest part of the 'privately contracted debts' that circulate as money."

Prior to fintech and innovations associated with nontraditional lenders, the implementation of monetary policy through more traditional measures (i.e., changing the reserve requirements and increasing or decreasing the monetary base to influence the Federal Funds Rate) seemed like adequate measures to take to successfully implement monetary policy actions. However, as these alternative credit facilities enter the market and are governed by a separate, laxer, set of regulatory oversight, the effectiveness of monetary policy actions could be stymied. Lucas and Nicolini (2015) contend that the relationship between monetary aggregates (such as M1, M2, and the Monetary Base) and prices and interest rates deteriorated in the 1980s and have yet to be re-established (this point is revisited in the section about demand). Therefore, when implementing monetary policy actions, central bankers rely mainly on interest rates as a tool to intervene in markets; hence, monetary aggregates seem to be of little interest to those that implement monetary policy. However, this transmission channel seems to be less effective in a system that has ample liquidity, as is evident today. Wolla (2019) contends that, in an environment where there is ample liquidity flowing through the system, small changes to the supply of reserves will not affect interest rates, in the case of the United States (US), the Federal Funds Rate. To overcome this obstacle, in the US, the Fed has created new rates (i.e., Interest on Excess Reserves, and Overnight Reverse Repurchase Agreements), which it uses to create arbitrage opportunities in the marketplace to force banks to either reduce or expand their borrowing and lending activities. The tools that central banks have previously used to implement monetary policy initiatives seem to be changing and the traditional banks are losing market share to credit- (i.e., money-) creating facilities in the fintech space; these two taken together seem to have some ramifications for the financial markets and the implementation of monetary policy.

As was noted in the introduction, from 2007 to 2015, the shadow banking industry's market share grew from 14% to 38% in the US

(Buchak et al. 2018). Given that the banks and, by association, the shadow banks, play a pivotal role in creating money and the fact that these nontraditional banks are exposed to a different set of standards and oversight, the increase in the market share of this sector leads to questions about how this rise is likely to affect the traditional channels that central banks use to implement monetary policy. There is already evidence that some of the more traditional methods are failing because there is excess liquidity throughout the financial system, i.e., manipulation of the Federal Funds Rate, and some of the institutions issuing credit are not exposed to the same requirements as traditional banks. In light of these emerging issues, this chapter examines how fintech and the rise of the shadow banking industry have influenced the money supply.

12.2.2 The Demand Side

Braun (2016) shows how two primary objectives of money are to strike a balance between elasticity and the public's trust in that money. Hendrickson and Salter (2018) state that a "key factor underlying the utility of money is imperfect commitment" (p. 23). Further, they contend that if individuals knew exactly what they were willing to trade for future actions, then all transactions would be executed on credit; however, in the face of uncertainty, money is necessary to facilitate exchange and it expands the individual's opportunity set. In their opinion, banks exist because of imperfect commitment and uncertainty, because if individuals were certain about their future needs, they would convert a certain portion of their savings to outside money and save the remaining in interest-bearing deposits; as financial innovation persists, the boundaries between these two assets seem to be disappearing.

Reiss (2018) claims that the movement toward a cashless society is neither new nor disruptive, but it has been occurring gradually, with money already becoming digital. Further, he contends that the monetary authorities are already aware of this change. In addition, Reiss (2018), in regards to the demand for money, illustrates that the ratio of cash in circulation outside of banks to broad money (i.e., M4) has been relatively stable from 2006 to 2015 for countries across the globe with a few minor exceptions. The three reasons that they provide for why people rely on an actual currency are: (i) as a medium of exchange when no other forms of payment are acceptable; (ii) as a protection against institutional instability throughout the financial sector; and (iii) for privacy concerns.

Lucas and Nicolini (2015) illustrate a negative relationship between the demand for currencies and M1 over GDP from 1915 to 1980, but indicate the breakdown in this relationship from 1980 onward, primarily due to the definition of M1 and M2 and the fact that the demand for "deposits" has shifted to a demand for money market deposit accounts since the 1980s. After redefining their definition of M1 to include money market deposit accounts, the negative relationship between the ratio of M1 to GDP compared to its opportunity cost (measured by interest rates) remains significant over time. The main purposes of highlighting this finding is to illustrate, as both Ireland (2015) and Lucas et al. (2015) relate, that the standard definitions associated with published monetary aggregates typically fail to illustrate a continued relationship between the monetary aggregates and short-term interest rates, which would question the empirical value of the quantity theory of money. However, as Lucas et al. (2015) illustrate, the relationship between rates and the demand for money is still apparent in practice, but financial innovations affect this relationship and how the theory works empirically.

Ireland (2015) indicates that the quantity theory of money links actual demand to the nominal money supplied by the banks and government through inflation, which provides its sound macroeconomic base. Further, he contends that, normally, central bankers refer to and rely on rates to make adjustments in policy throughout the economy and ignore discussions of the money supply; however, empirically, studies that focus explicitly on engaging in monetary policy actions during times of hyperinflation, central bankers implement policies to restrict the money supply to curtail inflation. Ireland (2015) questions whether monetary policy should be "summarized on observations of interest rates alone" (p. 67), as the New Keynesian models used today seem to suggest. He indicates how the Lucas et al. (2015) model, which illustrated that money demand has been relatively stable over time by creating a new monetary aggregate (similar to Reiss 2018), relates the velocity of money to short-term interest rates as the quantity theory of money predicts, and overcomes objections raised by economists that the association between the monetary aggregate and rates is no longer intact based on their use of traditional proxies for monetary aggregates (Goldfeld et al. 1976). This is because the traditional proxies do not seem to appropriately incorporate alternative forms of money, which are becoming very close substitutes to money as financial innovation changes the monetary policy landscape.

To summarize, the definition of money, both in physical terms and how policy makers measure it, is changing as financial innovations occur throughout the system. The underlying relationships that have been established through empirical studies and theoretical debates pertaining to the quantity theory of money and the relationship between the demand for money, inflation, and rates are still intact; however, the definitions that policy makers use to refer to money aggregates have to change as financial innovations occur in the economy. As the definition of money evolves, the channels that consumers use to access that money is likely to change as well. Policy makers should be more cognizant of the underlying changes in the alternative definitions of money and their potential ramifications for monetary policy as they relate to the quantity theory of money.

12.3 Overview of Financial Technology

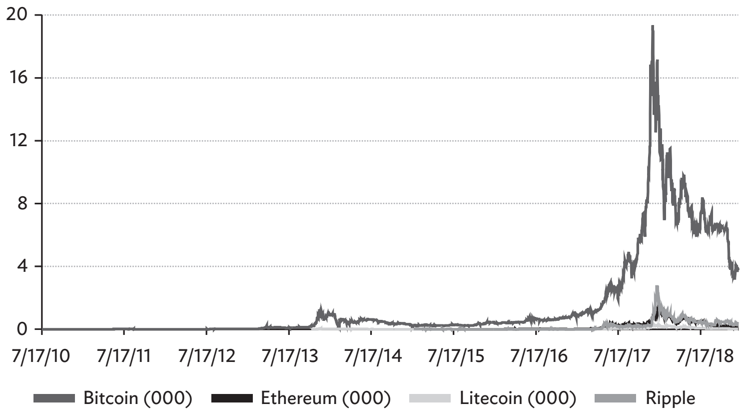
In this study, we consider the instruments of financial technology (fintech), which include mobile technology, internet technology, Bitcoin, Ethereum, Litecoin, and Ripple. This section specifically emphasizes digital currencies—more specifically, digital or virtual currencies that use cryptographic encryption techniques to generate units of the currency and verify transactions.

Digital currency is a broad term that can contain anything that represents value in a digital manner. Digital currency can contain what we would call electronic money, which is simply a digital representation of government-issued fiat currency; it can also cover virtual currency known as electronic currency that is not considered legal tender. Virtual currencies are controlled and created by their developers, with the value being appreciated in a specific community.

Bitcoin is an encrypted currency and a payment system. It was invented by an unidentified programmer or a group of programmers under the name Satoshi Nakamoto. Bitcoin was introduced into a cryptography mailing list on 31 October 2008, and was released as open-source software in 2009. There are various theories and speculations about Nakamoto's identity, but none has been confirmed. The system is peer-to-peer and trades are made directly between users without intermediaries. These transactions are verified by network nodes and recorded in a public distributed ledger called blockchain, which uses Bitcoin as the unit of account. Because the system operates without a central repository or a single administrator, the US Treasury classified Bitcoin as a decentralized virtual currency. Bitcoin is often called the first cryptocurrency, although there were previous systems. It is more accurately described as the first decentralized digital currency; Bitcoin is the largest of its kind. The rest of the digital currencies are gaining popularity.

Figure 12.1 presents the position of closing prices of digital currencies used in this study. Bitcoin is the older version of the cryptocurrency where closing prices were at an all-time high from 2013 to 2018. Litecoin is another digital currency, introduced in 2013; however, its closing prices are the lowest among other similar digital currencies. In

Figure 12.1: Pricing Pattern of Digital Currencies



Source: Authors.

January 2015, Ripple was launched and we can see from Figure 12.1 it is competing with other digital currencies. From our sample, Ethereum is another popular cryptocurrency that came onto market in August 2015; still its prices are compatible from the perspective of the market. While Bitcoin is receiving the attention and interest of investors, other digital currencies are also competitive, and their flows will further be enhanced once they are regularized by the concerned authorities.

12.4 Methodology and Data

To examine the effect of financial innovation on the environment of monetary policy, this study follows the categorization proposed by Meltzer (1978): (i) financial innovations that overcome the regulatory and legal restrictions which may occur in the non-existence of restrictions; (ii) financial innovations that enhance lending and borrowing possibilities which may influence demand for and supply of money; and (iii) financial innovations that have instant effect on a respective kind of institution which may affect the equilibrium of the entire economy.

In terms of financial innovations, earlier studies (Tule and Oduh 2017; Lenka and Bairwa 2016) used proxies like the number of ATMs, point of sales transactions, and online transactions. Since then, there has been a substantial change in the context of financial innovation. Over time, the surge of fintech affects the financial structure, as consumers are using digital currencies for placing their transactions outside the scope of the banking industry. These kinds of business transactions ultimately influence the demand for and supply of money. In this study, we use fintech as a proxy of digital currencies and mobile and/or internet banking to examine their role on money demand and output gap to determine the transmission mechanism of monetary policy. The ensuing subsections elaborate on the modelling framework, sample, and data.

12.4.1 Modelling Framework

This study develops a two-tier model. In the first tier, the surge of money supply (M2) around the world is the result of financial and technological innovation, and this is investigated by employing: (i) the stability of income velocity of money and the money multiplier; and (ii) the stability of demand for money function. The other tier of the model examines whether fintech activities influence the transmission mechanism of monetary policy.

