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SINGAPORE

Selected Issues

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Approved by the Asia and Pacific Department

July 1, 2008

Contents Page

EXECUTIVE SUMMARY

The ongoing turbulence in the world's economy and financial markets provides an opportunity to assess Singapore's exposure to international spillovers and possible policy responses. This *Selected Issues* paper accompanies the *Staff Report* for the 2008 Article IV consultation with Singapore and offers analytical underpinnings for the staff's views on international financial linkages and the effectiveness of monetary and fiscal policy. It consists of three chapters:

Chapter I—*Assessing the Stability of Singapore's Banking System in a Regional Context*—proposes a novel methodology for gauging domestic financial stability. The methodology gives preliminary estimates of measures of default interdependence between Singaporean and selected regional banks operating domestically. The analysis supports the staff's view that Singaporean banks have been resilient to the global financial turmoil, thus far.

Chapter II—*The Effects of Monetary Policy in Singapore*—analyzes the effects of monetary policy using structural vector autoregressions. Estimates show that the Monetary Authority of Singapore's exchange rate-centered framework is well suited to shape monetary decision making, given the large impact that changes in the nominal exchange rate have on activity and prices. The results are consistent with the staff's recommendation that a faster rate of appreciation of the Singapore dollar would help contain inflation risks, going forward.

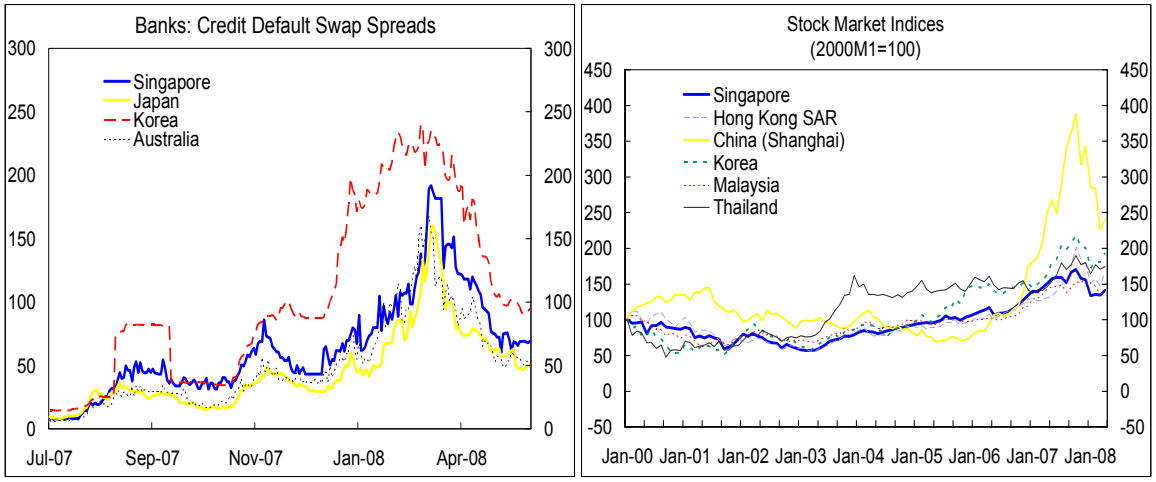
Chapter III—*Effectiveness of Fiscal Policy in Singapore*—assesses the impact of fiscal measures on macroeconomic activity. Econometric results confirm a role for fiscal policy as a counter-cyclical tool and support the staff's view that a carefully designed fiscal stimulus should play a part in re-orienting the policy mix to facilitate external adjustment.

I. Assessing the Stability of Singapore's Banking System in a Regional Context [1]

This chapter proposes a methodology for assessing the stability of the banking system in Singapore in a regional Asian context. The methodology allows for a quantification of the evolution of default interdependence of Singaporean and selected regional banks. The main results of the analysis indicate that the largest Singaporean banks have remained resilient to the global financial turmoil and have generally been less affected than regional banks operating in Singapore.

A. Introduction

1. **The direct impact of the global credit turmoil on Singaporean banks has been limited so far**. Credit default swap (CDS) spreads for Singaporean and Asian banks increased significantly since the second half of 2007 on the back of the global credit turmoil and have remained elevated even after a decline since March 2008. However, the reported subprime related exposures and estimated losses of Singaporean banks are lower than elsewhere in Asia, and in the United States and Europe. Moreover, Singaporean banks have made prudent provisions against losses on exposures to the U.S. subprime related assets.



2. **This chapter assesses the stability of the banking sector in Singapore using a novel methodology**. The methodology is still work in progress and the results should be interpreted with care. The central insight is to derive the probabilities of default (PoDs) of a sample of Singaporean and regional banks and estimate the joint probability of default (JPoD) and other conditional measures of banking sector stability. The chapter proceeds as follows: Section B summarizes the analytical framework, Section C presents the main finding, and section D concludes.

[1] Prepared by Elena Loukoianova and Miguel Segoviano (both MCM).

B. Analytical Framework

3. **The analysis provides novel measures of banking stability and contributes to the modeling of default risk**. It extracts market information to assess potential contagion effects and the resilience among Singaporean and selected regional banks operating in Singapore.[2] The exercise provides a new methodology and complements the study presented in the special feature in the 2007 Monetary Authority of Singapore's Financial Stability Review.[3]

4. **The central idea behind the methodology is to treat the banking system as a "portfolio of banks."** The estimates of banking system stability capture risks of the individual banks and interdependencies of the banks in the portfolio.[4] The model is applied to a portfolio of *Singaporean* banks only and one of *Singaporean and regional* banks.[5]

5. **The analytical framework uses two variables to estimate different measures of banking stability: daily equity prices and daily CDS spreads**.[6] Equity prices are used to calibrate the initial conditions for model simulations.[7] Based on the PoDs for individual banks extracted from CDS spreads, the framework then computes a multivariate density function (PMD) to capture the implied distribution of asset values of the banks included in the portfolio.[8] [9] The PMD embeds the default dependence among the banks in the portfolio and allows for the estimation of the JPoD of the bank portfolio under consideration.[10]

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[2] The methodology proposed here can be applied to alternative inputs for calculating PoDs of individual banks and JPoDs of different bank groups.

