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Data analytics on consumer behavior in omni-channel retail banking, card and payment services

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DATA ANALYTICS ON CONSUMER BEHAVIOR IN OMNI-CHANNEL RETAIL BANKING, CARD AND PAYMENT SERVICES

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Abstract

Innovations in financial services have created challenges for banks that Information Systems (IS) research can address. My interests involve transaction cost theory, substitution and complementarity theory, and consumer informedness theory to understand consumer behavior and firm performance in the omni-channel world of digital banking. At a high level, my research inquiry asks: How can financial institutions take advantage of the deep insights that data analytics and management science modeling create on consumer behavior and channel management decision-making? And how can changes in payments and services in retail banking be understood in spatial and temporal terms? I am working on three essays. They involve theoretical arguments and data analytics related to physical branch network, omni-channel behavior and credit card analytics in retail banking services. Essay 1 investigates branch network and omni-channel customer banking behavior. Essay 2 examines the impact of credit card partnerships between banks and retailers. Essay 3 applies spatiotemporal econometrics and data mining to explore the penetration of Bitcoin. Through sponsored research access to unique data from banks in U.S. and Singapore, and assistance from industry professionals, I will contribute new knowledge on consumer insights related the inner workings of financial services and technology.

Keywords: Big data analytics, branch networks, credit card rewards, cyber-currency, empirical research, financial innovation, omni-channel distribution, retail banking.

1 INTRODUCTION

Financial technology innovations have transformed the financial services sector's products, services and business models. The rise of Internet and mobile banking have encouraged customers to migrate from traditional physical channels to the digital and omni-channel environment. Smart phones and mobile security supported the emergence of mobile payments. And lower barriers to entry and technology advances have created new opportunities for non-financial institutions, which have broken into routine banking services, such as personal loans with peer-to-peer (P2P) lending and crowd-funding services. Other similar kinds of developments are underway in other banking service areas.

The digitalization of banking products and services has enhanced transaction performance for banks and customers. Banks are creating innovative product designs and distribution channels to adapt to changes in customer demand and preferences. There has also been more data from customer transactions and advanced data analytics. These allow banks to enhance value by understanding customer behavior and making more informed decisions. For example, Capital One, one of the earliest and most successful financial services firms in the card marketing arena, achieved higher revenue by leveraging data analytics to target the most profitable accounts and identify differences in customer receptiveness to product adoption in the presence of differential pricing (Clemons and Thatcher 2005).

In addition, recent industry reports point out that banks can further reduce their operating costs by transforming their physical distribution networks and migrating transactions to the new digital channels (McKinsey 2014). Tracking customer behavior also may create other benefits, including better customer relationship management, more successful marketing and higher brand awareness.

The literature on financial information systems and technologies, and the related innovations has been growing. Most prior research has focused on theoretical interpretations. It also has explored the structure, business goals and challenges of financial institutions with respect to changing technologies. The related empirical work has been limited, largely due to the lack of data sources. A few researchers have used customer-level or firm-level data to investigate online banking adoption, channel substitution and the value of financial intermediation (Xue et al. 2011, Campbell and Frei 2009). Others have explored online platforms for financial services, such as peer-to-peer lending and crowd-funding (Burtch et al. 2014). However, progress has been slow compared with the retailing, airlines and telecom services sectors.

My thesis work is based on theoretical perspectives related to a bank's physical branch network, customer behavior in omni-channel operations, credit card big data analytics, and adoption and diffusion of cyber-currencies. I ask: (1) How should banks transform their physical branch network in an omni-channel financial services environment? (2) How can banks leverage big data econometric methods to improve the performance of card-based partnerships with retailers. (3) How can banks, through target marketing and more informed decision-making, influence the buying behaviour of their customers. And (4) how should can we understand the spatial and temporal diffusion of cyber-currency? The theoretical perspectives include transaction cost economics, consumer informedness and the theory of learning, and spatial differences in technology diffusion.