The stability of income velocity of money (υ)and the money multiplier (m) are measured through trend (τ) and can be expressed as:

$$\upsilon = \beta_0 + \beta_1 \tau + \mu_1 \quad (1)$$

$$m = \beta_2 + \beta_3 \tau + \mu_2 \quad (2)$$

Analyzing how fintech affects the money demand function shows how monetary policy influences inflation and output and how the effect of the financial system on growth and development can be observed in the behavior of capital markets and real balances. Previous studies (e.g., Arrau and De Gregorio 1993; Tule and Oduh 2017) argued that long-run money demand function is normally distinguished by periods of “missing money”, unsteady factors, and autocorrelated errors. This consideration is important from the point of view that countries have experienced significant variations in economic conditions and financial markets. In light of these considerations, it is imperative to examine whether monetary policy is influenced by fintech activities and the stability of the demand for money function.

To examine the effect of fintech, we develop the money demand function by considering before and after its initiation. We presume that an equilibrium condition in the money market and the conventional Keynesian real balances, with wealth effect, is written as:

$$ln(m_{it}) = \lambda_0 + \delta_0 \ln(Income) + \gamma_0 r_{it} + \varpi_0 \ln(w) + \varrho_0 \pi + \upsilon_i + \xi_t + \varepsilon_{it} \tag{3}$$

where m_{it} refers to the real demand for money that is formed as the growing function of transactional (y) and uncertainty demand for money (r), and a decreasing function of price (π). We generally assume that an increase in income (δ_0) raises the transactionary demand for money, an increase in the opportunity cost of idle fund (γ_0) reduces the uncertain demand for money, whereas wealth effect (ϖ_0) has a complex connection with money demand (Friedman 1988). ξ_t represents specific time effects and (υ_i) represents unobserved country effects. The simplified version of the model can be expressed as:

$$ln(m_{it}) = \beta_0 + \beta_1 ln(Income_{it}) + \beta_2 r_{it} + \beta_3 \ln(Wealth_{it}) + \beta_4 \pi_{it} + \upsilon_i + \xi_t + \varepsilon_{it} \tag{4}$$

We replace the Keynesian conjecture in Eq. (3) and permit technological development in the form of financial technology (η). As a result, fintech (η) will influence the trade-off between the Keynesian transactionary (y) and uncertain (r) objectives of the demand for real balances as:

$$ln(m_{it}) = \lambda_1 + \delta_1 ln(Income_{it}) + \gamma_1 (r_{it}) + \varpi_1 ln(Wealth_{it}) + \varrho_1 \pi_{it} + \zeta ln(\eta) + \upsilon_i + \xi_t + \varepsilon_{it} \tag{5}$$

We measure (η) in terms of mobile and internet subscribers and digital currencies. Over the past few years, mobile and internet banking enable customers to transact through the online system and the cryptocurrencies provide the opportunity to buy and sell goods without the financial system. The innovation of fintech influences the volume of transactions, as well as the income velocity of money. The simplified form of the model is written as:

$$\begin{aligned} ln(m_{it}) = \; & \beta_0 + \beta_1 \, ln(GDP_{it}) + \beta_2 r_{it} \\ & + \beta_3 Wealth_{it} + \beta_4 \pi_{it} \\ & + \beta_5 \ln(Mobile\ Tech_{it}) \\ & + \beta_6 \ln(Internet\ Tech_{it}) \\ & + \beta_7 ln(Bitcoin_t) \\ & + \beta_8 ln(Ethereum_t) \\ & + \beta_9 ln(Litcoin_t) \\ & + \beta_{10} ln(Ripple_t) + \upsilon_i + \xi_t + \varepsilon_{it} \end{aligned} \quad (6)$$

where GDP_{it} is the natural logarithm of the GDP measured in real terms of country *i* at time *t*, and r_{it} refers real interest rate of country *i* at time *t*, $Wealth_{it}$ is estimated as the logarithm of stock market indices, π_{it} refers to price level, and fintech instruments include mobile and internet subscribers and digital currencies.

The other objective of this study is, thus, to examine the relationship between fintech and monetary policy from two perspectives. First, we formulate an association between the equilibrium interest rate to the output gap. The other factor relates to the output gap that includes the variables relating to fintech and an interaction term of fintech with interest rates. The purpose of interacting both these parameters is to examine the impact of fintech on the credit channel in terms of transmission of monetary policy mechanisms (short-term interest rates). The relationship can be examined by assessing two operational equations: (i) the product market (IS) equation, and (ii) the cost function, that is, the output gap-inflation expectation equation. The output gap is defined as the difference between real and potential output.

The output gap (y_g) is developed through the product market equation, which is a function of one-period lagged of the output gap and real interest rates. The output gap associates the relative demand and supply factors of economic movement and evaluates the extent of inflationary pressure in the economy, which connects inflation and the real economy. By employing the output gap, monetary bodies are presumed to perform in an organized way to overcome uncertainties in output around the natural rate, while, over a similar time period, being constrained by a trade-off between output and inflation. According to Walsh (2002), the central bank is required to stabilize the peripheral costs and assist in policy reforms. Output gap (y_g) is computed as: $y_t - y_t^p$, where y_t is the GDP in real terms and y_t^p is the potential output of the economy at time *t*. Potential output is defined as the level of GDP that is consistent with the full utilization of all factors of production and computed from the Hodrick-Prescott (1997) trend.

Real interest rates are estimated as the variance between the interbank call rate and inflation expectations. It can be measured as $r_t = R_t - \pi_{et}$, where r_t is the real interest rate, which is obtained by deducting inflation from the nominal interest rate (R_t). In light of the primary assumptions, the model implied the equilibrium of the product market, wherein the short-term interest rate clears the market. Hence, a change in interest rate affects the output gap and inflation, thereby impacting the cost of monetary policy.

In a traditional macroeconomic model, the transmission mechanism of monetary policy in the form of the interest rate is included in the IS framework. In the wake of the possibility of price stickiness, an increase in nominal interest rate inflates the cost of capital which restricts investment spending. The IS model is expressed by incorporating the real interest rate and output gap:

$$y_{g_{it}} = \beta_0 + \beta_1 y_{g_{it-1}} + \beta_2 r_{it} + \upsilon_i + \xi_t + \varepsilon_{it} \tag{7}$$

where y_{git} is an output gap of country i at time t, and r_{it} refers to the real interest rate of country i at time t. The effect of fintech on the transmission of monetary policy mechanism is measured by (a) mobile and/or internet banking and cryptocurrencies; and (b) the interaction of fintech with real interest rate. The model is expressed by incorporating the effect of fintech on the monetary policy credit channel of the transmission mechanism:

$$\begin{aligned} y_{g_{it}} = {} & \beta_0 + \beta_1 y_{g_{it-1}} + \beta_2 r_{it} + \beta_3 \pi_{it} \\ & + \beta_4 ln(Mobile\ Tech_{it}) + \beta_5 ln(Internet\ Tech_{it}) \\ & + \beta_6 ln(Bitcoin_t) + \beta_7 ln(Ethereum_t) \\ & + \beta_8 ln(Litecoin_t) + \beta_9 ln(Ripple_t) \\ & + \beta_{10} r_{it} * ln(Mobile\ Tech_{it}) + \beta_{12} r_{it} \\ & * ln(Internet\ Tech_{it}) + \beta_{13} r_{it} * ln(Bitcoin_t) \\ & + \beta_{14} r_{it} * ln(Ethereum_t) + \beta_{15} r_{it} * ln(Litecoin_t) \\ & + \beta_{16} r_{it} * ln(Ripple_t) + \upsilon_i + \xi_t + \varepsilon_t \end{aligned} \tag{8}$$

where π_{it} is the price level, $Mobile\ Tech_{it}$ refers mobile subscribers, $Internet\ Tech_{it}$ represents internet subscribers, and digital currencies include Bitcoin, Ethereum, Litecoin, and Ripple. We interact fintech instruments with interest rates to determine their impact on the transmission mechanism of monetary policy. We expect a negative relationship between fintech instruments and output gap as financial technology provides opportunities to make transactions through the online system as well as digital currencies which positively influence GDP, thereby reducing the output gap in an economy.

The other contribution of the study is to examine the parameters that cause fintech activities. To test this proposition, we formulate the following model:

$$ln(Fintech_t) = \beta_0 + \beta_1 GDP\ per\ capita_{it} + \beta_2 r_{it} + \beta_3 ln(Wealth_{it}) + \beta_4 Inflation_{it} + \beta_5 FDI_{it} + \varepsilon_t \quad (9)$$

where fintech activities are measured through mobile technology, internet technology, Bitcoin, Ethereum, Litecoin, and Ripple. The possible factors that cause fintech instruments include GDP, real interest rates, price level, and stock market indices. FDI_{it} refers to financial development index, which is a proxy of market openness of the financial sector and may influence digital currencies in the world.

Barnett (1978, 1980) initially proposed the Divisia monetary aggregate, which is estimated as the rate of change of the weighted sum of the rates of change of the individual part of assets. The Divisia index of money demand is expressed as

$$lnD_{it} - lnD_{it-1} = \sum_i n_{it}\left(lnM_{d_{it}} - lnM_{d_{it-1}}\right) \quad (10)$$

where *ln* represents the natural algorithm of a variable, D_{it} denotes the Divisia measure of country *i* at time *t*, and $M_{d_{it}}$ is the money demand of country *i* at time period *t*. The composition of Divisia weights (n_{it}) is measured as the money demand share average over the change in two-period $n_{it} = \frac{1}{2}(s_{it} + s_{it-1})$. For $i = 1,.....,n$ where s_{it} is the money demand share of asset *i* during time *t* and measured as: $s_{it} = \frac{p_{it}M_{d_{it}}}{\sum_i p_{it}M_{d_{it}}}$ where p_{it} indicates the user cost of asset *i* at time *t*.

12.4.2 Sample and Data

To examine the above linkages, this study considers 25 developed jurisdictions including Australia, Austria, Belgium, Canada, the People's Republic of China, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Singapore, the Republic of Korea, Spain, Sweden, Switzerland, the United Kingdom, and the US. For money demand and the output gap, this study utilizes quarterly data from 2001Q1 to 2018Q4 by splitting it into two subperiods, i.e., 2001–2009 (before fintech period) and

Table 12.1: Description of Variables and Data Sources

Variable	Description	Data source
GDP_i	Gross domestic product measured in real terms.	DataStream
$y_{g_{it}}$	It refers to the output gap, which is measured by taking the difference between real and potential GDP. Potential GDP is estimated using Hodrick-Prescott filters.	Authors' calculations
r_i	Real interest rate	DataStream
π_i	Inflation	DataStream
M2	A proxy of money supply in the country	DataStream
Mobile technology	Mobile telephone subscriptions that provide access to cellular technology.	World Bank
Internet technology	Fixed broadband subscriptions that provide high-speed access to the internet.	World Bank
Bitcoin	A proxy of digital currency; Bitcoin is considered as the most popular form.	Yahoo.finance
Litecoin	A proxy of digital currency	Yahoo.finance
Ethereum	A proxy of digital currency	Yahoo.finance
Ripple	A proxy of digital currency	Yahoo.finance
Wealth	A proxy of the stock market index of a country.	DataStream
Financial development index	A proxy of a country's financial openness whose value ranges between 1 and 0. Index close to 1 shows a higher value of openness.	IMF

Source: Authors.