[3] The special feature used panel data econometric estimates and analyzed data for the period from January 2002 to December 2006—prior to the onset of the credit turmoil in mid-2007. This analysis found that the East Asian banking systems became more resilient after the Asian financial crisis, the default risk of banks declined, and contagion among banks also declined. The MAS attributed lower default risk to income diversification.

[4] Goodhart and Segoviano, 2008. Box 1.5 in the April 2008 GFSR presents an application of this methodology for a group of large financial institutions.

[5] A number of multinational banks have branches in Singapore and thus have a bearing on domestic financial stability. Lack of branch-level data precludes, however, a quantitative analysis of the issue.

[6] The data for both variables are from Bloomberg.

[7] See Segoviano (2008) for details on calculation of PoDs.

[8] Segoviano, 2008.

[9] Under the probability integral transformation (PIT) criterion, the PMD produced by nonparametric techniques is an improvement over standard parametric PMDs used for modeling portfolio credit risks (See Diebold et al. (1999) for details).

[10] The methodology proposes a novel *nonparametric copula approach*—which assumes neither a particular distribution nor parameters, thus making possible a better fit to the data. The structure of linear and nonlinear

(continued)

6. **The JPoD represents the *unconditional* probability of default of all the banks in the sample, i.e. the tail risk of the system**. The JPoD accounts for the nonlinear dependencies among banks in this portfolio of banks.[11] In periods of financial distress, the JPoD of the banking system may experience larger fluctuations compared with those of the PoDs of individual banks because of stronger interdependencies during times of stress.

7. **The JPoD provides the base for calculating *conditional* measures of banking stability:**

- The *Banking Stability Index* (BSI), which shows the expected number of bank defaults, conditional on at least one bank defaulting.[12]

- The *Default Dependence Matrix* (DDM), which is a matrix of pairwise conditional probabilities of default, indicating the probability of default of a bank in the row, given that a bank in the column defaults;

- The *Conditional Systemic Relevance Factor* (SRF), which reflects the probability of default of all the banks in the system conditional on the default of a *specific* bank; and

- The *Conditional Resilience Factor* (RF), which indicates the opposite of the SRF, namely the probability that a bank defaults conditional on the default of all the other banks.

8. **The methodology is subject to some data limitations when applied to emerging market countries**. First, inputs (equity prices and CDS spreads) used may not be the best proxy for estimating banks' probabilities of default, especially in times of global market turmoil.[13] Second, limited data availability on CDS spreads constrains the choice of banks,

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dependencies among banks in a system can be represented by copula functions. This approach infers copulas from the joint movements of PoDs of individual banks, thus avoiding the difficulties involved in explicitly choosing and calibrating individual measurements of banks' defaults. This is the main contrast between and traditional copula modeling approaches, as explicit calibration in most cases is difficult because of data constraints.

[11] Accounting for nonlinear dependencies changing over time is a relevant technical improvement over most risk models, which typically account only for dependencies that are assumed constant over the cycle.

[12] The BSI is conditional of a default of any bank in the system, but not a *specific* bank. Moreover, such a default might never materialize.

[13] In the current episode, the risk landscape and consequently hedging strategies have shifted significantly since June 2007. The discrepancy between CDS spreads and bond prices, coupled with the increasing illiquidity of the credit markets (especially for CDS spreads of local banks), has clouded the information embedded in the CDS spreads.

which may result in a sample that is not fully representative of the banking sector under consideration.

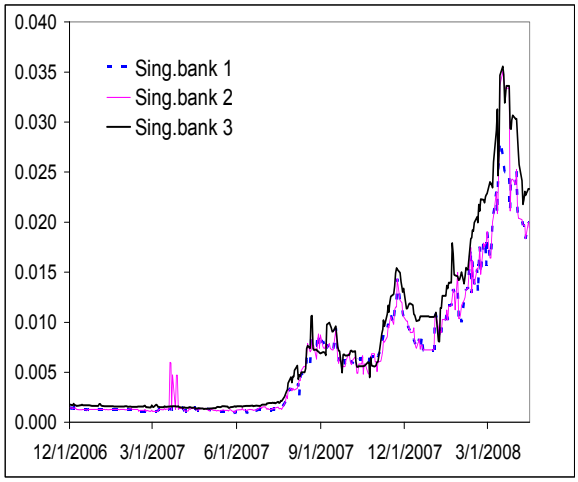
C. Main Findings

9. **An assessment of banking sector vulnerabilities involves a careful evaluation of a broad spectrum of indicators, in changes and levels**. Changes bespeak the impact from global financial reverberations, while levels provide evidence of resilience. In the case of Singapore, changes in the indicators confirm international spillovers, but the absolute levels of the measures suggest that overall resilience of the Singaporean banking system remains high. As regards linkages with regional banks, evidence is more ambiguous. In particular:

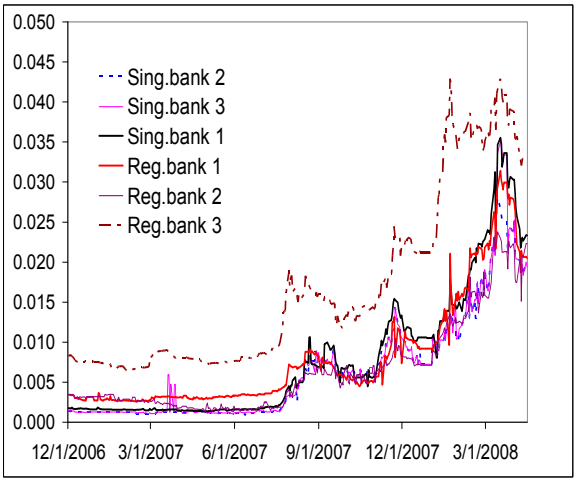
- *The PoDs and the JPoDs of both bank groups analyzed increased as the global credit crisis unfolded.* Between the end of July 2007 and the end of March 2008, the average PoD of the institutions in the "*Singaporean bank*" portfolio increased by about 7 times, while their JPoD increased by a larger factor.[14] The average PoD of the group of "*Singaporean and regional"* banks increased by 3½ times, while its JPoD rose by even more (Figures I.1 and I.2). The significant difference between the magnitude of increases in the average PoDs and the JPoDs reveals large increases in default interdependence among the banks during this period of financial distress. The JPoD of the *Singaporean-regional* bank portfolio is smaller than that of the *Singaporean* bank portfolio, which could reflect diversification gains and/or a nonrepresentative sample. Because of the data limitations mentioned above, this evidence needs to be interpreted carefully.

Figure I.1. Marginal Probabilities of Default

Singaporean banks



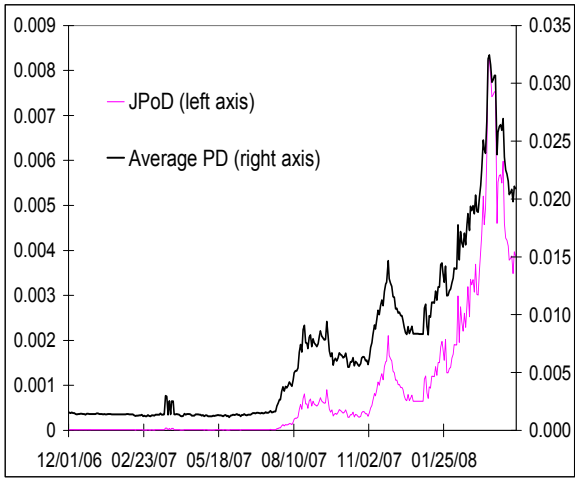
Singaporean-Regional banks



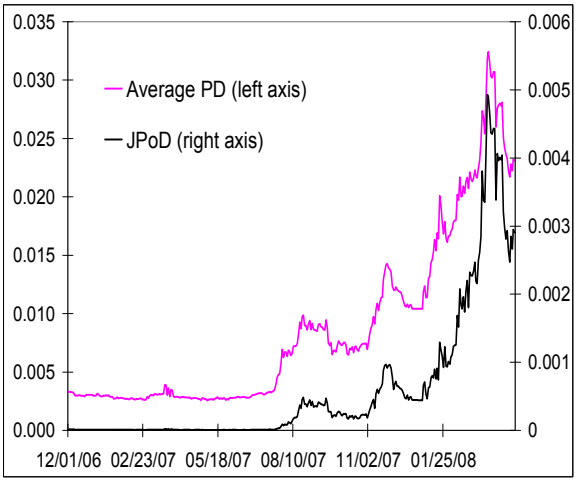
[14] The average PoD is defined here as a simple average of the PoDs of individual banks in a group.

Figure I.2. Joint Probability of Default and Average Marginal Probability

Singaporean banks



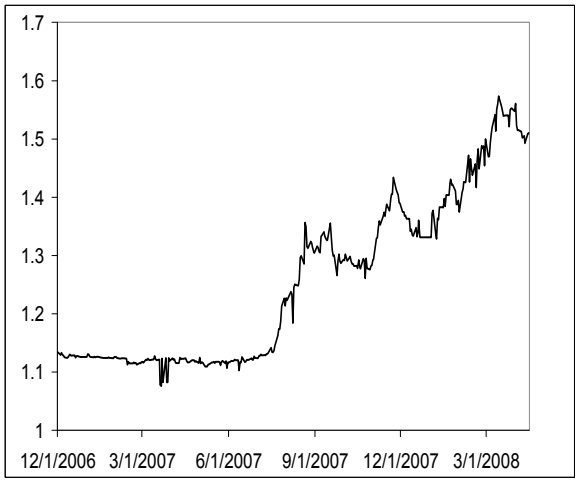
Singaporean-Regional banks



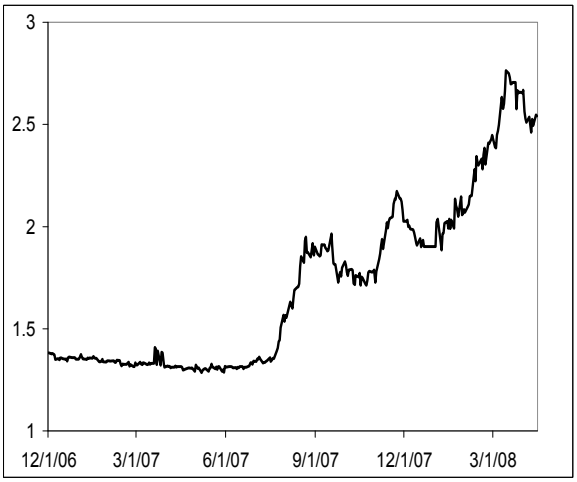
- *The BSI shows signs of an adverse impact from the global turmoil on Singapore's banking sector, but largely through regional banks* (Figure I.3). For the group of *Singaporean* banks, the BSI increased by only 0.5 reaching 1.6 between mid-2007 and the end of March 2008. Thus, before the onset of the market turmoil, only a partial default at one bank was expected, if another bank in the sample defaulted. For the group of *Singaporean and regional* banks, the BSI increased by about 1.3 reaching 2.7, implying that the presence of regional banks in the sample add some vulnerability or channels of contagion.