I employ multiple methods: (1) propensity score matching; (2) difference-in-differences modelling to establish causal relationships; (3) big data acquisition techniques and analytical techniques; and (4) spatial econometrics. I use *propensity score matching* to resolve customer some technical issues with branch network change, especially endogenous variables. I also apply the standard *difference-in-differences* model to deal with staggered and repeated branch openings and closures. To connect different data sets, I apply big data acquisition techniques. They include *screen-scraping* with various software tools and *database harvesting* to combine data from multiple sources. I also will use spatial and temporal analytics in my geography-based research work on Bitcoin penetration.

My thesis will contain three essays. In Essay 1, I use a proprietary customer-level dataset from a large commercial bank in the U.S. to investigate the traditional channel – bank branches – and the impact of network changes (branch opening or closure) on customer channel preferences and service

consumption behavior. Essay 2 combined external data from the food sector proprietary data from another financial services industry firm – this time in Singapore. I investigate the effects of credit card offers on the performance of merchant partnerships and customer behavior. Essay 3 is still being designed, and will either be a follow-on to Essay 2 from the same Singapore-based organization, or it will apply spatial and temporal analytics to study determinants of cyber-currency penetration, through data that are available from around the world on Bitcoin. I will write up the Bitcoin idea below.

2 ESSAY 1: BRANCH NETWORK AND OMNI-CHANNEL CUSTOMER BANKING BEHAVIOR

Background. The changing demand and preferences of customers, along with adoption of technology in financial services, have given rise to digital channels such as Internet banking, leading to a sharp decline in branch traffic. The current shift in consumer behavior has brought about opportunities and challenges for financial institutions though. Banks can reduce their operating costs and improve their performance, by transforming their physical distribution networks and migrating transactions to the digital channels (McKinsey 2014). But inconvenience, reduced quality in customer relationship management, and lower brand awareness may cause them to be adversely affected due to the closure of their branches (Accenture 2013). So banks must understand customer preferences much better.

Research questions. I examine the impact of branch network changes on customer omni-channel usage and banking behavior, using large and novel data. I ask: What are the effects of branch opening and branch closure on channel usage? How do the effects vary by customer segment? What short-term versus long-term impacts arise? Does a physical presence improve a bank's cross-selling performance?

Theory. My work is related to multi-channel studies in banking, retailing and advertising. In each, research has investigated service distribution performance online and offline, multi-channel usage and other customer behavior. Online banking changes have stimulated researchers to examine customer channel preferences and banking behavior that coincides with online banking adoption (Campbell and Frei 2009, Xue et al. 2011). Multi-channel retailing has achieved popularity and integration between the online and offline channels also.

Research in the retailing sector has focused on quantifying the pressure on physical channels due to the online channel (Deleersnyder et al. 2002, Bialogorsky et al. 2003). Others have studied physical store entry and its impact on customer behavior (Forman et al. 2009, Brynjolfsson et al. 2009, Kumar et al. 2014). Another stream is on the marketing effects of online ads relative to traditional media. Some researchers suggested that cross-media synergies in multi-channel ads are effective (Lambert and Pregibon 2008, Wilbur et al. 2010), while others identified substitution effects between online advertising and traditional media (Athey and Gans 2010, Goldfarb and Tucker 2010).

Prior research started with online channel usage and looked at the effects of offline channel usage on customer multi-channel behavior. Some authors have systematically studied the effects of changes in physical store networks too. I hope to complement what is known for financial services by exploring multi-channel customer behavior after branches are opened and closed.

Data and empirical analysis. I investigated branch network changes using transaction-level data from a retail bank in the U.S. that I gained access to while I was in a one-year 'visiting PHD program' at Carnegie Mellon University in the U.S. (2014-2015). There are four related data sets, including: banking transaction records; branch network information; banking account information; and customer demographics – all anonymized. I applied propensity score matching and created a unique panel of data with 45,000 customers from the bank in the first stage of my analysis.