2010–2018 (after fintech period). The digital currencies are a new concept and availability of data varies with financial instruments. For Bitcoin, we utilize data from 2010Q1 to 2018Q4, for Litecoin from 2013Q3 to 2018Q4, for Ethereum from 2015Q2 to 2018Q4 and for Ripple from 2015Q1 to 2018Q4. The description of the variables and data sources used in this study are described in Table 12.1.

12.5 Results

12.5.1 Summary Statistics

Table 12.2 presents the summary statistics of the variables used for 25 jurisdictions during the period from 2001Q1 to 2018Q4. The mean value of the natural logarithm of real GDP is 11.929, with a standard

Table 12.2: Summary Statistics

	Mean	Median	Maximum	Minimum	Std. Dev.
ln(GDP)	11.929	12.298	15.257	4.368	2.010
y_g	–0.319	–2.418	11.949	–12.315	2.279
Real interest rate	1.331	0.750	9.500	–0.500	2.212
π	1.834	1.814	12.694	4.478	1.624
ln(M2)	12.552	13.130	17.598	4.905	2.446
ln(Wealth)	7.777	7.752	10.732	3.882	1.328
ln(Mobile technology)	16.809	16.541	21.128	12.740	1.719
ln(Internet technology)	15.467	15.177	19.792	11.601	1.663
ln(Bitcoin)	23.255	25.148	34.595	4.892	7.472
ln(Ethereum)	22.336	24.655	30.148	10.351	6.828
ln(Litecoin)	19.586	18.525	28.838	3.178	5.697
ln(Ripple)	11.300	11.259	23.654	2.370	8.906
Financial Development Index	0.721	0.736	1.000	0.376	0.132

GDP = gross domestic product.

Notes: This table presents the summary statistics of the variables for 25 developed economies during the period from 2001Q1 and 2018Q4. However, the data relating to digital currencies varies.

Source: Authors.

deviation of 2.010. The output gap is measured by taking the difference between real and potential output and its median value is –2.418 with maximum and minimum values ranges between 11.949 and –12.315, respectively. On average, the real interest rate of the sample is 1.33%, with a standard deviation of 2.21%. The maximum and minimum values comprise 9.50% and –0.50% respectively. The mean value of inflation is 1.83%, with a median value of 1.81%. On average, the mean value of the logarithm of money supply (M2) is 12.552, with a standard deviation of 2.446. Wealth is a proxy of the stock market index of a respective country and the mean value of the logarithm of stock market indices is 12.552. The difference between maximum value (10.732) and minimum value (3.882) of ln(Wealth) shows the dispersion among sample countries. Mobile and internet subscribers and digital currencies are used as proxies of fintech. The mean value of mobile and internet technology subscribers is 16.809 and 15.467 respectively.

To observe the impact of digital currencies, this study uses the recognition of cryptocurrencies by a particular country as a dummy variable. The mean value is 0.857, which shows that 24 countries have recognized the activities of digital currencies except for the People's Republic of China. Financial development index refers to the openness of financial markets and its mean value is 0.721 with a standard deviation of 0.132.

12.5.2 Panel Unit Root Test

We use the Levin, Lin, and Chu (2002) method to test the stationarity of panel data. Table 12.3 exhibits the results of the panel unit root test and finds mixed results. Some variables are stationary at level and others at the first difference. To circumvent this problem, this study employs GMM.

GMM is considered superior to the alternatives in handling many econometric problems including endogeneity, heteroscedasticity, serial correlation, and identification. This technique uses a weighting matrix to account for serial correlation and heteroscedasticity of unknown form and for nonlinearities (see Hansen 1982; Newey and West 1987;

Table 12.3: Panel Unit Root Test

	Statistics	Order of integration
ln(GDP)	–17.102***	One
y_g	–4.557***	Zero
Real interest rate	–4.203***	Zero
π	–1.307*	Zero
ln(M2)	–8.039***	One
ln(Wealth)	–9.815***	One
ln(Mobile technology)	–4.315***	One
ln(Internet technology)	–5.306***	Zero
ln(Bitcoin)	–15.822***	Zero
ln(Ethereum)	–11.116***	Zero
ln(Litecoin)	–5.919***	One
ln(Ripple)	–3.263***	Zero
Financial Development Index	–12.292***	One

GDP = gross domestic product.

Note: This table shows the result of the Levin, Lin, and Chu (2002) panel unit root test.

Source: Authors.

White 1984). This technique requires moment conditions. A set of population moment conditions is specified on the regression errors. These set the expected value of the errors and the expected values of the products of errors with exogenous instrumental variables equal to zero. These population moments are then replaced by the sample moments to derive the parameter estimates. Identification in GMM requires that there should be at least as many instruments (including the intercept) and, hence, the moment conditions in each equation as the number of parameters to be estimated. An equation may be under-identified, exactly identified, or over-identified depending on whether the number of instruments and, thus, moment conditions in that particular equation are respectively less than, equal to, or greater than the number of parameters to be estimated.

12.5.3 Stability of Income Velocity and the Money Multiplier

To examine the stability of income velocity and the money multiplier, first we estimate the Hodrick-Prescott trend. This study considers the sample period between 2001Q1 and 2018Q4. The concept of digital currencies was initiated in 2010; thus, it is imperative to analyze the movements of income velocity and the money multiplier before and after fintech periods using the feasible generalized least square estimator (Table 12.4). We divide our sample into two subperiods: (i) 2001Q1 to 2009Q4 (pre-fintech), and (ii) 2010Q1 to 2018Q4 (post-fintech).

The velocity of money is the rate at which it is exchanged in an economy. It gauges the robustness of an economy by measuring the rate at which money in circulation is used for purchasing goods and services. We measure the velocity of money through the nominal GDP scaled by the average amount of money in circulation. During the period from 2001Q1 to 2018Q4 (Model I), the results show that an increase in trend of income velocity by 1% increases the velocity of money by 1.003%. Separating the two periods, we find the same trend in income velocity of money (i.e., 1.002%) prior to the fintech period. After the initiation of fintech activities, we report that income velocity of money surged to 1.026% in each quarter from 2010Q1 to 2018Q4. This shows that money in circulation has not affected the money by the fintech activities.

The money multiplier is also referred to as monetary multiplier, which measures central bank economic stimulus. If the government's goal is to stimulate the economy, they look to the multiplier to help decide how much should be applied and in what way. For example, the US government wants to increase the money supply and make it easier for businesses to access capital and vice versa. The finding suggests that

Table 12.4: Income Velocity of Money and Money Multiplier

	Income velocity			Money multiplier		
	I	II	III	I	II	III
Constant	−0.004 (−0.64)	−0.001 (−0.17)	−0.030* (−1.93)	0.079 (0.91)	0.202 (1.41)	−0.121 (−0.48)
Trend	1.003*** (179.21)	1.002*** (302.13)	1.026*** (72.00)	0.997*** (315.08)	0.993*** (151.57)	1.004*** (109.46)
Wald χ^2	576.02***	598.12***	465.76***	701.31***	521.83***	387.24***
No. of observations	1800	900	900	1800	900	900
Sample period	2001–18	2001–09	2010–18	2001–18	2001–09	2010–18

Notes: This table presents the results of growth of income velocity and money multiplier of 25 countries across different time periods. ***, and * show significance at 1%, and 10% level respectively.

Source: Authors.

an increase in trend by 1% enhances the money multiplier by 0.99% during the entire sample period. Prior to the fintech period, we find the same results as of the entire sample.

12.5.4 Monetary Policy and Money Demand

This section examines the factors that affect money demand using 25 jurisdictions, as well as segregating the sample into pre- and post-era of fintech activities. The purpose of splitting the sample is to analyze the factors that cause money demand before and after the initiation of financial technology. To examine the determinants, we estimate three equations using the GMM technique (Table 12.5). The results of Model I suggest that, as output increases, the money demand in the country increases. The coefficient of real interest rate is negative and significantly influences the money demand, which suggests that, as interest rates fall, this activity generates business opportunities for which investors borrow funds from financial institutions, thereby increasing money demand. The coefficient of inflation is inversely related to money demand but has an insignificant effect. ln(Wealth) is used as a proxy of the stock market indices. In line with the hypothesis on the substitution effect of near money, it has a positive substitution effect on money demand, indicating that, in a given investment portfolio, a rise in the stock prices shifts investors' preferences towards equity investment. This positive activity in the stock market increases the money demand in the country.

Table 12.5: Empirical Results: Monetary Policy and Money Demand

	I	II	III
ln(GDP)	0.118*** (16.79)	0.317** (2.35)	0.522*** (12.61)
Real interest rate	−0.099*** (−4.36)	−0.123* (1.72)	−0.135*** (−8.85)
Inflation	−0.161 (−0.81)	−0.534** (−2.45)	−0.518*** (−6.15)
ln(Wealth)	0.150*** (13.08)	0.318** (2.48)	0.357*** (4.41)
Sargan (*p*-value)[a]	0.41	0.11	0.18
AB 2 (*p*-value)[b]	0.53	0.59	0.40
F-test	83.92***	3.02**	45.48***
Observations	1800	900	900
Sample period	2001Q1–2018Q4	2001Q1–2009Q4	2010Q1–2018Q4

Notes: This table exhibits the results of the effect of monetary policy on the money demand using the GMM technique. The dependent variable is the Divisia index of money demanded. We use three models to estimate the results. ***, ** and * show significance at 1%, 5% and 10% level respectively.

a Sargan test of over-identification.

b Arellano-Bond test that second-order autocorrelation in residuals is zero.

Source: Authors.

Model II presents the empirical results prior to fintech activities and reports that an increase in output of the country generates an increase in money demand, which shows a good omen for the market. With regard to monetary policy, the results report that the significance level is deteriorated to 10%, though it negatively influences money demand. The coefficient of inflation is negative, which demonstrates that a higher price level may inflate the cost of doing business, thereby restricting the demand for money in the country. The stock market indices demonstrate a positive relationship with money demand.

Model III estimates the results of post-fintech activities and postulates that an increase in output and stock market indices results in increased money demand. With the introduction of fintech, the possibilities for investing in the stock market have increased. The results illustrate that if the stock market index increases by 1%, the money demand increases by 0.36% in each quarter. The real interest rate is used as a proxy for monetary policy and we find an inverse relationship between interest rates and money demand. This implies that people choose to use cash alternatives to obtain better returns.

Inflation also had a significantly negative impact on money demand in our analysis. To summarize, we identify that economic output has increased in the post-fintech period due to increased money demand, which is also positively related to stock market activities. However, real interest rates and inflation are negatively associated with money demand.

