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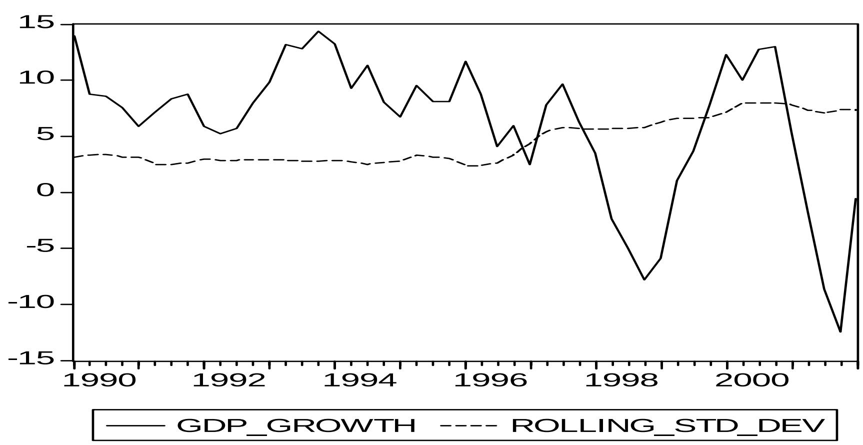
1. Introduction

The Singapore economy has experienced greater business cycle fluctuations in recent years, being subject to recurrent shocks from the external environment. Given the extreme openness of the economy—Singapore's export share of GDP is approximately 180%—it is not surprising that the main cause of the increase in economic volatility is a rise in the frequency and magnitude of exogenous shocks. These include the downswing in the global electronics industry in 1996–97, the Asian financial crisis in 1997–98, the burst of the information technology bubble in 2001, and the outbreak of the SARS respiratory disease in 2003. Such a close sequence of external shocks no doubt induced turbulences in the economy. Figure 1 below shows Singapore's annual GDP growth computed from quarterly data, plotted alongside its 4-year rolling standard deviation. Evidently, the latter has been on an uptrend since the mid-1990s.

Figure 1. Increasing Volatility in Singapore's Economic Growth



Note: The shorter sample period in the chart is due to the end effects of rolling standard deviations.

The primary role of monetary policy in such a volatile environment is to react to cyclical fluctuations in inflation and output in order to compensate, at least partially, for the impact of exogenous shocks.[1] However, to conduct monetary policy successfully, policy makers must first have an accurate assessment of the timing and impact of policy changes on real activity. In other words, an understanding of the propagation of monetary policy shocks known as the monetary transmission mechanism is essential for good policy making. Following the seminal work of Sims (1980), a popular approach is to apply a Vector Autoregressive (VAR) model to examine the effects of monetary policy.

The VAR model is a dynamic system of equations that allows for interactions between economic variables while imposing minimal assumptions about the underlying structure of the economy. Hence, the use of the VAR approach confers two distinct advantages. First, the VAR model explicitly allows for the endogeneity of variables, thereby accommodating the interdependence between monetary policy and economic developments. Second, as opposed to a large-scale fully specified structural model, the VAR analysis focuses on reduced form relationships and thus only requires a simple model with a small number of variables.

The emphasis of the VAR approach is on policy innovations, that is shocks to the measure of monetary policy. Clearly, the shocks to policy are not intrinsically important as the role of monetary policy is not to add new disturbances to the economy. Rather, the impulse response functions derived from the VAR model—which basically trace out the dynamic adjustment paths of the macroeconomic variables in the system following a one time shock to the monetary policy innovation—illustrate the unfolding of the monetary

[1] One strand in the literature uses monetary reaction functions to address how monetary authorities react to changes in macroeconomic variables. (see Clarida et al., 1999) An estimate of the monetary reaction function for Singapore can be found in Parrado (2004).

transmission mechanism and provide a means of assessing the effects of a policy change on the economy. For a survey of the extensive literature on VAR analysis of the effects of monetary policy, see Christianio et al.. (1999).

This study aims at performing a VAR analysis of the monetary transmission mechanism in Singapore.[2] The conduct of monetary policy in Singapore is rather unconventional in that the central bank, the Monetary Authority of Singapore (MAS), targets the effective exchange rate instead of using the short-term interest rate as its policy operating instrument. (see MAS, 2000) Since the MAS implements policy actions through changes in the trade-weighted index, we assume that the effective exchange rate variable may be used as an indicator of the monetary policy stance. In particular, we interpret the VAR innovations to the effective exchange rate as shocks to MAS policy. Impulse response functions can then be generated from the VAR model to examine the responses of key macroeconomic variables like output, inflation and the interest rate to an unanticipated monetary policy disturbance.