I also applied a difference-in-differences model that controls for individual differences in transaction behavior to estimate the causal effects of branch network change on multi-channel behavior.

$$Y_{ijt} = C_{ij} + \beta_1 \#BranchOpened_{jt} + \beta_2 \#BranchClosed_{jt} + \beta_3 \#FirstBranch_{jt} + \beta_4 \#LastBranch_{jt} + \phi X_{it} + \varepsilon_{ijt}$$

Y_{ijt} is the number of transactions through each channel by customer i in location j at month t . I estimated the model for each channel, including branches, automated teller machines (ATM), voice response units (VRU), call center and online banking channels. I also tested the impact of branch network changes on branch transactions within and outside of the customer's zipcode (*BranchWithin* and *BranchOutside*), the overall usage of offline channels including ATMs, VRU and call center (*Offline*), the total number of channels used (*#Channels*) and the number of non-branch channels used (*#Non-BrhChls*). $\#BranchOpened_{jt}$ and $\#BranchClosed_{jt}$ are for location j at or before month t .

I assumed that banks make independent decisions to open or close branches. I also assumed that the first branch opened and the last branch closed in an area had non-linear effects on the outcomes. I used $\#FirstBranch_{jt}$ and $\#LastBranch_{jt}$, the number of occurrences of a first branch opening and a last branch closing in location j at or before time t . X_{it} is a set of control variables. They include the transaction amount, and the number of account types and transactions by available service types on the estimated channel. C_{ij} is customer-location fixed effects and ε_{ijt} is an error term.

Omni-channel migration patterns. I summarize the results in Table 1. A branch that opened nearby brought transaction traffic from offline to online banking. After a nearby branch closed, customers tended to move to online banking instead of back to the offline channels. The results reveal an interesting customer migration pattern from offline to online banking after branch network changes.

TRANSACTIONS FROM ESTIMATED CHANNEL(S)					
Model Variables	Branch	Offline	Online	BranchWithin	BranchOutside
#BranchOpened	-0.030*** (0.002)	-0.078*** (0.001)	0.024*** (0.000)	0.116*** (0.004)	-0.231*** (0.005)
#BranchClosed	-0.032*** (0.003)	-0.028*** (0.001)	0.098*** (0.001)	-0.002 (0.006)	-0.106*** (0.008)
#FirstBranch	0.023*** (0.005)	-0.002 (0.002)	0.069*** (0.001)	0.400*** (0.013)	-0.046*** (0.010)
#LastBranch	-0.062*** (0.009)	-0.017*** (0.004)	-0.068*** (0.002)	-2.038*** (0.045)	0.493*** (0.018)
Observations	1,178,586	1,178,586	1,178,586	694,256	694,256
TRANSACTIONS FROM ESTIMATED CHANNEL(S)					
Model Variables	ATM	VRU	Call Center	#Channels	#Non-BranchChnls
#BranchOpened	-0.029*** (0.001)	-0.211*** (0.002)	-0.110*** (0.003)	-0.011*** (0.001)	-0.009*** (0.001)
#BranchClosed	-0.001 (0.002)	0.023*** (0.003)	-0.182*** (0.005)	-0.007*** (0.002)	-0.002 (0.002)
#FirstBranch	-0.017*** (0.003)	0.045*** (0.005)	-0.030*** (0.007)	0.003 (0.003)	0.004 (0.003)
#LastBranch	0.043*** (0.006)	-0.014 (0.009)	-0.063*** (0.013)	0.015*** (0.005)	0.024*** (0.006)
Observations	1,178,586	1,178,586	1,178,586	1,178,586	1,178,586
Controls — <i>LogTransaction\$</i> — <i>#AccountTypes</i> — <i>#Transactions</i> (on available transaction types)					
Notes. Model: Poisson; SEs in parentheses; location-based fixed effects. Signif.: * 10% level; ** 5% level; *** 1% level.					

Table 1. Effects of Branch Network on Customer Omni-Channel Banking Behavior

Segment analysis. To explore how the effects varied among different customer segments, I stratified customers into heavy, light and non-branch users, according to branch users. Estimated effects are shown in Figure 1. Heavy branch users were more sensitive for online banking transactions while light ones mostly changed their offline banking usage in response to branch network changes.

Post-treatment trends. I further explored post-treatment trends with five indicator variables. I plotted the trends for customer multi-channel usage in Figure 2. Branch opening tended to cause a short-term boost in transaction volume through online banking as opposed to growing effects after branch closure. In contrast, while branch closure created downward pressure on offline transactions over time, lagged effects appeared for branch opening on transactions through the offline channels.