12.5.5 Fintech, Monetary Policy and Money Demand

To investigate the impact of fintech on money demand, we estimate three models and Table 12.6 reports the empirical findings. In Model I, we estimate the determinants of money demand by considering mobile and internet technologies during the period lasting from 2010Q1 to 2018Q4. The results indicate that the output of the economy positively and significantly influences money demand. Inflation is another significant factor that negatively affects money demand. The monetary policy rate inversely affects the money demand, which shows that firms borrow funds at a lower interest rate and expand their business activities, thereby increasing the money demand in the country. Mobile technology and its use could be an indicator of prosperity in a given country, which would likely increase wealth and the money demand. We find a direct association between internet technology and money demand, which suggests that the internet provides an opportunity for business transactions using online networks, which inflates the demand for money in a country.

In Model II, we incorporate digital currencies to determine their impact on money demand and identify that GDP, real interest rates, and inflation are robust predictors of money demand. Among digital currencies, Bitcoin is the only determinant that inversely and significantly influences money demand. This evidence shows that people are using Bitcoin as a mode of conducting their business transactions, which restricts the possibilities of transacting in cash and eventually reduces the money demand in the economy. This finding holds true, as Bitcoin is being used as the major facilitator of business activities. However, we did not find any evidence of other digital currencies affecting money demand.

In Model III, all the fintech instruments are added to find their impact on money demand. We report that mobile and internet technologies are significantly influencing money demand, which illustrates that access creates opportunities for businesses to transact with consumers. Bitcoin is the sole predictor among digital currencies that enable business activities using blockchain, thus reducing the money demand.

Table 12.6: Empirical Results: Fintech, Monetary Policy, and Money Demand

	I	II	III
ln(GDP)	0.218*** (1.95)	0.481*** (10.18)	0.605*** (10.94)
Real interest rate	−0.143* (−1.84)	−0.272** (−2.56)	−0.426*** (−3.46)
Inflation	−0.255*** (−3.93)	−0.544*** (−5.08)	−0.568*** (−5.74)
ln(Wealth)	0.462*** (5.12)	0.159 (1.55)	0.200* (1.68)
ln(Mobile $Tech_t$)	0.261** (2.02)		0.525*** (4.70)
ln(Internet $Tech_t$)	0.425*** (2.03)		0.619*** (4.19)
ln($Bitcoin_t$)		−0.286*** (−2.96)	−0.227** (−2.22)
ln($Ethereum_t$)		−0.024 (−1.38)	−0.029 (−1.42)
ln($Litcoin_t$)		−0.005 (−1.02)	−0.008 (−1.23)
ln($Ripple_t$)		−0.007 (−0.15)	−0.019 (−0.47)
Sargan (*p*-value)[a]	0.31	0.39	0.50
AB 2 (*p*-value)[b]	0.78	0.93	0.92
F-test	43.92***	25.88***	22.17***
Observations	900	600	600
Sample period	2001Q1-2018Q4	2001Q1-2009Q4	2010Q1-2018Q4

Notes: This table exhibits the results of the effect of monetary policy on the output gap using the GMM technique. The dependent variable is the Divisia of money demanded. ***, ** and * show significance at 1%, 5% and 10% level respectively.

a Sargan test of over-identification.

b Arellano-Bond test that second-order autocorrelation in residuals is zero.

Source: Authors.

12.5.6 Monetary Policy and the Output Gap

To examine the effect of monetary policy on the output gap, we estimate three models using the GMM technique. Table 12.7 presents the finding of monetary policy on the output gap. Model I covers the

Table 12.7: Empirical Results: Monetary Policy and the Output Gap

	I	II	III
$y_{g_{t-1}}$	0.991*** (616.74)	1.010*** (404.86)	1.022*** (97.93)
Real interest rate	−0.386*** (−7.74)	−0.531*** (−16.01)	−0.077 (−1.54)
Sargan (*p*-value)[a]	0.43	0.33	0.16
AB 2 (*p*-value)[b]	0.67	0.34	0.18
F-test	901.71***	919.18***	546.98***
Observations	1800	900	900
Sample period	2001Q1–2018Q4	2001Q1–2009Q4	2010Q1–2018Q4

Notes: This table exhibits the results of the effect of monetary policy on the output gap using the system GMM technique. The dependent variable is the output gap (y_{g_t}). $y_{g_{t-1}}$ represents the lagged output gap. ***, ** and * show significance at 1%, 5%, and 10% level respectively.

a Sargan test of over-identification.

b Arellano-Bond test that second-order autocorrelation in residuals is zero.

Source: Authors.

period lasting from 2001Q1 to 2018Q4. The output gap measures how far the economy is from its full employment or potential level. It is a noisy signal of economic activity as it is based on the potential output, which is unobservable and depends on estimates of GDP. The result shows that the lagged output gap positively and significantly affects the output gap (y_{g_t}). We also report that the coefficient associated with the real interest rate negatively and significantly influences the output gap. This shows that a decrease in real interest rate reduces the cost of borrowing, thereby increasing the output of the economy.

We divide our sample into pre- and post-fintech emergence periods to examine the effect of monetary policy on the output gap. Model II shows that the real interest rate inversely influences the output gap and Model III shows that the real interest rate has no effect on the output gap. This illustrates that there is excess liquidity throughout the financial system and traditional monetary policy tools may no longer be useful tools to conduct monetary policy interventions.

12.5.7 Fintech, Monetary Policy, and the Output Gap

This section investigates the impact of fintech instruments on the output gap and their interaction with interest rates through estimating five equations using GMM (Table 12.8). In Model I, we consider mobile

Table 12.8: Empirical Results: Fintech, Monetary Policy, and the Output Gap

	I	II	III	IV	V
$y_{g_{t-1}}$	1.011*** (560.96)	0.919*** (204.94)	1.011*** (468.73)	0.918*** (190.37)	0.914*** (106.01)
Real interest rate	−0.452*** (−7.89)	−0.525*** (−4.19)	−0.128*** (−6.15)	−0.073 (−1.05)	−0.177*** (−2.98)
ln(Mobile $Tech_t$)	−0.187*** (−8.23)		−0.374*** (−11.06)		−0.335*** (−3.59)
ln(Internet $Tech_t$)	−0.304*** (−7.84)		−0.624*** (−10.82)		−0.005*** (−3.50)
ln($Bitcoin_t$)		0.304** (2.58)		0.423** (2.10)	0.608** (2.50)
ln($Ethereum_t$)		0.226*** (4.34)		0.403*** (3.85)	0.253* (1.89)
ln($Litecoin_t$)		0.043 (0.67)		−0.114 (−0.96)	−0.182 (−1.26)
ln($Ripple_t$)		−0.064 (−1.50)		−0.122 (−1.57)	−0.190** (−2.02)
r_t * ln(Mobile $Tech_t$)			−0.048*** (−7.01)		−0.058** (−2.59)
r_t * ln(Internet $Tech_t$)			−0.075*** (−6.48)		−0.097*** (−2.81)
r_t * ln($Bitcoin_t$)				−0.042 (−0.60)	−0.045 (−0.54)
r_t * ln($Ethereum_t$)				−0.075* (−1.92)	−0.172*** (−3.48)
r_t * ln($Litcoin_t$)				−0.043* (−1.93)	0.045 (0.85)
r_t * ln($Ripple_t$)				−0.000 (0.22)	−0.097*** (−2.81)
Sargan (*p*-value)[a]	0.23	0.20	0.19	0.29	0.68
AB 2 (*p*-value)[b]	0.15	0.18	0.14	0.28	0.30
F-test	616.45***	523.98***	673.92***	489.56***	632.89***
Observations	900	550	900	550	550

Notes: This table presents the empirical findings of fintech and monetary policy using the generalized method of moments covering 25 developed economies during the period lasting from 2010Q1 to 2018Q4. t-values are reported in parenthesis. ***, ** and * show significance at 1%, 5%, and 10% level respectively.

[a] Sargan test of over-identification.

[b] Arellano-Bond test that second-order autocorrelation in residuals is zero.

Source: Authors.

and internet technologies as proxies of fintech. The effect of internet technology on the output gap is indicative of an increase in aggregate demand, which increases the country's production capacity. On the other hand, mobile technology negatively influences the output gap, which illustrates that the output increases as people are able to make transactions using it. However, both of these variables have a significant effect on economic output.

We include Bitcoin, Ethereum, Litecoin, and Ripple to inquire about their impact on output as well as interaction with interest rates. Model II suggests that the economy is affected positively by Bitcoin, which increases the difference between actual and potential output. The coefficient of Ethereum is positive and significantly affects the output gap of the economy. However, other digital currencies are insignificantly contributing to the output of the countries in this study.

The other objective of the study is to determine the effect of fintech instruments along with the real interest rate. In Model III, we interact both mobile and internet technologies with real interest rates and find that they decrease the output gap, showing the importance of the interest rates. There is a surge in the volume of mobile-based banking transactions, including borrowing funds, which ultimately affects monetary policy. We also report a negative effect associated with both interest rates and internet technology on the output gap that illustrates that this mode of fintech provides an opportunity for firms to obtain bank funds and increase their production facilities, which lowers the output gap of the economy.

In Model IV, we employ other fintech instruments to find their impact on the real interest rates, showing that only Ethereum and Litecoin affect the output gap. The final model interacts all fintech instruments with interest rates, reporting that Bitcoin, Ethereum, and Ripple are significantly affecting the output gap but their directions are different. These digital currencies may influence the financial system once they are used for business transactions; however, alternatively they are affecting the output of the economy. In terms of the interaction of interest rates, Ethereum and Ripple may influence the transmission mechanism of monetary policy as well as the output gap. An attempt to explain these results is as follows: Ripple helps businesses to convert currencies when engaging in global trade; so, Ripple may reduce the output gap by creating efficient ways for businesses to accept and convert global payments and Bitcoin and Ethereum may be used more as alternatives to money in countries that have questionable governance regimes.

12.5.8 Determinants of Fintech Activities

Considering the importance and development of financial technology over the past few years, we determine the factors that cause innovation and development of fintech. In this context, we use GDP, real interest rate, inflation, financial development index, and wealth as the predictors that may affect financial technology. Table 12.9 presents the results of the empirical findings.