Figure I.3. Banking Stability Index

Singaporean banks



Singaporean-Regional banks



- *The DDM for the Singaporean banks suggests that the conditional pairwise probabilities of default increased* somewhat since the *second half of 2007* (Table I.1). In particular, the default interdependence between two Singaporean banks was higher than it was between each of these and the third bank.

Table I.1. Singaporean Banks: Default Dependence Matrix (DDM).[15]

Date	Sing.bank 1	Sing.bank 2	Sing.bank 3	Average[1]
6/29/07				
Sing.bank 1	1.00	0.34	0.02	0.18
Sing.bank 2	0.25	1.00	0.03	0.51
Sing.bank 3	0.02	0.03	1.00	0.52
9/28/07				
Sing.bank 1	1.00	0.57	0.10	0.33
Sing.bank 2	0.50	1.00	0.10	0.55
Sing.bank 3	0.09	0.11	1.00	0.55
12/31/07				
Sing.bank 1	1.00	0.69	0.14	0.41
Sing.bank 2	0.47	1.00	0.12	0.56
Sing.bank 3	0.10	0.12	1.00	0.56
3/31/08				
Sing.bank 1	1.00	0.81	0.31	0.56
Sing.bank 2	0.63	1.00	0.28	0.64
Sing.bank 3	0.24	0.28	1.00	0.64

[1] Row average.

- *The DDM for the Singaporean and regional group of banks suggests, that the regional banks in the sample could depend more on the Singaporean banks than vice versa.* Although the conditional PoDs of the *Singaporean* banks rose since mid-2007, they stayed below the conditional PoDs of the regional banks throughout the whole period (Table I.2). These results are consistent with the view that worsening liquidity or solvency conditions at regional banks would have a modest effect, if any, on the Singaporean banks. However, this could also reflect weaker balance sheets of regional banks compared to Singaporean banks, which could imply that the former would probably face financial strains if the latter do (i.e. in response to a common adverse shock).

[15] Probability of Default over one year of a bank in a row, conditional on the default of a bank in a column.

Table I.2. Singaporean and Regional Banks: Default Dependence Matrix (DDM).[16]

Date	Sing.bank 1	Sing.bank 2	Sing.bank 3	Reg.bank 1	Reg.bank 2	Reg.bank 3	Average1
6/29/07							
Sing.bank 1	1.00	0.13	0.11	0.11	0.13	0.10	0.12
Sing.bank 2	0.10	1.00	0.15	0.06	0.12	0.06	0.28
Sing.bank 3	0.09	0.18	1.00	0.07	0.13	0.05	0.29
Reg.bank 1	0.21	0.17	0.17	1.00	0.15	0.15	0.33
Reg.bank 2	0.15	0.19	0.18	0.09	1.00	0.09	0.31
Reg.bank 3	0.48	0.36	0.31	0.38	0.40	1.00	0.49
9/28/07							
Sing.bank 1	1.00	0.32	0.29	0.30	0.32	0.28	0.30
Sing.bank 2	0.29	1.00	0.38	0.23	0.35	0.21	0.43
Sing.bank 3	0.27	0.40	1.00	0.25	0.34	0.20	0.44
Reg.bank 1	0.27	0.24	0.24	1.00	0.23	0.23	0.39
Reg.bank 2	0.29	0.36	0.34	0.23	1.00	0.23	0.43
Reg.bank 3	0.54	0.46	0.41	0.49	0.50	1.00	0.57
12/31/07							
Sing.bank 1	1.00	0.41	0.38	0.37	0.41	0.32	0.38
Sing.bank 2	0.28	1.00	0.40	0.24	0.36	0.20	0.44
Sing.bank 3	0.26	0.40	1.00	0.24	0.35	0.19	0.43
Reg.bank 1	0.32	0.31	0.31	1.00	0.29	0.26	0.43
Reg.bank 2	0.28	0.36	0.34	0.23	1.00	0.21	0.43
Reg.bank 3	0.65	0.59	0.54	0.60	0.63	1.00	0.67
3/31/08							
Sing.bank 1	1.00	0.59	0.57	0.55	0.60	0.54	0.57
Sing.bank 2	0.46	1.00	0.58	0.43	0.55	0.41	0.59
Sing.bank 3	0.44	0.58	1.00	0.43	0.54	0.39	0.59
Reg.bank 1	0.51	0.50	0.51	1.00	0.50	0.48	0.60
Reg.bank 2	0.44	0.52	0.51	0.40	1.00	0.40	0.56
Reg.bank 3	0.70	0.67	0.64	0.67	0.70	1.00	0.73

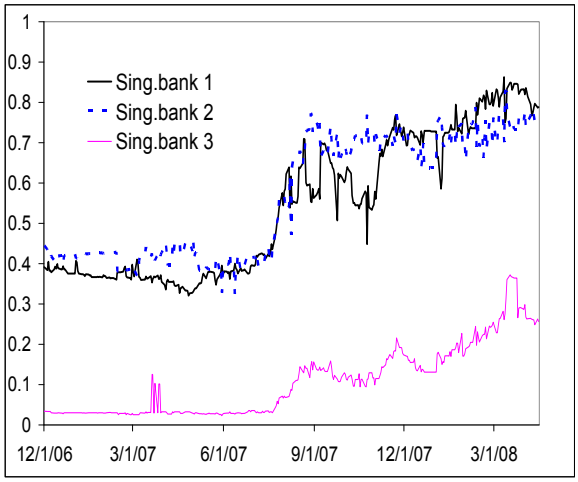
[1] Row average.