To abstract from the impact of extraneous factors, we incorporate in the empirical model a broad set of foreign variables namely, the world oil price index, the US federal funds rate and output in the US. Since the shocks originating from Singapore are unlikely to have an impact on the rest of the world, the foreign variables are treated as exogenous in the empirical model. Within this framework, the dynamic impulse responses produced by the VAR model—with the exception of insignificant price responses—are found to be generally consistent with the conventional view of the monetary transmission mechanism:

[2] On related literature, Fung (2002) uses a semi-structural VAR model to examine the effects of monetary policy in East Asian countries including Singapore. Our study differs in that it focuses on the case of Singapore and estimates a recursive VAR model on a slightly different set of variables as well as sample period.

following a contractionary policy shock, output declines, interest rate rises and the domestic currency appreciates. These findings reflect plausible effects from unpredictable monetary policy shocks, suggesting that the identified innovations do represent monetary policy disturbances.

We further employ the VAR model to investigate another aspect of Singapore's monetary transmission mechanism, specifically the role of the interest rate as a channel of transmission. In view of the openness of the Singapore economy and the monetary policy regime adopted by the MAS, the transmission mechanism is expected to operate mainly through the exchange rate channel. Nevertheless, a relevant question is whether the interest rate, which is the conventional monetary policy instrument used by other countries, also serves as a secondary channel of monetary transmission in Singapore.[3]

To determine the relative importance of exchange rate and interest rate shocks to fluctuations in output and inflation, we perform a variance decomposition of the VAR model, which gives the share of fluctuations in each macroeconomic variable caused by different innovations. Next, we examine the relevance of the interest rate channel in acting as a conduit for propagating exchange rate shocks. This is carried out by comparing the output response path to monetary policy shocks when the interest rate is exogenized in the VAR to the baseline response when the interest rate channel is allowed to operate. To anticipate the results, we find that the exchange rate is more influential than the interest rate as a source of macroeconomic fluctuations; indeed, the latter does

[3] Other identified channels of monetary transmission include inflationary expectations, bank lending, balance sheet effects and wealth effects. (see Mishkin, 1995) However, a comprehensive analysis of the operation of each of these channels and their relative importance in Singapore is beyond the scope of this chapter.

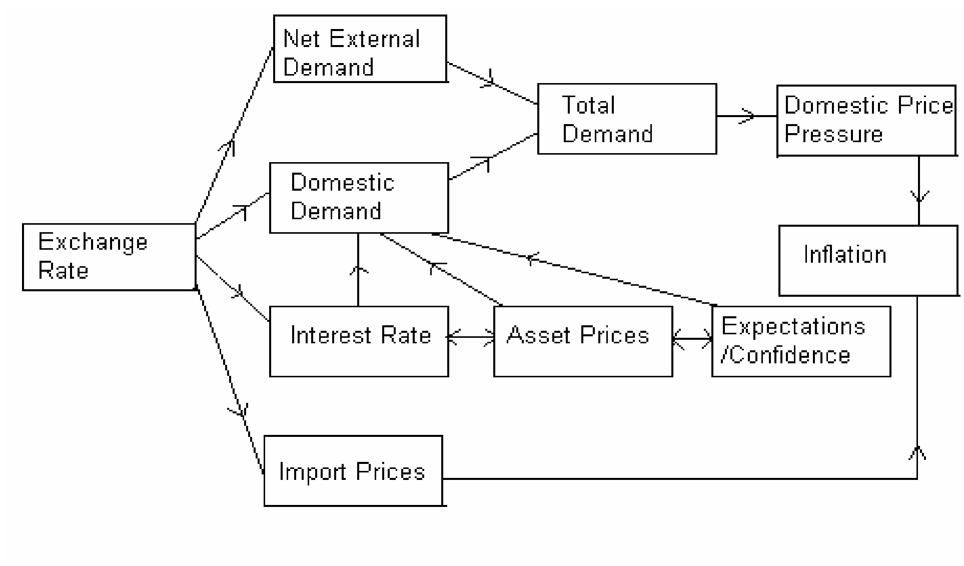
not even appear to be an important channel for transmitting changes in the exchange rate to the real economy during the sample period investigated.

2. The Transmission Mechanism of Monetary Policy

Monetary policy works chiefly through its impact on aggregate demand and has real effects in the economy in the short to medium term. However, the quantitative effect of a policy change is uncertain and depends on, *inter alia*, the degree to which the policy change has been anticipated and how the change affects expectations of future policy. Moreover, a change in the monetary policy stance has an ambiguous influence on the level of consumer and business confidence in the economy. On the one hand, monetary tightening can signal the monetary authority's optimism on future economic prospects and thus, boost confidence. On the other hand, the same policy action can be interpreted as the monetary authority's attempt to slow economic growth in order to maintain price stability, which will have the opposite effect of lowering expectations of future growth. In light of these uncertainties, we hold expectations and confidence constant in the ensuing discussion, along with other factors like fiscal policy.

Figure 2 depicts the key linkages in the monetary transmission mechanism of an exchange rate disturbance. Changes in the exchange rate—which is the relative price of domestic and foreign currency—lead to movements in the relative prices of domestic and foreign goods and services. Such relative price fluctuations in turn can affect the pattern and level of spending in the domestic economy. For instance, an exchange rate appreciation lowers the domestic price of imports and thus reduces the competitiveness of domestic producers of import-competing goods and services. This encourages a switch of expenditure away from home-produced towards foreign-produced goods and services. At the same time, an appreciation of the local currency raises the foreign price of domestic exports, thereby reducing the competitiveness of domestic producers of exports. The attendant decline in exports contributes to the deterioration in the trade balance. Furthermore, if the economy has significant levels of wealth (or debt) that are denominated in foreign currency, an exchange rate appreciation translates to a decline (increase) in net wealth that can depress (raise) the level of expenditure.