Model I shows that the coefficient of GDP is positive and significantly influences the mobile technology variable. This illustrates that mobile technology is utilized for business transactions, which may increase production activities in the country. However, the coefficient of other variables is insignificant. In Model II, we identify the factors that influence internet technology and report that GDP and inflation

Table 12.9: Determinants of Fintech Activities

	I (Mobile Tech)	II (Internet Tech)	III (Bitcoin)	IV (Ethereum)	V (Litecoin)	VI (Ripple)
lnGDP	0.701*** (4.50)	0.037*** (4.09)	0.599*** (5.59)	0.686*** (5.74)	0.180* (1.98)	0.326*** (3.25)
Real interest rate	0.003 (0.80)	0.000 (1.01)	–0.454* (–2.01)	–0.587* (–1.78)	–0.511** (–2.39)	–0.528** (–2.33)
Inflation	–0.004 (–1.01)	–0.000 (–0.49)	–0.496* (–1.92)	0.991*** (3.59)	0.978** (2.25)	0.145*** (3.75)
FDI	0.229 (0.73)	0.037* (1.83)	0.274 (0.17)	0.367** (2.80)	0.100 (0.53)	0.618 (0.34)
ln(Wealth)	0.011 (0.61)	0.387 (0.33)	0.432*** (7.31)	0.179 (1.59)	0.149*** (7.87)	0.117*** (6.72)
Sargan (*p*-value)[a]	0.16	0.17	0.38	0.41	0.36	0.20
AB 2 (*p*-value)[b]	0.78	0.23	0.61	0.30	0.28	0.32
F-test	4.51***	5.23***	50.59***	68.17***	99.33***	125.67***
Observations	900	900	900	400	550	550

Notes: This table presents the factors that cause fintech instruments considering 25 jurisdictions during the period from 2010Q1 to 2018Q4. The t-values are reported in parenthesis. ***, ** and * show significance at 1%, 5% and 10% level respectively.

[a] Sargan test of over-identification.

[b] Arellano-Bond test that second-order autocorrelation in residuals is zero.

Source: Authors.

are robust predictors. Presently, it is a general practice that businesses are interconnected, thereby increasing GDP. We further identify that higher-level reforms relating to regulations of financial development facilitate businesses flourishing using internet technology.

We also classify four digital currencies to examine their determinants (Model III to VI). In Model III, Bitcoin is employed as an important mode of fintech and the results reflect that it increases production activities. In the event of lower real interest rates and inflation, the volume of trade in Bitcoins is higher. To emphasize the substitution effect of money, firms make transactions, which increase the use of Bitcoin. An increase in Bitcoin trading volume provides an opportunity for the investors to get funds and invest in firms listed on the stock market to get abnormal returns. The other digital currencies like Ethereum, Litecoin, and Ripple indicate the same determinants as Bitcoin except inflation. In summary: (i) stronger financial development regulations promote digital currencies to trade in a rigorous manner; (ii) fintech instruments generate competition and promote stock market development; and (iii) the trading possibilities of fintech create opportunities to increase the output of the country.

12.6. Conclusion

With the innovation associated with financial technology around the world, the dynamics of the financial system have drastically changed. Firms use different modes of fintech to facilitate business transactions, which may influence income velocity, money demand, and output gap for different countries. Fintech is a novel concept that may also influence the transmission mechanism of monetary policy. To address these concerns, this study empirically investigates the role of fintech in the transmission mechanism of monetary policy.

First, we report that there is no effect in income velocity and the money multiplier after the initiation of fintech activities. We also evaluate the money demand function and identify that GDP, real interest rates, inflation, and stock market indices are significant factors that affect money demand. By incorporating the fintech instruments into the money demand function, we identify that mobile technology, internet technology, and Bitcoin are influencing the money demand, while the other digital currencies have no effect.

We also examine the relationship between monetary policy and output gap and identify that, in the post-fintech era, the former may have an insignificant effect on the latter. In addition, we included fintech instruments as well as their interaction with the real interest rates to explore their relationship with the output gap. This study determines that Bitcoin, Ethereum, and Ripple are significant determinates of the output gap, whereas the transmission mechanism of monetary policy may influence mobile and internet technology, Ethereum, and Ripple. Lastly, we examine the factors affecting fintech instruments and find that GDP, the real interest rate, inflation, the financial development index, and stock market indices are the robust factors that influence fintech instruments.

This study is useful for policy makers and should aid them in constructing a regulatory framework for digital currencies which may be implemented in true spirit and with consideration of the income velocity, money demand, and monetary policy. As these financial innovations become more commonplace and the historical data associated with them increase, researchers will be able to formulate a clearer picture of the relationship between monetary policy and fintech activities, specifically focusing on the transition mechanism.

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Foreign-Currency Exposures and the Financial Channel of Exchange Rates: Eroding Monetary Policy Autonomy in the Asia and Pacific Region?

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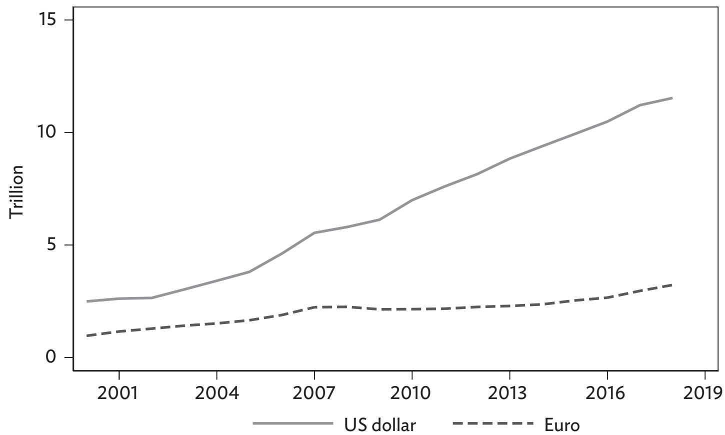
13.1 Introduction

A cornerstone of international macroeconomics is the notion that exchange rate flexibility confers monetary policy autonomy. The underlying rationale is that because in a flexible exchange rate regime the future exchange rate may change, deviations of a small open economy's (SOE) interest rate from that in the rest of the world do not represent arbitrage opportunities and can hence persist. A large empirical literature has documented that the data have been consistent with this prediction since the 1970s and even over much longer, historical time periods (see, for example, Shambaugh 2004; Obstfeld, Shambaugh, and Taylor 2005; Klein and Shambaugh 2015). However, much has happened relative to the time periods studied in most of this literature. For one thing, financial globalization has taken off. For example, developed economies have accumulated large international investment positions, almost quadrupling the ratio of gross foreign assets and liabilities to gross domestic product (GDP). Emerging market economies (EMEs) have accumulated smaller international investment positions, but, in contrast to developed economies, exhibit large foreign-currency exposures. Particularly in the aftermath of the global financial crisis when interest rates in developed economies reached historic lows, EMEs issued large amounts of foreign-

Figure 13.1: Evolution of US Dollar and Euro Nonresident Credit



US = United States.

Note: The figure displays the evolution of US dollar and euro credit (bank loans and debt securities) of nonresidents and nonbank entities. The data are taken from the Bank for International Settlements Global Liquidity Indicators (BIS 2019).

Source: Authors.

currency-denominated debt (Aldasoro and Ehlers 2018; BIS 2019). Figure 13.1 plots the evolution of total cross-border credit—including corporate bonds and bank loans—denominated in United States (US) dollars and euros to nonfinancial corporations. Clearly, both have risen substantially, even since the global financial crisis. In this study, we explore whether foreign-currency exposures that were accumulated since financial globalization took off have implied trade-offs between financial stability and macroeconomic stabilization and eventually eroded monetary policy autonomy as reflected in the "fear of floating" in SOEs in the Asia and Pacific region.[1]

It is widely known that foreign-currency exposures come with risks, as was vividly illustrated by a series of EME crises in the 1990s; hence the term "original sin" (Eichengreen and Hausmann 1999). For example, Durdu, Martin, and Zer (2019) document that US monetary policy tightening has continuously raised the probability of banking and currency crises in the rest of the world since 1870,

[1] Georgiadis and Zhu (2019) consider a broader country sample.

especially when economies exhibited foreign-currency exposures. In particular, when an SOE's exchange rate depreciates—for example in response to a US monetary policy tightening—then foreign-currency liabilities become more difficult to service and to roll over, which might eventually put financial stability at risk (Bruno and Shin 2015). Against this background, SOE monetary policy may try to reduce exchange rate variation in a floating regime by mimicking base-country monetary policy; it may do so both in order to avoid foreign-currency exposures building up in the first place when the local currency has appreciated, and later in order to preserve financial stability when the local currency faces depreciation pressures after the accumulation of foreign-currency exposures. As a result, in this case, monetary policy would not only be geared toward stabilizing the business cycle, but also towards dampening the financial cycle. As these cycles are in general not synchronized and the transmission lags of monetary policy are different, foreign-currency exposures imply a trade-off. In other words, despite—and, in fact, precisely because of—a flexible exchange rate, monetary policy autonomy in the sense of being able to focus exclusively on macroeconomic stabilization would be reduced due to a trade-off with financial stability implied by foreign-currency exposures.[2] Whether it is optimal for SOE monetary policy to reduce exchange rate variation in order to dampen the financial cycle rather than focus exclusively on macroeconomic stabilization depends on the strength of this "financial channel of exchange rates," and is thus an empirical question (Gourinchas 2018). But at least some policy makers claim that such a financial channel of exchange rates operating on foreign-currency exposures is large in their economies (Basci, Ozel, and Sarikaya 2008; Gudmundsson 2017; Vegh et al. 2018).[3]

Early work discussing how SOE monetary policy may be reluctant to let the exchange rate float freely due to foreign-currency exposures goes back to Calvo and Reinhart (2002). More recently, a growing

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2 Foreign-currency exposures may also imply a trade-off between output and inflation stabilization. In particular, as an SOE's exchange rate depreciates, the tightening in local financial conditions resulting from foreign-currency liabilities becoming more difficult to both service and roll over may depress output growth, while inflation may still be rising due to increasing local-currency import prices. The latter is particularly pronounced in the case of dominant-currency pricing, i.e., global import prices, even for trade not involving the US being invoiced in US dollars (Gopinath et al. 2020; Georgiadis and Schumann 2019).