- *The conditional resilience factor (RF) suggests that Singaporean banks are resilient to an adverse systemic event.* Among the Singaporean banks, one stands out as more resilient (Figure I.4) and the other two banks demonstrate almost identical resilience, confirming the finding from the DDMs that these two banks are becoming increasingly interlinked. Among the regional banks in the sample, one bank stands out as less resilient (Figure I.4).

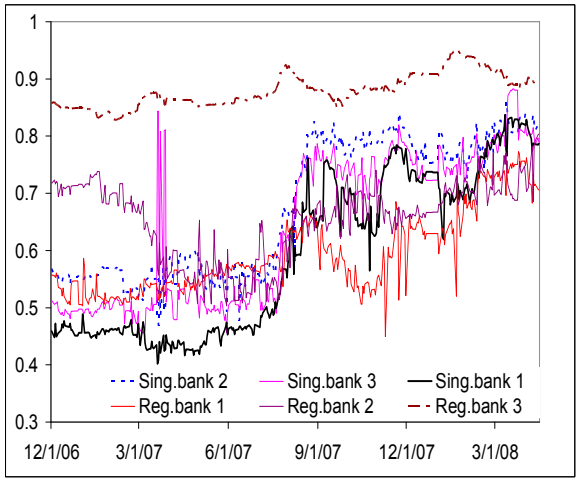
[16] Probability of Default over one year of a bank in a row, conditional on the default of a bank in a column.

Figure I.4. Resilience Factor

Singaporean banks



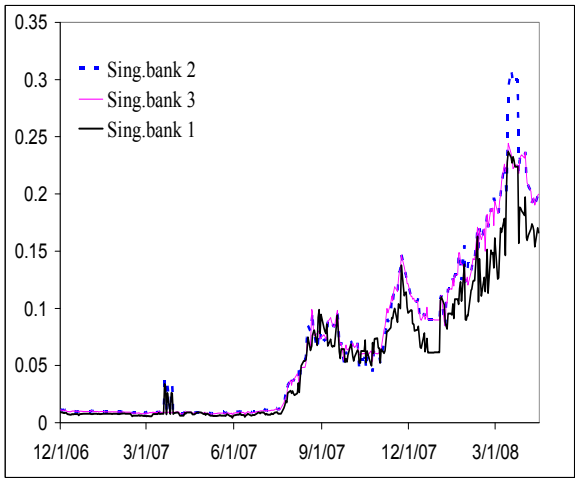
Singaporean and Regional banks



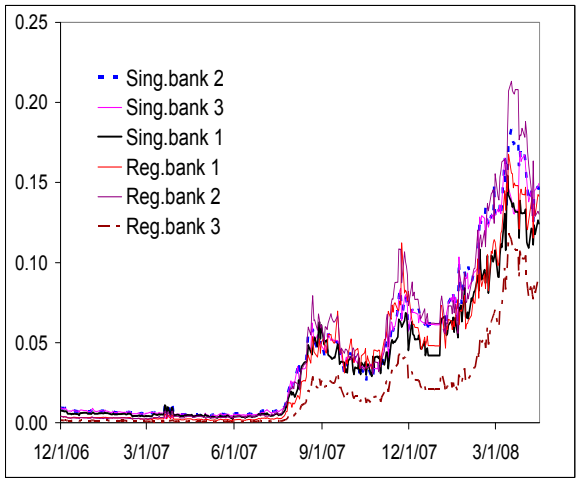
- *Finally, the conditional systemic relevance factor (SRF) has been very similar for all the banks.* However, its magnitude goes down when the group of regional banks is also taken into account (Figure I.5), most likely reflecting diversification gains.

Figure I.5. Systemic Relevance Factor

Singaporean banks



Singaporean and Regional banks



D. Concluding Remarks

10. **This chapter provides an indicative assessment of the vulnerability of Singapore's banking system**. The methodology builds on market indicators to derive measures of banking system stability and can be extended to perform stress testing of the banking system. In addition, the methodology provides technical improvements over other methods to assess financial stability. For example, the estimated measures of vulnerability account for time-varying dependencies among various banks. Thus, they go some way toward capturing dynamic interdependencies among banks during times of financial distress.

11. **Although the results need to be interpreted with care, overall they point to two main findings**:

- Ripple effects from the global credit crisis have been felt, but overall resilience of Singapore's banking system remains strong; and

- Regional bank integration appears to have an ambiguous impact, as diversification gains may counter the opening up of addition channels for financial contagion. This said, sample selection may also play a part in shaping this result.

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II. The Effects of Monetary Policy in Singapore[1]

Singapore's monetary policy is unique. It uses the exchange rate as an intermediate target to achieve low inflation and sustainable growth. Over the past year, rising inflation and slowing growth have posed challenges to the conduct of monetary policy. In this paper we seek to understand better the impact of monetary policy on inflation and output using structural vector autoregressions (SVAR). According to the empirical model, a contractionary monetary policy shock (identified as a nominal effective exchange rate appreciation) has powerful effects on both output and prices, providing support for the exchange rate-centered monetary framework.

A. Introduction

1. **Singapore manages its exchange rate against an undisclosed basket of currencies**. The Monetary Authority of Singapore (MAS) sets the rate of change of the nominal effective exchange rate (NEER)—its intermediate target—to achieve low inflation and sustainable growth. This framework has been in place since 1981 and over this period annual inflation has been 1¾ percent (on average), while GDP growth has averaged 7 percent. Unemployment has also been remarkably low, at less than 3 percent during 1987–2007.

2. **Starting in mid-2007, inflation has risen sharply—reaching almost 7 percent in the first quarter of 2008—while growth has remained relatively strong**. Several factors have been in play, including a 2 percentage point increase in the sales tax (July 2007), a sizable upward reassessment of property values (January 2008) and, more recently, spikes in global commodity prices. In response, the MAS tightened monetary policy in October 2007 (steepening the slope of the exchange rate band) and April 2008 (recentering the band), despite flagging external demand. Given Singapore's exceptional trade openness, the current environment poses challenges to Singapore's exchange rate-centered policy framework.