Figure 2. Monetary Transmission Mechanism



Note: This diagram is modified from MAS (1999) and for simplicity, does not show all interactions between variables.

In the event that the monetary authority does not carry out complete sterilization of its interventions in the foreign exchange market, a policy-induced change in the exchange rate will alter the supply of local currency, resulting in movements in the interest rate. For instance, when the monetary authority buys local currency and sells foreign currency in order to induce an exchange rate appreciation, a shortage of domestic currency will follow and this in turn drives up the interest rate. As the interest rate[4] reflects the opportunity cost of present versus future expenditure, changes in the interest rate alter the incentives to defer current consumption and investment spending to a later date. Indeed, a higher interest rate raises the cost of capital that directly reduces the profitability of current investment projects. A rise in the interest rate also tends to encourage households to reduce current consumption expenditure because of the increase in both the return on saving and the cost of borrowing to finance consumption. While net borrowers are made worse off, net savers are concomitantly made better off with a rise in the interest rate. This redistributional effect of an interest rate change implies that the overall impact on expenditures is determined by the more dominant of these two influences.

Both consumption and investment spending can also be affected by asset price effects. Higher interest rates make bonds more attractive relative to equities, consequently lowering equity prices. This in turn depresses Tobin's q—which is the market value of firms divided by their replacement cost of capital—thereby discouraging firms from purchasing new investment. At the same time, the fall in stock prices reduces household's financial wealth or increases the likelihood of financial distress, which can lead to a decline in consumption spending. Moreover, a rise in the interest rate tends to reduce other asset values such as land and property prices. Such a decline in asset values not only makes households feel poorer but also makes it harder for them to borrow, especially when assets like houses are used as collaterals for loans. Similarly, bank loans

[4] Strictly speaking, it is the real interest rate which accounts for the loss of purchasing power due to inflation that serves as the relative price influencing intertemporal substitution between present and future expenditure. However, the nominal and real interest rates are linked through the Fisher equation which decomposes the observed nominal interest rate into an expected inflation component and an expected real rate.

to firms are typically secured on assets, so that a fall in asset prices which reduces the net worth of a firm can result in a decrease in lending to finance investment spending. Firms and households not directly affected by the financial impact of the monetary policy change can still be influenced by the induced change in aggregate expenditures. These second round multiplier effects are largely felt by producers for the home market and their suppliers.

Regarding the pass-through effect of exchange rate changes to aggregate prices, we observe from Figure 2 that this could occur through two different channels. Firstly, an exchange rate appreciation has a direct effect on domestic prices by lowering the prices of imported goods and services. Secondly, a reduction in aggregate demand caused by an appreciation of the local currency, as discussed above, alleviates inflationary pressures indirectly through the easing of domestic costs such as wages.

3. Econometric Methodology and Data Pre-Tests

The vector of endogenous variables in our VAR model is {*ip*,*cpi*,*ir*,*twi*}, where *ip* is the industrial production index, *cpi* is the consumer price index, *ir* is the three-month interbank rate and *twi* is the trade-weighted exchange rate of Singapore against her major trading partners. The output, price and interest rate series are standard variables in the monetary business cycle literature and are crucial for identifying monetary policy shocks. The inclusion of the exchange rate variable is necessary for the case of a small open economy. (see Cushman and Zha, 1997) After all, the exchange rate is the announced operating target of monetary policy in Singapore. We exclude monetary aggregates measures because the MAS does not focus on them in the conduct of monetary policy.

This follows from the lack of control over money supply—a reflection of Singapore's openness to capital flows and a very liberal policy towards foreign direct investment.

The three variables {*oil*,*ffr*,*usip*} are assumed to be exogenous, where *oil* is the world oil price index, *ffr* is the US federal funds rate and *usip* is the US industrial production index. The oil price is included to capture inflationary pressures which the monetary authority may react to. (see Sims, 1992) Controlling for such systematic policy responses facilitates the identification of exogenous monetary policy changes. Similarly, the US fed funds rate, which reflects changes in international financial conditions, is incorporated to allow for domestic policy responses to the international transmission of a US monetary policy shock. Finally, the US output variable is included to capture the close trade links between the US and Singapore economies. These three exogenous variables enrich the specification of the model and are potentially critical in resolving the 'price puzzle'[5] commonly found in studies on monetary policy employing VAR approaches.