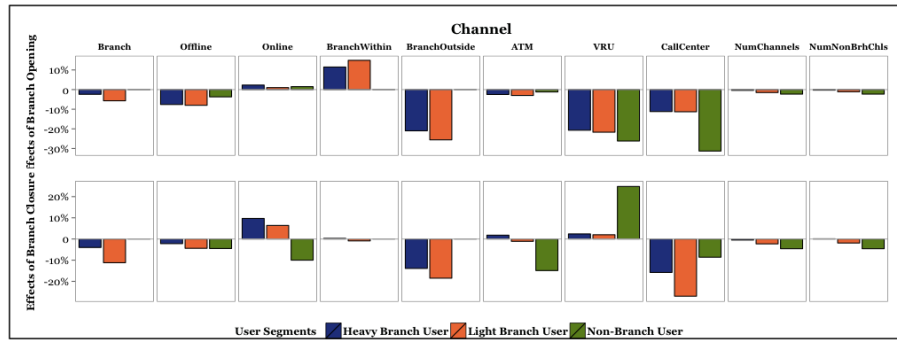


Figure 1. Multi-channel Usage with Customer Segmentation

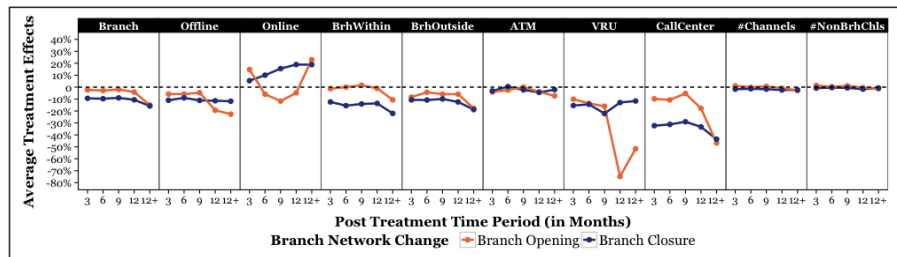


Figure 2. Post-Treatment Trends of Customer Omni-Channel Usage

3 ESSAY 2: CARD PARTNERSHIPS WITH BANKS & RETAILERS

The credit card economy. Card products in financial services, especially credit cards, have new features to create value for customers. With customers increasingly relying on credit cards for their transactions, there is potential for banks to leverage card-based partnerships and enhance their low margins. Such partnerships are also likely to encourage bank customers to generate new revenue with the retail partners. Thus, benefits for both banks and merchants, together with offers and discounts for customers, suggest a win-win-win situation (McKinsey 2011).

Banks face competition with other participants in the same marketplace. Issuers in the card market have learned that an ineffective program may backfire after its costs are reduced (Booz & Co 2005). To survive and thrive in a saturated market, banks must become more deeply aware of the behavior of their customers. They also must figure out whether the bundled benefits with a credit card are crafted to drive increasing revenue with the partner merchant in a way that builds valued customer centricity.

Research questions. Essay 2 uses big data techniques, with data from a large financial services firm in Singapore, to investigate credit card programs and the performance of partnering merchants and customer behavior. I ask: What are the effects of card-based partnerships between banks and retailers on merchant sales and individual customer spending through credit cards? How do the effects vary for the credit card promotions? How do the effects vary across different merchant and customer segments?

Prior literature. Research related to credit card programs has been on the rise, showcasing the new perspectives of academic business strategists and data analytics specialists. A number of papers in the Finance, Marketing and Retailing literatures have studied the biases with consumer preferences, redemption behavior, and customer loyalty in credit card programs (Meier and Sprenger 2010, Liu and Brock 2009, Bolton et al. 2000). Others have used behavioral methods and looked into the impact of credit card programs on customer buying behavior (Wirtz et al. 2007, Ching and Hayashi 2010). However, few previous works have examined the performance of card-based partnership programs. This and their growth around the world motivate Essay 2.

Context and data. To create a valid and useful basis for this research, I focus on the credit card market in Singapore, which is dominated by three local banks: DBS Bank, Oversea Chinese Banking

Corporation (OCBC) and United Overseas Bank (UOB), and the food and dining sector, as it is one of the most popular segments in credit card programs (Singapore Tourist Board 2016).