3. **This paper sheds light on Singapore's unique monetary transmission mechanism**. It follows a well-established literature on estimating the effects of monetary policy using structural vector autoregressions (SVARs). The paper uncovers powerful effects of the exchange rate on output and inflation, supporting the rationale for the exchange rate-centered monetary framework. Section B provides an overview of inflation developments in Singapore, in particular its persistence and correlation with the nominal effective exchange rate. Section C motivates the main assumptions underlying the SVAR. Section D presents the main empirical results and briefly discusses alternative specifications, focusing on the impact of monetary policy shocks on output and inflation. Section E concludes. The data and technical estimation details are presented in the Annex.

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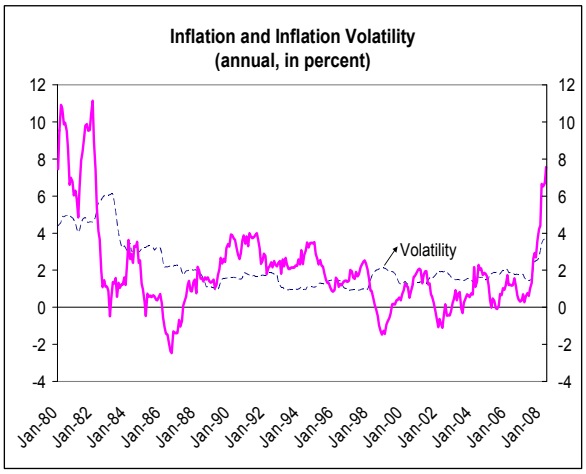
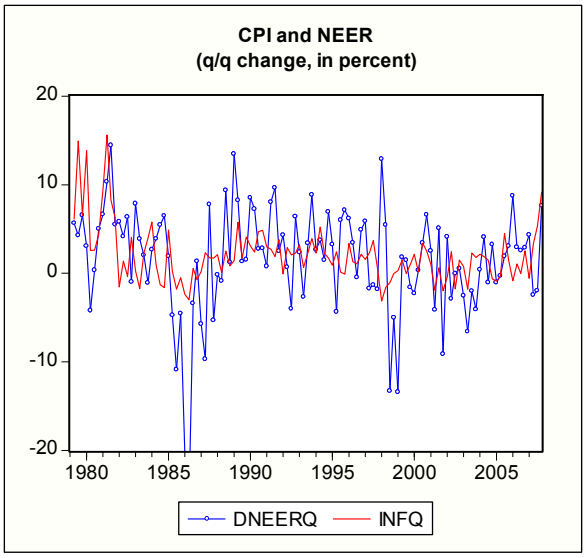
[1] Prepared by Roberto Guimaraes-Filho.

B. Inflation in Singapore: Some Stylized Facts



4. **As noted above, inflation in Singapore has been remarkably low and stable but has recently picked up significantly, reaching a 26-year high in Q4 2007**. The recent spike marks a deviation from a declining trend. Inflation has generally been trending downward since the beginning of the1980s, averaging 2½ percent in the 1980s, 1¾ percent in the 1990s, and just over 1 percent during 2000–2007. With the exception of the early 1980s, the volatility of inflation has been generally low—ranging between 1 to 2 percent. Volatility has gone up since the second half of 2007 on the wake of rising inflation.



5. **Inflation has only been mildly persistent over the last two decades**. As measured by the half-life of shocks from simple univariate autoregressive (AR) models, shocks to inflation have been relatively short lived.[2] The empirical model estimated for quarterly inflation is an AR(1) or AR(2), depending on the sub-sample.[3] The sum of the AR coefficients is about 0.5–0.6, indicating that the half-life of inflation shocks is about 1–1½ quarter.[4]

6. **Inflation in Singapore is correlated with both the nominal effective exchange rate and output**. The contemporaneous correlation between quarterly inflation and the NEER is relatively high at

[2] The estimated degree of persistence at time t reflects what inflation is expected to be at time $t + s$, conditional on all the present and past inflation up to time t.

[3] The model is chosen according to the Bayesian information criterion. Low-order autoregressive dynamics are present in the data, with one lag (or two, depending on the effective estimation sample) providing a good fit.

[4] This is much lower than the estimated persistence calculated by Reis and Pivetta (2007) using post-WWII U.S. data.

minus 0.4, suggesting that NEER appreciations tend to occur in tandem with lower inflation. Granger predictability tests reveal that inflation Granger-causes the NEER, but the evidence that the NEER causes inflation is weaker and not statistically significant. This suggests that while monetary policy (captured by NEER changes) responds to inflation shocks rather quickly, the pass-through from the exchange rate to inflation may be low and that the effect of the NEER on inflation may operate with a long lag. Consistent with a Phillips curve relationship, inflation is positively correlated with deviations of output from its trend.[5]

C. Data and Empirical Model

7. **The data are quarterly and span the period 1979–2007**. The variables included in the SVAR are the consumer price index (CPI), real GDP, the NEER, the domestic 3-month nominal interbank interest rate (SIBOR), money aggregates (M1 and M2), and foreign variables. The latter includes the "world" oil price (average from the IMF's WEO), a trade-weighted foreign GDP, and the 3-month LIBOR. In the case of GDP and CPI, the series are seasonally adjusted. The data series are shown in the Annex.