The model is estimated for the period 1989:1 to 2003:10 using monthly, seasonally adjusted data.[6] All data series are sourced either from the *International Financial Statistics* or the Singapore Department of Statistics' *Trend* database. With the exception of the two interest rates, *ir* and *ffr*, all variables are converted into natural logarithms and scaled by a factor of 100. We investigate the integration properties of the series by applying the Dicky-Fuller unit root test. Without exception, the series are

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[5] This refers to the seemingly contradictory positive response of prices to a contractionary monetary policy shock, often attributed to the model's failure to include information about future inflation that is available to policymakers. As such, positive innovations in the exchange rate may be associated with higher prices because they partly reflect systematic policy responses to indications of oncoming inflation.

[6] Singapore's rebased monthly industrial production series is available publicly only from Jan 1989, which shortens the overlapping data sample period for all the series.

integrated of order one. Using the Johansen trace test, cointegration is detected amongst the variables, motivating us to build a VAR model in levels given by:

$$y_t = \tau + \Pi_1 y_{t-1} + ... + \Pi_k y_{t-k} + \Gamma x_t + \varepsilon_t \qquad (1)$$

for t=1,2,…,T; where y_t'=(*ip*,*cpi*,*ir*,*twi*); x_t'=(*oil*,*ffr*,*usip*); Π_i and Γ are fixed (4x4) and (4x3) matrices of parameters respectively; τ is a (4x1) vector of constants; and ε_t is a multivariate white noise error term with zero mean.

Subject to a maximum of 12 lags, the Akaike and Hannan-Quinn information criteria selected an optimal lag length of 2. However, the white noise assumption is violated when only 2 lags are used in the VAR model; in particular the residuals exhibit serial correlation and most of them are not normally distributed, rendering post-estimation inferences invalid. Besides, we think a lag length of 2 is too short for the VAR model to adequately capture the underlying dynamics of the system. By contrast, including 4 lags in the VAR model eliminates serial correlation and only the residuals in the interest rate equation failed the Jarque-Bera normality test. Hence, a VAR model with 4 lags is used in this study.

For meaningful application of innovation accounting techniques, namely impulse response and variance decomposition analyses, the error terms in the VAR system should be serially and mutually uncorrelated. Since the innovations from a reduced form VAR model are typically correlated, we apply the Cholesky decomposition which recovers the underlying structural shocks by recursive orthogonalisation.[7] The causal ordering of

[7] Alternatively, a Structural VAR which allows for contemporaneous feedback between variables can be used. However, it has been found that more complex identification schemes remain arbitrary and tend to give similar qualitative effects of monetary policy, see Christiano et al. (1999).

variables—output, prices, interest rate and exchange rate—is determined by their level of exogeneity and reflects an implicit assumption about the dynamic structure of the economy. Specifically, the conjecture is on how fast the variables respond to shocks: with output being the least responsive, followed by prices, then the interest rate and finally the exchange rate.

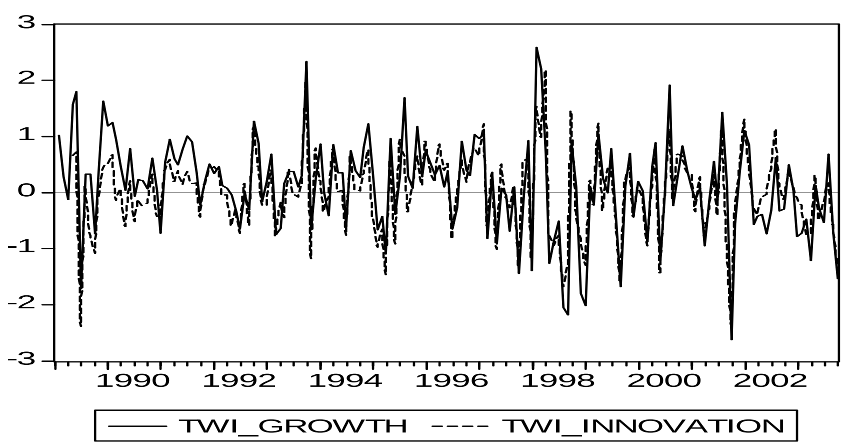
Such a causal ordering seems reasonable as it is takes a longer time for changes in output and prices to be effected compared with the typically faster adjustment rates of financial variables. For instance, price stickiness could arise from slow adjustment of expectations and the existence of explicit or implicit contracts that are not indexed to the rate of inflation. The ordering of the interest rate before the exchange rate takes into account interest parity arguments which imply that changes in domestic interest rates will induce fluctuations in the exchange rate. Under uncovered interest parity, for example, the differential between the domestic and foreign interest rates reflects expected movements in the exchange rate. Therefore, any change in the domestic interest rate affecting this differential would mean that either the exchange rate and/or the expected exchange rate must change. The exchange rate is also ordered last as a reflection of policy makers setting monetary policy with at least some contemporaneous information on output, prices and interest rates.

In any case, the contemporaneous correlations among the innovations turn out to be so small that orthogonalization has little effect and as shown later, the results are robust to alternative orderings of the variables.