3 Notice the subtle point also mentioned by Gourinchas (2019) that, for policy makers to decide to reduce exchange rate variation, it is sufficient that they believe such behavior to be optimal, regardless of whether this is true given the structure of the economy.

body of work has explored optimal monetary policy in the presence of foreign-currency exposures in state-of-the-art New Keynesian general equilibrium models. Specifically, Aoki, Benigno, and Kiyotaki (2018) study an SOE with currency mismatches on banks' balance sheets. In the model, movements in the exchange rate triggered by shocks to foreign interest rates amplify spillovers to the SOE by worsening the balance sheets of banks, creating a trade-off between macroeconomic stabilization and financial stability. Davis and Presno (2017) consider an SOE model with collateral constraints in which variation in capital inflows triggered by shocks to foreign interest rates jeopardize financial stability. In the model, optimal monetary policy in a floating exchange rate regime manages the SOE's external accounts by mimicking foreign monetary policy. Akinci and Queralto (2019) consider a two-country model in which spillovers from a US monetary policy tightening to EMEs are amplified due to currency mismatches. In contrast to Davis and Presno (2017), however, in the model of Akinci and Queralto (2019), it is not optimal for EME monetary policy to stabilize the exchange rate by mimicking US monetary policy. Mimir and Sunel (2019) explore the welfare implications of a variety of monetary policy rules in a rich medium-scale SOE model with currency mismatches on banks' balance sheets. While they find that the optimal policy is not unique and depends on the particular model specification and the shocks hitting the SOE, reducing exchange rate variation by responding to US interest rates is generally welfare improving relative to standard Taylor rules.[4]

While the amount of theoretical work on the subject is large and growing, empirical evidence on how important foreign-currency exposures are in shaping trade-offs and fear of floating faced by SOE monetary policy in the data is limited. For example, little systematic empirical evidence exists on whether SOEs systematically pursue policies such as those prescribed by Davis and Presno (2017), that is, on whether SOE monetary policy mimics base-country monetary policy in order to reduce exchange rate variation in the presence of foreign-currency exposures. Of course, it is widely known that foreign exchange interventions are being used in order to reduce excessive exchange rate volatility. But much less evidence exists on the recourse to conventional monetary policy instruments in this context. Indeed, Carstens (2019)

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4 Earlier work finding that reducing exchange rate variation may be optimal in the presence of foreign-currency exposures includes Cook (2004), Choi and Cook (2004), Elekdag and Tchakarov (2007), Rappoport (2009), and Kolasa and Lombardo (2014). In contrast, Cespedes, Chang, and Velasco (2004), Devereux, Lane, and Xu (2006), and Gertler, Gilchrist, and Natalucci (2007), as well as Faia (2010) find that it is optimal to let the exchange rate float freely.

forcefully discusses the importance of improving our understanding of monetary policy challenges in SOEs in the context of a highly financially integrated world from a policy maker's perspective.

In this study, we first document evidence that supports the hypothesis that SOE monetary policy exhibits fear of floating in the presence of foreign-currency exposures in a dataset for 10 SOEs in the Asia and Pacific region.[5] In particular, we find that, even after controlling for real-time forecasts of macroeconomic fundamentals, as well as global variables, SOE monetary policy still responds to changes in base-country policy rates. Moreover, in line with the optimal policy prescriptions in Davis and Presno (2017), we find that the sensitivity of SOEs to base-country monetary policy is stronger the larger the SOE's foreign-currency net short position; that is, the more foreign-currency-denominated foreign liabilities exceed foreign-currency-denominated foreign assets. We also find that the sensitivity of SOEs to base-country monetary policy is particularly large when the foreign-currency exposures stem from portfolio debt instruments or bank loans rather than from more resilient foreign direct investment (FDI) and portfolio equity instruments with state-contingent payoffs and longer investment horizons; this finding is consistent with existing literature that documents that portfolio debt and other investment items are more fickle and more sensitive to swings in investor sentiment than portfolio equity and FDI. Finally, we find that the sensitivity of SOEs to base-country monetary policy is larger when the latter is tightened rather than loosened, suggesting that SOE monetary policy addresses immediate threats to financial stability in the face of depreciation pressures rather than pre-emptively mitigating the build-up of foreign-currency exposures when the currency is appreciating.

We obtain these findings by estimating fixed effects dynamic panel data regressions of monetary policy reaction functions for 10 SOEs in the Asia and Pacific region with floating regimes for the time period from January 2002 to December 2012. The reaction function arguments we consider include real-time forecasts of real GDP growth and consumer price inflation, the implied volatility index, commodity prices, and the base-country policy rate. The inclusion of real-time forecasts and global variables accounts for the correlation between SOE and base-country policy rates that is due to common shocks and spillovers through conventional macroeconomic and financial channels. Hence, the coefficient estimate on the base-country policy rate indicates the

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5 In Georgiadis and Zhu (2019), we explore a broader country sample and find very similar results.

extent to which an SOE mimics base-country monetary policy over and above what we would expect to observe if macroeconomic stabilization was the only policy objective; in other words, we interpret a positive coefficient estimate on the base-country policy rate as empirical evidence of fear of floating. In order to explore the role of the financial channel of exchange rates in shaping this fear of floating, we additionally include interaction terms between the base-country policy rate and various variables reflecting the SOE's foreign-currency exposure in the regression. While doing so, we control for alternative reasons why SOE monetary policy may want to reduce exchange rate variation, in particular high exchange rate pass-through to consumer prices and a low stock of foreign exchange reserves.

13.2 Empirical Framework

13.2.1 Estimated Monetary Policy Reaction Functions

We estimate the dynamic panel data regression

$$i_{it}^{p} = d_i + \rho i_{i,t-1}^{p} + (1-\rho)\left(\vartheta' x_{i,t+M}^{e} + \gamma' z_t + \alpha i_{b_i,t}^{p}\right) + u_{it}, \quad (1)$$

where i_{it}^{p} is the SOE monetary policy rate, x_{it}^{e} includes real-time forecasts of local macroeconomic fundamentals, z_t is a vector that includes global variables, and $i_{b_i,t}^{p}$ is the monetary policy rate of SOE i's base-country b_i. We include the vector of global variables z_t in order to reduce the risk that the estimate for α is driven by common shocks, although the latter should already be captured by the real-time forecasts of local macroeconomic fundamentals.

In order to test whether fear of floating is shaped at least in part by financial stability considerations related to exchange rate variation and foreign-currency exposures, we further estimate the regression

$$\begin{aligned} i_{it}^{p} = d_i + \rho i_{i,t-1}^{p} + (1-\rho)\Big(&\vartheta' x_{i,t+M}^{e} + \gamma' z_t \\ &+ \alpha_1 i_{b_i,t}^{p} + \alpha_2 i_{b_i,t}^{p}\xi_{it}\Big) + \theta\xi_{it} + u_{it}, \end{aligned} \quad (2)$$

where ξ_{it} represents a measure of the SOE's foreign-currency exposure.

We omit time-fixed effects in the baseline specification because these would be highly correlated with the base-country policy rate, particularly given that we only consider two base countries—the US and the euro area (see below)—and that the correlation between their policy rates during our sample period was very high.[6] Moreover, notice that even if the coefficient estimate on the level of the base-country policy rate might be contaminated by common shocks, akin to a Bartik instrumental variable, the coefficient estimate on the interactions with SOE variables continue to be determined by variation in SOE monetary policy's reluctance to let the exchange rate float freely across different degrees of foreign-currency exposures.

Notice also several remarks on the econometrics underlying the estimation of Equations (1) and (2). First, as we describe below, we consider a small-N/large-T panel data setting. This implies that, in contrast to the traditional large-N/small-T panel data setting, we expect the Nickell bias in the dynamic fixed effects panel regression—typically addressed by using generalized method of moments estimators—to be very small (Judson and Owen 1999). Second, Equations (1) and (2) can be interpreted as an error correction model. Then, if at least some of the variables are nonstationary, the corresponding equilibrium relationship is a cointegrating relationship; and if all variables are stationary, the equilibrium relationship is a long-run-level relationship. Importantly, if such an equilibrium relationship exists, then inference about the coefficient estimates is standard, regardless of whether the variables are nonstationary or stationary (Pesaran and Shin 1999). Third, we could in principle test for the existence of such an equilibrium relationship at the country level, even without knowledge of the orders of integration of the variables involved (Pesaran, Shin, and Smith 2001). However, we have a very strong prior that such an equilibrium relationship exists, as local monetary policy is almost surely determined either by forecasts of local macroeconomic fundamentals, global variables, or the base-country policy rate. Moreover, while the corresponding tests have been worked out at the country level, they are not available in the panel context. One could then argue that it would be best to resort to panel cointegration analysis, which is, however, known to be rather sensitive to the assumptions on the nature of cross-country heterogeneity under the null and alternative hypotheses, as well as to pretesting for unit roots in panel data, which has its own, nontrivial pitfalls. We thus proceed assuming that there exists an equilibrium relationship between local policy rate, forecasts of local macroeconomic fundamentals, global variables, and base-country policy rates without carrying out formal tests at the (cross-)country level.

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6 In Shambaugh (2004), Obstfeld, Shambaugh, and Taylor (2005), and Klein and Shambaugh (2015), the number of base countries is much larger and the sample period is much longer so that the correlation between base-country policy rates and the time dummies is much smaller.

13.2.2 Data and Definition of Variables

Sample Period and Economies Included

We consider a sample of monthly data for 10 SOEs in the (broadly defined) Asia and Pacific region. We only consider country-month observations with floating regimes. Specifically, we consider the de facto exchange rate regime classification of Shambaugh (2004) and Obstfeld, Shambaugh, and Taylor (2010), and include in our sample only country-month observations that are classified as a "float," i.e., we drop observations classified as a "peg" or a "soft peg."[7] We additionally require that, for an economy to enter the sample, there are at least 12 country-time observations. The resulting sample of economies includes Australia, Bangladesh, India, Indonesia, Israel, Malaysia, New Zealand, the Republic of Korea, Thailand, and Turkey.

We specify the US as the base country. The time period we consider spans from January 2002 to December 2012; however, we drop the time period from July 2007 to December 2009 in order to preclude our estimates being unduly driven by events related to the global financial crisis. We cannot consider after 2012 because the data we use to measure economies' foreign-currency exposure are not available for later years (see below).

Real-Time Forecasts and Global Variables

For the real-time forecasts of consumer price inflation and real GDP growth in x_{it}^{e}, we would ideally use actual central bank projections. However, many central banks do not publish their projections. Moreover, among those central banks that do publish their projections, many

7 In particular, a country-year observation is coded as a "peg" by Shambaugh (2004) in a particular year if its bilateral exchange rate vis-à-vis its base country stays within a +/– 2% band over the course of that year, or if its exchange rate changes only in 1 month. A country-year observation is coded as a "soft peg"' by Obstfeld, Shambaugh, and Taylor (2010) if it is not classified as a "peg" and if the bilateral exchange rate vis-à-vis the base country stays within a +/– 5% band in a given year, or if there is no month in which the exchange rate changes by more than +/– 2%.

produce them only a few times per year.[8] For these reasons, instead of considering actual central bank projections, we use data on real-time forecasts from Consensus Economics. In Georgiadis and Zhu (2019), we document that Consensus Economics real-time forecasts are highly correlated with publicly available, actual central bank projections.[9] We include 12-months-ahead real-time forecasts of real GDP growth and inflation in x_{it}^{e}.[10] In the vector of global variables z_t, we include the first difference of the logarithm of global commodity prices, and the level of the volatility index.

Local and Base-Country Policy Rates

Our sample reaches into the period in which the Federal Reserve hit the zero lower bound. A widely used measure that reflects the Federal Reserve monetary policy stance during this time period is the shadow

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8 This does not mean that policy makers are not updating their views on the outlook before monetary policy decision meetings that take place between the projection exercises. Typically, the projections are updated between projection exercises using a variety of macroeconometric tools, as well as anecdotal evidence and judgment. For example, the European Central Bank's macroeconomic projections for the euro area are produced just four times a year, namely in March and September when they are produced by their staff alone, and in June and December when they are produced jointly by their staff and those of euro area national central banks. For the monetary policy decision meetings that take place between the projection exercises, the projections are updated using a variety of macroeconometric tools.