I use consolidated data from multiple sources. I acquired credit card program information, including the banks' names, the merchants' names and offer descriptions from the banks' websites. I also acquired data by screen-scraping with various software tools and through database harvesting, to collect dining information from HungryGoWhere.com. This is one of the most popular online aggregators for food and dining in Singapore. For each merchant, I obtained the merchants' names, their location by zipcode, the perceived quality scores they achieved as rated by local web users, the number of votes they received at different quality levels, their price levels, their cuisine types and other related information about their operational scenarios (mall, separate business, and so on). In order to measure and report on customer purchasing behavior in response to credit card programs, I used transaction data that a financial institution might use, were it to conduct this kind of study.

Preliminary analysis. I combined the multiple data sets with a fuzzy matching algorithm to construct a unique panel data set. I created several useful insights from my preliminary analysis also.

Credit card campaigns of leading banks. I first summarize the credit card offers from four banks in Figure 3, where I observed number of dining merchant partners and total dining offers with Banks A, B, C and K. I recognize differentiated business strategies, merchant preferences and offer sizes for the credit card campaigns among difference banks.

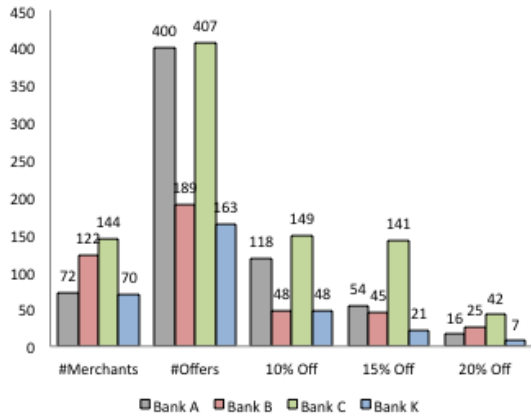


Figure 3. Credit Card Offers of Four Banks

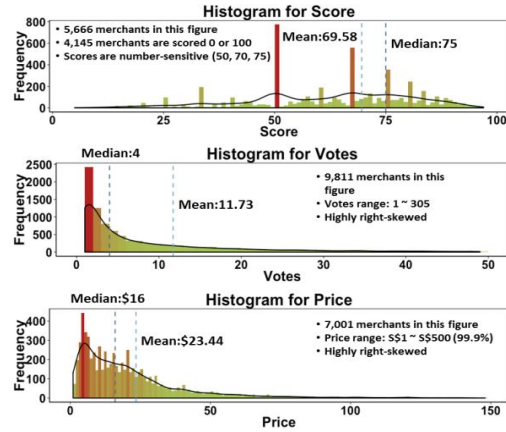


Figure 4. Local Dining Market Overview

Dining market overview. Similarly, based on the HungryGoWhere data, I observe the total number of dining merchants and the distributions of review scores, number of votes and price levels. See Figure 4. Based on a large user base, the data from the review site effectively presents the properties of the merchants and reflects consumer preferences too.

Model development. I tested two models to examine the impact of credit card offers on merchant performance and customer behavior. To have a more intuitive understanding of the effects, I started with a merchant-level model:

$$\log(\text{Sales}_{jt}) = \beta_0 + \beta_1 \text{Partnership}K_{jt} + \beta_2 \log(\text{Score}_j) + \beta_3 \log(\# \text{Votes}_j) + \beta_4 \log(\text{Price}_j) + \beta_5 \# \text{Stores}_j + \beta_6 \text{MerchantTenure}_{jt} + \beta_7 \text{Partnership}A_{jt} + \beta_8 \text{Partnership}B_{jt} + \beta_9 \text{Partnership}C_{jt} + \alpha \text{Cuisines}_j + \gamma \text{SuitableScenarios}_j + \sigma \text{Zipcode}3d_j + \delta \text{Time}_t + \epsilon_{jt}$$