4. Empirical Results

At the outset, we examine if it is reasonable to interpret the exchange rate innovations in the estimated VAR model as monetary policy shocks. The exchange rate variable used in this study is expressed in terms of the amount of foreign exchange that can be bought for one unit of local currency. It follows that a rise in the exchange rate signals an appreciation of the Singapore dollar. We thus check whether positive structural innovations in the *twi* variable can be associated with monetary policy contraction and that negative values do represent episodes of monetary expansion. Figure 3 plots *twi*'s structural innovations recovered from the VAR model against the month-on-month growth of *twi*. It is clear from the plot that the positive (negative) innovations are indeed generally associated with increases (declines) in the effective exchange rate.

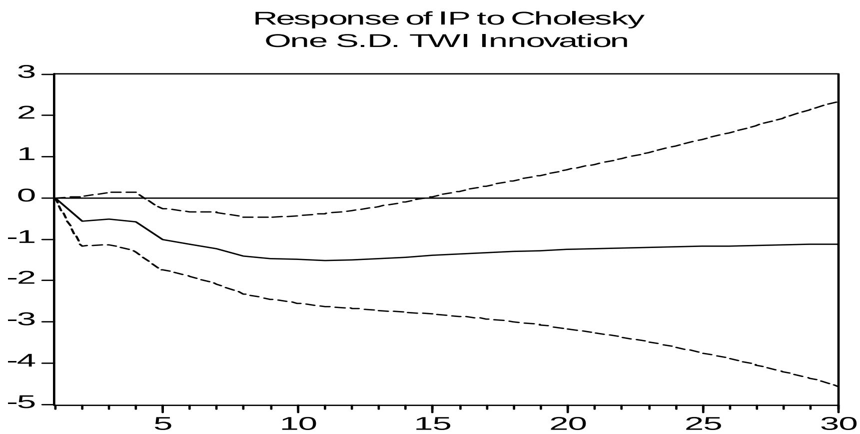
Figure 3. Structural Innovations of Exchange Rate



4.1 Impulse Response Analysis

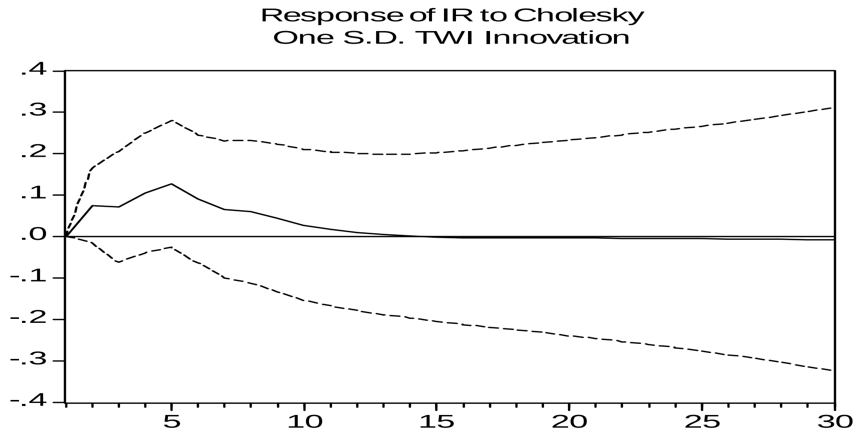
Figures 4-7 plot the impulse response functions of the macroeconomic variables included in the VAR model for an innovation to the exchange rate shock. Given the way the effective exchange rate is defined, an innovation represents a one-standard deviation appreciation which corresponds to a 0.75% rise in the effective exchange rate. We obtained Monte Carlo standard errors from 1000 replications for the impulse responses and then used them to construct two-standard error bands. These are shown as dashed lines in the figures. The time horizon over which the responses are plotted following the monetary policy innovation extends to 30 months, by which time all the impulses are insignificantly different from zero.

Figure 4: Impulse Response of Output to Exchange Rate Shock



An unexpected tightening of monetary policy elicits an immediate negative response from output, see Figure 4. The positive exchange rate shock precipitates a decline in output which bottoms out 11 months after the initial impulse, at 1.5% below the baseline level, and becomes statistically insignificant after 15 months. The contractionary effect of monetary policy stemming from an appreciation of the Singapore dollar can be traced principally to a reduction in exports occurring through a loss of competitiveness. The relatively large output reaction obtained in the short-run is expected, in light of the external trade-driven nature of the Singapore economy (see Abeysinghe, 2000). An inverted hump-shaped response of output like the one we find here is a robust finding of the monetary VAR literature, documented by, amongst others, Kim (1999) for different countries and Bernanke and Mihov (1998) for various measures of monetary policy.

Figure 5: Impulse Response of Interest Rate to Exchange Rate Shock



As depicted in Figure 5, a positive exchange rate shock instantly increases the interest rate which steadily rises until a peak of 0.13% above the baseline level is reached around 5 months after the initial impulse, although this is marginally insignificant. Thereafter, the interest rate response reverts back to the baseline value. When the MAS buys Singapore dollars and sells foreign currencies to induce an appreciation of the effective exchange rate, the resulting shortage in the local currency explains the rise in the interest rate. Nevertheless, the small magnitude of the reaction can be attributed to neutralization of the impact on the interest rate through effective sterilization carried out by the MAS.