9 Notice that using Consensus Economics forecasts has the advantage of considering a large number of economies at the monthly frequency. Monthly data on real activity and inflation are typically available only for a smaller set of economies, and there are generally no real-time data available. Moreover, for real activity, one would typically consider industrial production, which is not defined identically across economies, and is more volatile than, and also only reflects a limited share of, overall real activity.

10 One disadvantage of Consensus Economics data is that they are fixed-event forecasts; that is, for example, a forecast in month t in year T of real GDP growth over year T+1. We adopt the approach of Dovern, Fritsche, and Slacalek (2012) to transform the Consensus Economics fixed-event forecasts into fixed-horizon forecasts.

rate constructed by Wu and Xia (2016).[11, 12] All data on interest rates are obtained through Haver. For conventional policy rates, we generally consider central bank policy rates obtained from the IMF's International Financial Statistics, amended in a few cases by data from country-specific sources.

Foreign-Currency Exposure Measurement and Data

We use the data on foreign-currency exposures of Lane and Shambaugh (2010a), as well as the update provided by Benetrix, Lane, and Shambaugh (2015). Unfortunately, at the time of writing, the data of Lane and Shambaugh (2010a) and Benetrix, Lane, and Shambaugh (2015) are available only until 2012. Hence, and as mentioned above, we estimate the sensitivity of local to base-country policy rates based on Equations (1) and (2) only for the period between January 2002 and December 2012. For the regressions, we linearly interpolate the foreign-currency exposure data—which are available at the annual frequency—to monthly frequency. Figure 13.2 presents the averages of the foreign-currency-denominated foreign assets and liabilities relative to GDP over the time period from 2002 to 2012—excluding foreign exchange reserves on the asset side—for the Asia and the Pacific SOEs in the country sample of this study, as well as an additional set of economies considered in Georgiadis and Zhu (2019).

Lane and Shambaugh (2010a) define the net foreign-currency exposure as the difference between the foreign-currency-denominated foreign assets and liabilities, both scaled by GDP. The net foreign-currency exposure is negative (positive) for an economy that is net short (long) in foreign currency on its external balance sheet. When an economy is net short in foreign currency, a depreciation of its currency implies an exchange rate valuation loss on its external balance sheet, as the local-currency value of its foreign-currency-denominated foreign

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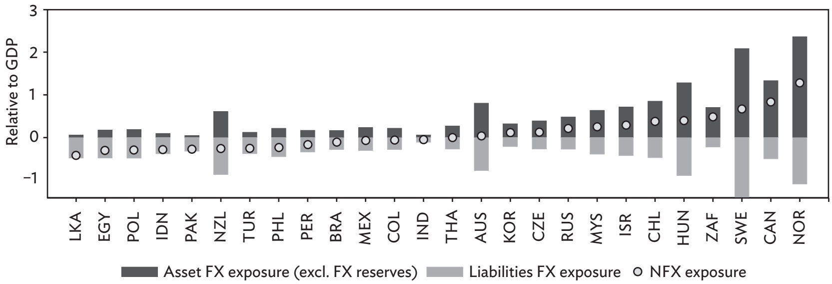
11 Longer-term, such as 2-year, rates are another frequently used alternative. However, these are not available for several of the EMEs in our sample and/or for the period we consider. Moreover, even for the base countries we consider these to have been close to, or essentially at, the zero lower bound, especially for the euro area, for which German Bund yields are typically used.

12 Notice that even when short-term interest rates hit the zero lower bound, monetary policy—and in particular forward guidance—matters for exchange rate determination. This can easily be seen by iterating forward the uncovered interest rate parity condition and noticing that one of the fundamental determinants of the spot exchange rate is the path of future expected short-term interest rates, the so-called "expectations component" of the yield curve. Incidentally, shadow rates are constructed exploiting information about the entire yield curve, thereby including the latter expectations component and thus being particularly appealing in a sample period in which the zero lower bound was binding.

Figure 13.2: Foreign-Currency Exposures from 2002 to 2012



GDP = gross domestic product; FX = foreign currency; NFX = net foreign currency.

Note: The figure shows the net foreign-currency exposure relative to GDP averaged over the sample period from 2002 to 2012. The data are taken from Lane and Shambaugh (2010a), as well as Benetrix, Lane, and Shambaugh. (2015).

Source: Authors.

assets rises by a smaller amount than that of the foreign-currency-denominated foreign liabilities. More specifically, the net foreign-currency exposure also reflects the change in an economy's net foreign asset position relative to GDP that results from a uniform depreciation of its currency against all foreign currencies by 1% (see Appendix B in Georgiadis and Mehl 2015). Hence, in terms of economic magnitude, Indonesia's net foreign-currency exposure of about –25% of GDP implies that its net foreign asset position relative to GDP would decline by 0.25 percentage points if its currency depreciated by 1%. Thus, for many of the economies in our sample, the net foreign-currency exposures are economically nontrivial.

13.3 Empirical Results

In this section we present the results for the estimation of Equations (1) and (2). In order to account for alternative motivations for fear of floating, in Equation (2) we include additional variables interacted with the base-country policy rate. In particular, we interact the base-country policy rate with estimates of the SOE's exchange rate pass-through to consumer prices (Hausmann, Panizza, and Stein 2001). Moreover, we interact the base-country policy rate with the SOE's stock of foreign exchange reserves, which indicates the government's ability to support firms that are running out of foreign currency in the case of funding stress;[13] a large stock of reserves also indicates ample ammunition for exchange rate interventions. For ease of interpretation of the coefficient estimates in the regression tables, we standardize the data on net foreign-currency exposure variables in ξ_{it}.

13.3.1 Baseline Results for the Role of Foreign-Currency Exposures in Fear of Floating

Column (1) in Table 13.1 reports the result of the regression of Equation (1), i.e., without any interaction terms between the base-country policy rate and the SOE's foreign-currency exposure. The coefficient estimate on the base-country policy rate is positive and statistically significant. The evidence in column (1) suggests that SOE monetary policy responds to exchange rate pressures of the local against the base-country currency over and above what we would expect if macroeconomic stabilization was the only policy objective. The evidence is thus consistent with SOEs from Asia and the Pacific having exhibited fear of floating in the early 2000s. We next test for the role of foreign-currency exposures in shaping this fear of floating.

Column (2) reports the results from the regression of Equation (2), in which we add interaction terms between the base-country policy rate and the SOE's foreign-currency asset and liability exposures shown in Figure 13.2; for the regressions, we use positive numbers for the foreign-currency foreign liabilities, in contrast to Figure 13.2. The coefficient estimates for the SOE's foreign-currency foreign asset and liability exposures are negative and positive, respectively, and statistically significant. The positive sign of the coefficient estimate on the interaction with the liability foreign-currency exposure is consistent with the notion that variations in the exchange rate give rise to variations in whether borrowing constraints of SOE firms with foreign-currency foreign liabilities are binding, and hence elicit positive feedback that might jeopardize financial stability and that monetary policy may want to prevent by reducing exchange rate variation. In turn, the negative coefficient estimate on the interaction with the foreign-currency foreign asset exposure is consistent with the notion that there are offsetting valuation effects on firms' balance sheets that mitigate the extent to which variations in the exchange rate give rise to variations in whether borrowing constraints are binding. The results are

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13 Estimation of the exchange rate pass-through to consumer prices is described in Georgiadis and Zhu (2019).

Table 13.1: Foreign-Currency Exposures and the Sensitivity of SOE Policy Rates to Base-Country Policy Rates

	(1)	(2)	(3)	(4)	(5)	(6)
Base-country policy rate	0.41** (0.03)	0.53*** (0.00)	0.50*** (0.00)	0.53*** (0.00)	0.53** (0.00)	0.52*** (0.00)
× FX assets rel. to GDP		−0.81*** (0.01)				
× FX liabilities rel. to GDP		0.76*** (0.00)				
× NFX rel. to GDP			−0.72*** (0.01)			
× NFX rel. to GDP × I(NFX ≥ 0)				−0.34* (0.06)		
× NFX rel. to GDP × I(NFX < 0)				−0.50* (0.06)		
× Non-debt NFX rel. GDP					−0.61 (0.11)	−0.54 (0.17)
× Debt NFX rel. to GDP					−0.52*** (0.00)	
× Debt NFX rel. to GDP × I(NFX ≥ 0)						−0.21** (0.02)
× Debt NFX rel. to GDP × I(NFX< 0)						−0.52*** (0.01)
× FX reserves rel. to GDP		−0.59** (0.04)	−0.77*** (0.00)	−0.64*** (0.01)	−0.84* (0.06)	−0.77* (0.07)
× ERPT		−0.11 (0.79)	−0.46 (0.24)	−0.07 (0.87)	−0.36 (0.51)	−0.30 (0.56)
R-squared (within)	0.12	0.20	0.18	0.17	0.19	0.20
Observations	513	513	513	513	513	513
Countries	10	10	10	10	10	10

GDP = gross domestic product; FX = foreign currency; NFX = net foreign currency; ERPT = exchange rate pass-through; SOE = small open economy.

Note: *p*-values in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01. Driscoll-Kraay robust standard errors. Coefficient estimates of real-time forecasts and global variables not reported.

Source: Authors.

thus consistent with the hypothesis that the fear of floating documented in column (1) is at least partly due to the financial stability implications of foreign-currency exposures.[14]

Given the coefficient estimates on the foreign-currency asset and liability exposures in column (2) in order to increase efficiency in the following, we consider the latter's difference, i.e., economies' net foreign-currency exposures. While doing so, it should be understood that a balanced net foreign-currency exposure might mask large gross exposures. As for the analysis of gross relative to net capital flows, large gross flows and foreign-currency exposures might imply nontrivial vulnerabilities even if the net positions are balanced. Moreover, to the extent that negative foreign-currency exposures are concentrated in systemic sectors or firms—such as large banks—exchange rate variation might have a nontrivial effect on the local financial cycle even if the SOE's aggregate net foreign-currency exposure is balanced or even positive.

With these words of caution in mind, column (3) reports the results from a regression in which we enter an interaction term between the base-country policy rate and the SOE's net foreign-currency exposure. The relevant coefficient estimate is negative and highly statistically significant, which is consistent with the results in column (1). The results thus suggest that the sensitivity of the SOE to the base-country policy rate falls with the former's net foreign-currency exposure; put differently, the sensitivity increases with the SOE's net short position and falls with its net long position. Again, this finding is consistent with the hypothesis that exchange rate variation has affected financial cycles in SOEs, and, in particular, that SOE monetary policy has attempted to reduce exchange rate variation by mimicking base-country monetary policy in order to mitigate associated financial stability risks (Basci, Ozel, and Sarikaya 2008; Gudmundsson 2017; Vegh, Morano, and Friedheim 2018).