I also developed a customer-level model that controls for customer differences. Based on the merchant-level model, I added variables representing customer demographics and banking status. The customer level model is:

$$\log(\text{Spending}_{ijt}) = \beta_0 + \beta_1 \text{Partnership}K_{jt} + \beta_2 \log(\text{Score}_j) + \beta_3 \log(\# \text{Votes}_j) + \beta_4 \log(\text{Price}_j) + \beta_5 \# \text{Stores}_j + \beta_6 \text{MerchantTenure}_{jt} + \beta_7 \text{Partnership}A_{jt} + \beta_8 \text{Partnership}B_{jt} + \beta_9 \text{Partnership}C_{jt} + \alpha \text{Cuisines}_j + \gamma \text{SuitableScenarios}_j + \sigma \text{Zipcode}3d_j + \varphi X_{it} + \delta \text{Time}_t + \epsilon_{ijt}$$

Preliminary results. By estimating the merchant-level and customer-level models, I can report some early research results about the effects of credit card programs. (1) Card-based partnerships between banks and dining merchants are associated with improvement in merchant performance. (2) After controlling for customer differences, credit card offers are associated with higher customer spending and visits to the partner merchant. And (3), the effects vary with the sizes of the promotions as well as across different merchant and customer segments.

4 ESSAY 3: SPATIOTEMPORAL PENETRATION FOR BITCOIN

Background. Essay 3 will investigate Bitcoin, an emerging cyber-currency, and geography, time and other determinants of its penetration around the world. The price of Bitcoin fluctuates, but trading volumes on major Bitcoin exchange platforms has been rising exponentially since 2012. In addition, the number of Bitcoin wallets has grown by 72% from 2014 to 2015, with a 32% increase in transactions through these wallets (Coindesk 2016). This suggests that instead of acting as a currency for speculation, Bitcoin has begun to attract more users for its ability to act as a payment instrument.

Meanwhile, Bitcoin is accepted by online and offline retailers, such as Overstock, Newegg and TigerDirect as a payment option. This has been creating pressure on banks to expand their capabilities and to support Bitcoin. Many firms are at the early stage of adopting Bitcoin now. A critical question for them is: Who will use currencies like Bitcoin in the near future? Framing an answer will help to understand the markets and customer segments, and how the new cyber-currency is developing.

Research questions. I plan to examine the penetration of Bitcoin based on aggregate usage in different geographic locations over time. I ask: What drives Bitcoin penetration? Are there spillover effects? Does geography affect Bitcoin penetration? And what about the role of time, and other things?

Planned research process. Research on Bitcoin has focused on the economic perspective of new market development. Some data-related work has investigated its price fluctuations and trading volume as a measure of the growing popularity of the cyber-currency. I am interested in the penetration of Bitcoin as an emerging payment system with retail merchants. So I will use transaction-level data from a large Bitcoin exchange platform, plus current online public data on Bitcoin, together with geography-based census data in my research. I will explore some new empirical methods, including spatial econometrics, spatiotemporal analytics, and machine learning for spatial pattern discovery which will make me more ready for future research on geospatial studies in financial services.

5 WORK IN PROGRESS

I presented Essay 1 at the 2015 International Conference on Information Systems (ICIS 2015). I am revising for journal publication based on comments received from different places. Essay 2 is progressing and I have early findings. I will work on establishing causal explanations by implementing advanced methods. I will do more analysis to offer useful insights for decision support in applied settings. Essay 3 is being planned now. The easy way for me to go is to extend Essay 2. But the sponsored research relationship is beyond my control. So I am exploring a second route on cyber-currency, for which I have access to data from a Bitcoin exchange platform. I expect to obtain other data from sources to help me to identify geographic spatial and related temporal data that change over time from government websites. I expect to use econometrics, data mining and machine learning.

Essays 1 and 2 are sponsored research projects in the U.S. and Singapore. I have access to a massive amount of data related to customers, channels and card services through from two large commercial banks. I also have an industry mentor for my thesis in Singapore, a Vice President who manages data analytics for retail banking operations. I also work closely with a Senior Vice President, who heads the country data analytics, and a Managing Director, who manages analytics in the Asia Pacific regional.

I visited Carnegie Mellon University (CMU) from August 2014 to May 2015, as a member of an overseas training residency program sponsored by the Living Analytics Research Centre (LARC) at

SMU. I have advising assistance from faculty members at SMU, and my research is assisted by faculty from CMU too. So my exposure and experience in academic and industry research have been solid.

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