The plot in Figure 6 shows the exchange rate impulse response to its own innovation. We see that the exchange rate shock is quite persistent, remaining significantly above the baseline level for 12 months. This suggests a lasting deviation of the exchange rate from its trend, with only a gradual reversal to the pre-shock level.

Figure 6: Impulse Response of Exchange Rate to Exchange Rate Shock

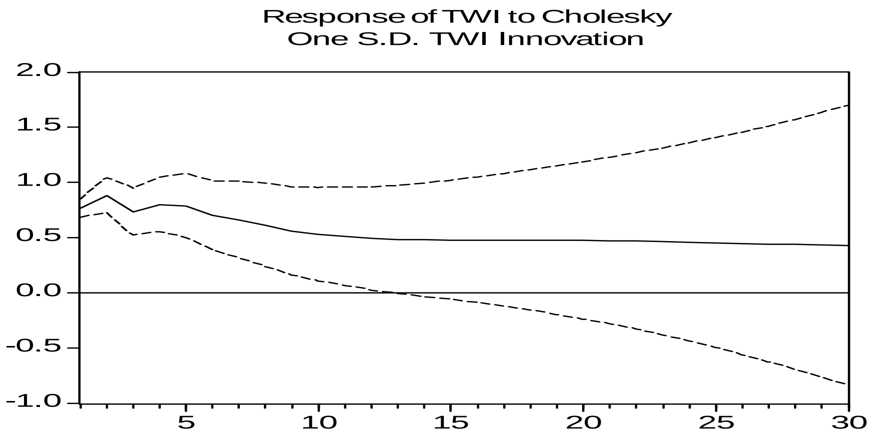
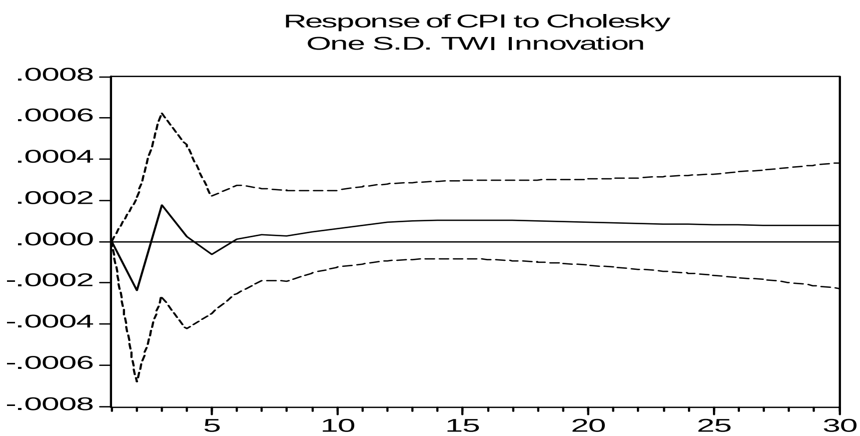


Figure 7: Impulse Response of Prices to Exchange Rate Shock



Finally, Figure 7 shows that the price response to an exchange rate shock is statistically undetectable and tiny in magnitude.[8] This is not compatible with *a prior* theory which predicts a fall: the deflationary impact of a Singapore dollar appreciation can occur through the direct channel of lower imported inflation, as well as the indirect

[8] Fung (2002) found price responses for Singapore to be sluggish, falling significantly below the baseline level more than a year after the initial exchange rate impulse.

channel whereby a reduction in exports eases domestic cost pressures. Nonetheless, a decline in the strength of pass-through effects has recently been observed, particularly for countries in a low inflationary environment. (see Gagnon and Ihrig, 2001) It follows that the statistically negligible price response we obtained here is perhaps not surprising, given Singapore's low inflation record. Besides, Toh (1999) found the inflationary effects of an exchange rate depreciation in Singapore to be more evident in producer prices rather than consumer prices.

Another possible explanation for this somewhat puzzling response is that the MAS does not have complete control over the policy variable. Rather, the exchange rate is typically influenced by other factors that may not be captured by the specification of the VAR model. For example, as pointed out by Fung (2002), it is doubtful that macroeconomic variables included in the model account for capital flows due to major mergers and acquisitions which could affect the exchange rate. Unfortunately, such an exogenous disturbance may be mis-interpreted as a monetary policy shock in the VAR model. In addition, the MAS uses a prescribed policy band in its monetary policy operations. (see MAS, 2003) Specifically, the MAS intervenes in the foreign exchange market only when the effective exchange rate is near to or have exceeded the undisclosed band limits. As such, movements in the exchange rate within the policy band are largely market determined and do not exclusively reflect monetary policy actions. Clearly, the monetary policy shock is not perfectly identified in the VAR model.

Notwithstanding the difficulties in isolating policy-induced movements in the Singapore dollar, our choice of the effective exchange rate as the measure of monetary policy in Singapore produces results that are generally consistent with conventional thinking about the monetary transmission mechanism. Furthermore, we obtained very similar patterns from generalized impulse response functions—which are independent of the causal ordering of variables (Pesaran and Shin, 1998)—confirming the robustness of our analysis.