8. **The SVAR methodology is applied to identify monetary policy shocks and simulate their impact on output and inflation**. The baseline identification assumption is adapted from Kim and Roubini (2000). They present a nonrecursive identification scheme that generate hump-shaped response of output to a contractionary monetary policy shock and has been widely used.[6] One of the main departures from Kim and Roubini (2000) is that the NEER substitutes for the short-term interest rate in the policy reaction function. More specifically, the SVAR model in this paper assumes that the model economy can be represented by:

$$B_0 y_t = k + B_1 y_{t-1} + ... + B_p y_{t-p} + u_t$$

where $y_t = [p_t^{oil} \;\; i_t^* \;\; x_t \;\; p_t \;\; m_t \;\; neer_t \;\; i_t]$ is the *n x 1* data vector containing the oil (or commodity) price index (p^{oil}), foreign interest rate (i^*), real GDP (x), domestic CPI (p), monetary aggregate (m), NEER, and domestic interest rate (i); k is a vector of constants, B_k is an *n x n* matrix of coefficients (with $k = 1, ..., K$), and u_t is a white-noise vector of structural shocks. All variables enter the VAR in natural logarithms.

9. **The SVAR approach is well-suited to the analysis of monetary policy effects in Singapore**. One of the SVAR main advantages is its simplicity and the fact that it does not

[5] This result is robust to at least two different measures of the trend (i.e., applying the HP and band-pass filters).

[6] Other identification schemes are applied to assess the robustness of the results. The recursive identification of Eichenbaum and Evans (1995) and the sign approach proposed by Uhlig (2005) are briefly discussed below.

impose potentially restrictive assumptions about behavioral relationships and the dynamics of the economy. In the case of Singapore, the same monetary policy regime since the early 1980s provides a relatively long sample to identify monetary policy shocks without concerns about structural breaks typically associated with changes in the policy regime.

10. **The following contemporaneous restrictions are imposed to identify the structural shocks** (the details and the associated matrix are presented in the Annex):[7]

- The commodity price index is exogenous with respect to all the variables in the system; in contrast, the domestic interest rate (being a financial variable) is affected by shocks to all other variables included in the VAR;

- The foreign interest rate and domestic output responds contemporaneously to the oil price (or commodity prices) within a quarter, but the latter is not affected by the former contemporaneously (zero restriction); as in Kim and Roubini (2000), firms adjust output in response to policy shocks or financial market shocks *with a lag*;

- Domestic prices respond contemporaneously to oil price shocks and to output (the second restriction can be relaxed without affecting the results);

- Money responds to domestic output and interest rates, consistent with standard money demand theory. The restriction that the coefficient on the interest rate is zero may be imposed without affecting the estimated impulse response functions; and

- The NEER responds to output, prices, the oil price, and domestic interest rates. The inclusion of the oil price may account for the pre-emptive nature of monetary policy as it responds to expected price pressures consistent with its medium-term orientation.

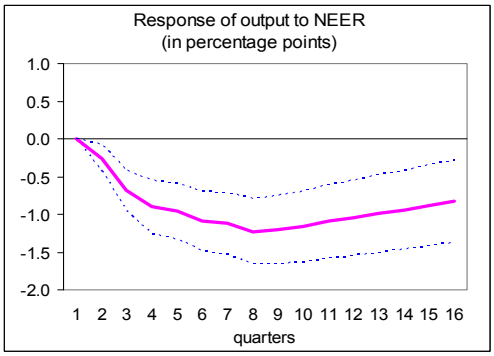
D. Main Findings

11. **The main results from the SVAR are consistent with a strong effect of monetary policy on output and prices**. To evaluate the impact of the NEER on activity and the CPI, the empirical model is used to estimate impulse-response functions. The results may be described as follows:

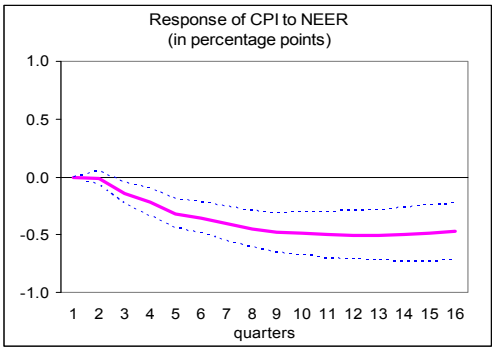
- A contractionary monetary policy shock is described as a NEER appreciation. The appreciation is highly persistent and remains statistically significant up to 8 quarters;

[7] No restrictions are imposed on the lagged structural parameters of the model.

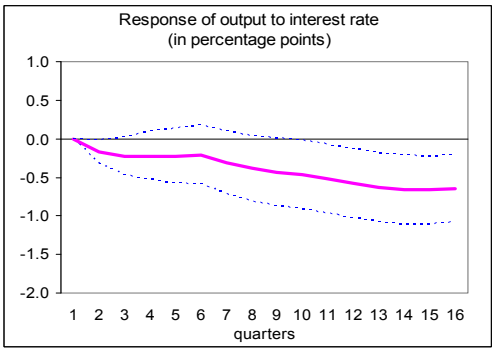
- Consistent with the MAS' own findings, contractionary monetary policy shocks have strong effects on output. A NEER appreciation shock lowers output (with a hump-shaped impulse response function)—the effect is economically and statistically significant after 2 quarters and peaks at 8 quarters. The lagged impact justifies a forward-looking orientation of monetary policy;



- A monetary policy contraction has a persistent and strong negative effect on the price level; the effect of the contractionary shock on the CPI becomes economically and statistically significant after 2 quarters and peaks after 8 quarters;

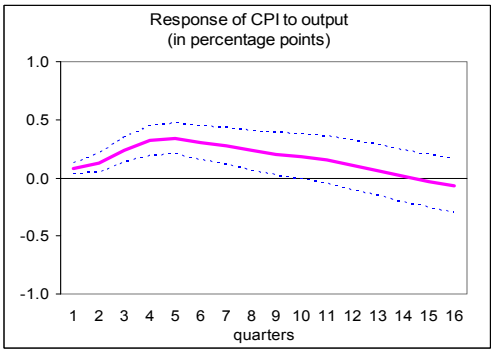


- Underscoring the rationale for an exchange rate-centered monetary policy framework, the effect of an interest rate increase on output is small and statistically insignificant at the 5 percent level;