13.3.2 Results for Net Long/Short Positions and Different Financial Instruments

Columns (4) to (6) document results from regressions that explore more refined hypotheses regarding the role of foreign-currency exposures for shaping fear of floating in SOE monetary policy. First, column (4)

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14 Note that the coefficient estimate on the interaction between the base-country policy rate and the SOE's foreign exchange reserves is consistent with the findings in Cheng and Rajan (2019). Specifically, Cheng and Rajan (2019) find that the sensitivity of an SOE to base-country policy rates is reduced when the SOE features larger foreign exchange reserves.

reports results from a regression that distinguishes between negative and positive net foreign-currency exposures. The coefficient estimates on the interaction terms between the base-country policy rate and positive and negative net foreign-currency exposures are statistically significant. Notice that the coefficient estimate on the interaction with the negative net foreign-currency exposure is much larger than that on the interaction with the positive net foreign-currency exposure. This finding is consistent with the emphasis on negative foreign-currency exposures—i.e., net short positions—in the context of the financial channel of exchange rates and its financial stability implications of foreign-currency exposures. Specifically, variations in the exchange rate are more likely to induce positive feedback loops—i.e., loosen firms' borrowing constraints in the case of positive shocks to the economy that are followed by local currency appreciation, and tighten borrowing constraints in the case of adverse shocks such as base-country monetary policy tightening that are followed by local currency depreciation—when an SOE is net short in foreign currency.

Second, the overall net foreign-currency exposure arises as the sum of individual components. Specifically, in terms of instruments, in the definition of Lane and Shambaugh (2010a), the overall net foreign-currency exposure is the sum of debt and nondebt components.[15] Interestingly, differences in the payoff and maturity structures between these two instruments imply testable predictions that allow us to corroborate the evidence that foreign-currency exposures shape fear of floating. In particular, foreign-currency exposures imply greater vulnerabilities if they stem from more fickle portfolio debt instruments and bank loans with nonstate-contingent payoffs than from more stable FDI and portfolio equity instruments with state-contingent payoffs and longer investment horizons. Indeed, Lane and Milesi-Ferretti (2012) and Milesi-Ferretti and Tille (2011) document that bank loans and other investment instruments exhibited the greatest volatility during the retrenchment in global capital flows in the global financial crisis; similarly, Forbes and Warnock (2012) document that debt instruments are particularly likely to exhibit abrupt swings in capital flows. Against

15 In the data of Lane and Shambaugh (2010a) and Benetrix, Lane, and Shambaugh (2015), non-debt instruments are given by portfolio equity and FDI, and debt instruments by portfolio debt and other investments, including bank loans. Lane and Shambaugh (2010a) and Benetrix, Lane, and Shambaugh (2015) assume that portfolio equity and FDI are always denominated in the currency of the issuer. Hence, a nondebt net foreign-currency exposure stems exclusively from holdings of foreign-currency-denominated foreign portfolio equity and FDI and can only assume positive values.

this background, we expect that SOE monetary policy is more concerned about dampening the financial cycle when the economy's net foreign-currency exposure stems from debt rather than nondebt instruments. In line with these predictions, the results in columns (5) and (6) suggest that the sensitivity of SOEs to base-country policy rates is indeed stronger for smaller—in particular negative—debt net foreign-currency exposures.

13.3.3 Results for Fear of Floating across Local-Currency Appreciations and Depreciations

It is natural to explore asymmetries, not only in the sign of economies' net foreign-currency exposures, but also in the direction of change of the base-country policy rate. Specifically, immediate financial stability risks arise, in particular in the case of a depreciation of the local currency and in the presence of negative net foreign-currency exposures. In contrast, even if the optimal policy is symmetric in theory, for political economy reasons it may plausibly be more difficult for SOE monetary policy to limit local-currency appreciation when base-country monetary policy is loosened in order to dampen a build-up of foreign-currency liabilities that could threaten financial stability only later when the tide turns as base-country monetary policy is tightened. Against this background, we expect the sensitivity of an SOE to base-country monetary policy to be greater when the latter is tightened rather than when it is loosened, and when the SOE exhibits negative net foreign-currency exposures. To test these predictions, we first run a regression analogous to that in Equation (1), but we additionally enter separate coefficients for the cases in which the base-country policy rate is raised and when it is lowered.

Accordingly, column (2) in Table 13.2 reports the results from a regression with separate coefficients for increases and reductions in the base-country policy rate without any interactions with foreign-currency exposure variables. In line with the hypothesis that the trade-off between financial stability and macroeconomic stabilization for SOE monetary policy is perceived to be weaker by policy makers when the local currency appreciates, we find that the sensitivity of SOE policy rates to base-country policy rates documented in the baseline results in Table 13.1 exclusively stems from cases in which base-country monetary policy is tightened; hence, our findings indicate evidence of a narrower "fear of depreciation" rather than a more general, symmetric fear of floating.

Column (3) in Table 13.2 reports results from a regression analogous to that in Equation (2) in which we combine the hypothesis relating to asymmetries in the sensitivity of SOE monetary policy to

Table 13.2: Accounting for Asymmetries in the Sensitivity of SOE Policy Rates to Base-Country Policy Rates

	(1)	(2)	(3)	(4)
Base-country policy rate	0.41** (0.03)			
× $I(\Delta i_{b_i,t}^P \geq 0)$		0.41** (0.04)	0.50*** (0.00)	0.25 (0.15)
× $I(\Delta i_{b_i,t}^P \geq 0)$ × NFX exposure rel. to GDP			−0.75*** (0.01)	
× $I(\Delta i_{b_i,t}^P \geq 0)$ × NFX exposure rel. to GDP × I(NFX ≥ 0)				−0.42 (0.14)
× $I(\Delta i_{b_i,t}^P \geq 0)$ × NFX exposure rel. to GDP × I(NFX > 0)				−1.19*** (0.00)
× $I(\Delta i_{b_i,t}^P \geq 0)$		−2.98 (0.31)	−1.87 (0.40)	−2.72 (0.29)
× $I(\Delta i_{b_i,t}^P \geq 0)$ × NFX exposure rel. to GDP			−0.35 (0.69)	
× $I(\Delta i_{b_i,t}^P \geq 0)$ × NFX exposure rel. to GDP × I(NFX ≥ 0)				3.65 (0.17)
× $I(\Delta i_{b_i,t}^P \geq 0)$ × NFX exposure rel. to GDP × I(NFX < 0)				−1.85** (0.04)
× FX reserves rel. to GDP			−0.82*** (0.00)	−0.70*** (0.00)
× ERPT			−0.48 (0.27)	−0.24 (0.52)
R-squared (within)	0.12	0.14	0.20	0.21
Observations	513	513	513	513
Countries	10	10	10	10

GDP = gross domestic product; FX = foreign currency; NFX = net foreign currency; ERPT = exchange rate pass-through; SOE = small open economy.

Note: *p*-values in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01. Driscoll-Kraay robust standard errors. Coefficient estimates of real-time forecasts and global variables not reported.

Source: Authors.

base-country monetary policy across local-currency depreciations and appreciations with that relating to differences in foreign-currency exposures. Specifically, we consider separate interaction terms between the base-country policy rate and SOEs' net foreign-currency exposures for the cases in which the former is raised and in which it is lowered. In line with the previous findings, the results suggest that the sensitivity of the SOE to the base-country policy rate when the latter is raised is amplified the smaller the net foreign-currency position, i.e., the more net short, the less net long in foreign currency the SOE has on its external balance sheet. In contrast, none of the coefficient estimates relating to the instances in which base-country monetary policy is loosened is statistically significant.

Finally, in column (4) we report results from a regression in which we again introduce separate interaction terms between the base-country policy rate when it is raised/lowered as well as negative/positive net foreign currency exposures, respectively. As in columns (4) and (6) in Table 13.1, only the coefficient estimate involving the interaction with the negative net foreign-currency exposure is statistically significant. This finding suggests that the sensitivity of an SOE to base-country monetary policy is particularly strong when the latter is tightened and the SOE is net short in foreign currency on its external balance sheet. This is the classic context in which several EME currency crises have erupted in the past, and hence it may not be surprising that this case stands out in our estimates. However, and in contrast to the results for the broader country sample considered in Georgiadis and Zhu (2019), the coefficient estimate on the base-country monetary policy loosening interacted with a negative net foreign-currency exposure also is statistically significant. This suggests that SOEs in the Asia and Pacific region may potentially be subject to a somewhat more symmetric fear of floating.

13.4 Conclusion

We estimate dynamic panel data regressions for a panel of 10 SOEs in the Asia and Pacific region with floating exchange rate regimes for the period from 2002 to 2012 in order to assess whether local responds to base-country monetary policy over and above what we would expect to observe if macroeconomic stabilization was the only policy objective. We find that the data are consistent with the hypothesis that SOE monetary policy in floating exchange rate regimes is generally subject to fear of floating, and that this is at least in part due to threats to financial stability implied by foreign-currency exposures. We find that the evidence of fear of floating due to financial stability considerations is particularly pronounced when the foreign-currency exposures arise through debt rather than nondebt instruments and when base-country monetary policy is tightened. In this context, mimicking base-country monetary policy tightening reduces exchange rate depreciation and thereby prevents negative valuation effects on the economy's external balance sheet from making local borrowers hit borrowing constraints. From a policy perspective, our findings are particularly relevant at the current juncture, as many EMEs have accumulated large foreign-currency—typically US dollar—debt liabilities and US monetary policy is expected to be tightened, at least in the medium term.

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Macroeconomic Stabilization in the Digital Age

Macroeconomic Stabilization in the Digital Age provides insights into factors affecting the macroeconomic management of the economy in the digital age. Policy makers need to be aware of the increasing prominence of the digital economy and digital finance and seek to understand better how continued digitalization will affect policies aimed at managing the economy. For emerging market economies (EMEs), macroeconomic policy challenges have been exacerbated by the digital finance revolution in the aftermath of the global financial crisis and the coronavirus disease (COVID-19) pandemic, i.e., when many EMEs experienced large and volatile capital flows. Policy makers must also navigate through fluctuating trends in productivity and difficulties in estimating potential output in the era of digitalization.

The book is organized into three main parts: (1) digital finance and the macroeconomy, (2) capital flows and systemic risk in the digital age, and (3) macroeconomic uncertainty and new challenges for central banks. Part I is set against the context of the shift in financial intermediation away from traditional banks as large technology firms have increasingly provided financial services over the past decade. This part of the book focuses on the macroeconomic effects of digital finance and financial technology. Part II examines capital flow-related developments in the digital age, where the expansion in cross-border capital flow channels can create additional hurdles for EME authorities in managing capital flows. Finally, Part III relates the digital age to challenges faced by central banks and the implications of digitalization for the monetary policy transmission mechanism.

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