4.2 Variance Decomposition Analysis

To assess the relative importance of exchange rate and interest rate shocks as sources of macroeconomic fluctuations in Singapore, we compute the variance decompositions for the output and price variables. The variance decompositions shown in Tables 1 and 2 are for half-yearly forecast horizons running up to 30 months, by which time both the output and price forecast error decompositions due to the various disturbances have stabilized. The figures in parentheses below the decompositions represent Monte Carlo standard errors from 1000 replications. Each column gives the percentage of the forecast error variance due to innovations to the variable listed in the column, so that each row adds up to 100.

Table 1. Variance Decomposition of Output

Horizon	*ip*	*cpi*	*ir*	*twi*
6	88.71	0.028	1.04	10.21
	(7.32)	(0.25)	(2.69)	(6.91)
12	67.35	0.098	3.63	28.90
	(13.12)	(0.59)	(6.58)	(12.99)
18	59.78	0.10	3.83	36.28
	(15.03)	(0.73)	(8.72)	(15.50)
24	56.74	0.09	3.62	39.53
	(16.03)	(0.81)	(10.21)	(16.84)
30	54.83	0.09	3.44	41.63
	(16.66)	(0.86)	(11.24)	(17.66)

As shown in Table 1, the contribution of exchange rate policy shocks is very critical, accounting for around 40% of output movements at the longer horizons. This concurs with the significant output impulse response to an exchange rate innovation, see Figure 4. It is not surprising for exchange rate disturbances to exert a strong influence on Singapore's output in view of the extreme openness of the economy. In sharp contrast, interest rate shocks matter little to output fluctuations. The proportion of the output forecast error variance due to the interest rate turns out to be statistically insignificant, amounting to less than 4% at all forecast horizons. Since the contribution of the exchange rate shock overshadows that of the interest rate shock, we conclude that the exchange rate has a higher leverage effect than the interest rate on output in Singapore. This result is in line with the MAS's monetary policy framework whereby the exchange rate rather than the interest rate is the relevant policy instrument.

Table 2. Variance Decomposition of Prices

Horizon	*ip*	*cpi*	*ip*	*twi*
6	2.97	94.59	1.32	1.09
	(3.04)	(4.18)	(2.20)	(2.04)
12	4.15	93.01	1.48	1.34
	(3.84)	(5.08)	(2.42)	(2.25)
18	4.56	91.73	1.67	2.03
	(4.44)	(6.41)	(2.65)	(3.01)
24	4.94	90.78	1.72	2.55
	(5.39)	(8.16)	(2.83)	(4.06)
30	5.24	90.06	1.73	2.95
	(6.53)	(10.21)	(3.06)	(5.26)

The fluctuations in prices are caused primarily by its own shocks which account for virtually all (around 90%) of price movements throughout the forecast horizons, see Table 2. Interpreting these innovations as foreign price disturbances that are not captured by the model, their dominance indicates the importance of imported inflation in

Singapore. Both exchange rate and interest rate shocks explain negligible fractions of price variability. In fact, their shares of the forecast error variance for the price level turn out to be insignificantly different from zero at all forecast horizons. The low explanatory power of the exchange rate reflects the insignificant price impulse response to an exchange rate shock, see Figure 7.[9]

For robustness, we compute variance decompositions corresponding to alternative Cholesky decompositions. We obtained qualitatively similar results even for the case where the causal ordering of variables is completely reversed. This is evident in Tables 3 and 4 which give the variance decompositions of output and price respectively yielded by the reverse ordering {*twi*,*ir*,*cpi*,*ip*}. As with the impulse response analysis, the variance decomposition findings are invariant to the ordering of the variables.

Table 3. Variance Decomposition of Output with Reverse Ordering

Horizon	*Ip*	*cpi*	*ir*	*twi*
6	87.89	0.44	2.27	9.38
	(7.48)	(1.09)	(3.94)	(6.57)
12	66.48	0.33	6.10	27.07
	(12.9)	(0.86)	(8.57)	(12.87)
18	58.98	0.29	6.54	34.17
	(14.74)	(0.79)	(11.12)	(15.41)
24	56.03	0.28	6.34	37.34
	(15.69)	(0.76)	(12.68)	(16.7)
30	54.18	0.27	6.14	39.39
	(16.24)	(0.74)	(13.66)	(17.61)

[9] While Parrado (2004) also found the exchange rate shock to have a weak influence on prices, Choy (1999) obtained opposing results from a Structural VAR model of the Singapore economy.

Table 4. Variance Decomposition of Prices with Reverse Ordering

Horizon	*ip*	*cpi*	*ip*	*twi*
6	2.21	92.22	4.36	1.20
	(2.51)	(4.48)	(3.16)	(2.20)
12	3.36	90.68	4.53	1.41
	(3.35)	(5.25)	(3.30)	(2.44)
18	3.76	89.42	4.75	2.05
	(3.97)	(6.46)	(3.57)	(3.14)
24	4.14	88.50	4.81	2.53
	(4.91)	(8.17)	(3.92)	(4.23)
30	4.45	87.79	4.83	2.91
	(6.04)	(10.34)	(4.41)	(5.61)

4.3 The Interest Rate as a Conduit of Monetary Policy

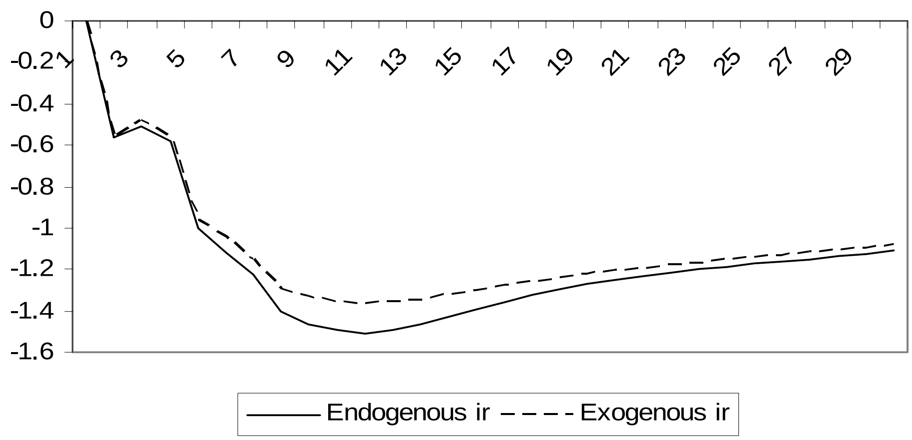
Given that the interest rate shock is found not to have a major influence on output fluctuations in Singapore, we go on to investigate whether the interest rate at least serves as a conduit of monetary policy to the real economy. After all, the interest rate channel has been a standard feature in the economics literature and is often incorporated in macroeconomic models used by policy makers such as the International Monetary Fund's *MULTIMOD* model for industrial countries (Laxton et al., 1998). We gauge the strength of the interest rate channel by calculating two sets of impulse responses: one with the interest rate treated as endogenous in the VAR model and another where it is included as an exogenous variable. The latter VAR model is given by:

$$y_t = \tau + \Pi_1 y_{t-1} + ... + \Pi_4 y_{t-4} + \Gamma x_t + \lambda_1 ir_{t-1} + ... + \lambda_4 ir_{t-4} + \varepsilon_t \qquad (2)$$

for t=1,2,…,T; where y_t' =(*ip*,*cpi*,*twi*); x_t' =(*oil*,*ffr*,*usip*); Π_i and Γ are fixed (3x3) matrices of parameters respectively; τ and λ_i are (3x1) vector of constants and parameters respectively; and ε_t is a multivariate white noise error term with zero mean.

This model effectively blocks off the responses within the VAR system that passes through the interest rate variable. A comparison of the output responses of the two models thus provides an idea of the significance of the interest rate channel in propagating exchange rate shocks. (see Morsink and Bayoumi, 2001) Figure 8 depicts the impulse responses of output to an innovation in the exchange rate with and without the interest rate exogenized. Evidently, blocking off the interest rate channel only marginally dampens the reaction of output. The largest difference between the two responses is 0.14%, obtained at the 12-month forecast horizon. This suggests that the interest rate does not serve as a strong channel of monetary transmission over the sample period used.

Figure 8: Impulse Response of Output to Exchange Rate Shock



Such a result is not in the least unexpected, given the dominance of external demand in the composition of the aggregate demand for Singapore's goods and services. At the same time, domestic investment is not particularly sensitive to the interest rate because Singapore's heavy reliance on foreign direct investment limits the impact of the cost of domestic borrowing. As for domestic consumption, houses are a major component of personal wealth in Singapore but a decline in housing wealth—plausibly caused by a rise in mortgage rates—does not seem to have any discernible dampening effect on aggregate consumption. (see Abeysinghe and Choy, 2004; Phang, 2004) This rather unusual finding has been attributed to the illiquid nature of Singapore's housing assets as well as the strong bequest motives of Singaporean households.

5. Conclusion

In this study, we employ a VAR model to examine the monetary transmission mechanism in Singapore. Since the effective exchange rate is the announced operational target, we identify shocks to the exchange rate as monetary policy innovations. Overall, the impulse response functions obtained are broadly consistent with the conventional view of the monetary transmission mechanism. We highlight the following results. Firstly, impulse response analysis reveals that output reacts immediately and significantly to a contractionary monetary policy shock, and that the exchange rate innovation is quite persistent. Secondly, the variance decompositions show that the exchange rate innovation is a more important source of output fluctuations, compared with the interest rate shock. Finally, the interest rate does not appear to be a strong channel for transmitting exchange rate disturbances, at least over the sample period under study.

We note that the analyses in this study are performed on historical data and therefore reflect past monetary policy actions, in particular the use of the effective exchange rate as the monetary policy instrument. To determine if the conduct of monetary policy would have been more responsive had the interest rate been used as the policy operating instrument in place of the exchange rate would require counter-factual experiments and simulation analysis. We think future research along these lines is warranted and represents a possible extension of this study.

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