- Output shocks have a strong positive impact on the CPI, as implied by a Philips curve relationship (see also Parrado, 2004). The impact is strongest at 4–6 quarters and dissipates after 8–10 quarters as the effect of nominal and other rigidities diminish;

- The NEER responds with relatively short lags to shocks to the CPI and output. In particular, the NEER appreciates in response to increases in output (after 2 quarters) and the CPI (after 1 quarter). The effect of the latter on the NEER is generally small and is not statistically significant at the 5 percent level. This is in tune with an empirical characterization of



monetary policy decisions in which the MAS targets the rate of change of the NEER according to a Taylor-rule. Parrado (2004) and McCallum (2007) show that in fact a Taylor rule for the NEER provides a good fit to the MAS' policy reaction function.

- The effects of output (positive) and interest rate (negative) on monetary aggregates (M1 or M2) is consistent with a well-behaved money demand curve; and

- As expected, the NEER and domestic interest rate respond strongly to foreign interest rate shocks; also, domestic interest rates decline (on impact) following a NEER appreciation.

12. **Alternative identification schemes yield broadly similar results**.[8] Applying a slightly modified version of the Eichenbaum and Evans (1995) recursive assumptions, the estimated VAR becomes $y_t = [p_t^{oil} \;\; i_t^* \;\; x_t \;\; p_t \;\; m_t \;\; neer_t \;\; i_t]$. [9] As noted above, the effect of an interest rate shock on output is slightly stronger as well as the response of the NEER to CPI shocks. Reversing the ordering of *x* and *p* or *neer* and *i* does not affect the qualitative results. The results from imposing sign restrictions on the impulse responses (Uhlig, 2005) are also consistent with those of the baseline model, but are less robust to the changes in the underlying assumptions. For example, the negative response of the CPI to a contractionary monetary policy shock is in line with results generated by standard monetary models, but the impulse response (and its shape) depends largely on the assumed lagged effect of NEER shocks on output.

E. Concluding Remarks

13. **This paper assesses the effects of monetary policy on economic activity and inflation**. The findings suggest an important role for monetary policy in delivering low and stable inflation, a salient feature of Singapore's recent monetary history.

14. **The results provide support for the exchange rate-centered monetary framework**. The main findings confirm that the effects of the interest rate shocks on output

[8] In addition, there is no evidence of significant structural instability in the reduced-form VAR. For each equation of the reduced-form VAR, Andrews' *sup-Wald* test is applied to test jointly for the stability of all the coefficients on the lags of a given variable. In this regard, the impulse response functions for the interest rate and NEER based on a reduced form estimated over the 1991–2007 period are broadly similar to those reported above, suggesting that there have been no major changes in the monetary transmission mechanism. (This may change with the rising importance of domestic demand and interest rate-sensitive sectors). Interestingly, the impact of interest shocks is larger (but is only marginally significant) when additional over-identifying restrictions are imposed (see Annex).

[9] The baseline recursive structure in Eichenbaum and Evans (1995) does not include the oil price but incorporates the ratio of U.S. nonborrowed reserves to total (banking) reserves to identify the monetary policy shocks.

and prices are significantly less important than those of the nominal exchange rate. In addition, according to the estimated models, monetary policy can be empirically characterized as a Taylor rule in which the NEER responds to output and inflation shocks. The powerful effects of monetary policy combined with the credibility of the framework may explain the relatively low inflation persistence.

Annex II.1. Estimation Details

15. **The reduced form model is estimated with six lags in log-levels, except for the domestic and foreign interest rate**.[10] While all variables can be characterized as nonstationary (or near-nonstationary as in the case of interest rates) according to standard unit roots tests, most findings are robust to first differencing and inference can still be conducted with the estimated model in levels (Canova, 2007, page 125). The structural model can be rewritten in reduced form as:

$$y_t = c + C_1 y_{t-1} + ... + C_p y_{t-p} + e_t$$

where $e_t = B_0^{-1} u_t$ is also white-noise vector process, with variance-covariance matrix given by $\Omega = B_0^{-1} D (B_0^{-1})'$, where D is the variance-covariance matrix of the structural shocks. The matrix Ω can be rewritten as $\Omega = ADA'$ where D is diagonal. In this case, since $u_t = A^{-1} e_t$, with $A = B_0^{-1}$, then $E(u_t u_t') = E(A^{-1} e_t e_t' (A^{-1})') = A^{-1}(ADA')(A^{-1})' = D$, i.e., the vector u_t is orthogonal and can now be interpreted as "structural" shocks.[11] In practical terms, identification amounts to imposing restrictions on the matrix B_0^{-1} that orthogonalizes the reduced form errors, eliminating their contemporaneous correlation.[12] A widely used identification scheme is the recursive ordering (Cholesky decomposition) proposed by Sims (1980), which assumes that A has a lower triangular structure. This is equivalent to a hierarchical ordering of the variables, with the most exogenous variable ordered first.

16. **Statistical inference can be conducted directly based on the estimated log-likelihood**. If there are n^* estimated parameters in B_0, the number of over-identifying restrictions (r) is given by $r = (n(n-1)/2) - n^*$. The test for over-identifying restrictions is based on the maximized value of the log-likelihood and has a *chi-square* distribution with r degrees of freedom.[13]

---

[10] The estimated reduced form has 4 lags and a time trend also yields a good fit, with the reduced form passing the standard specification tests for autocorrelation and heteroskedasticity. Regarding the normality of the residuals, there is some excess kurtosis as indicated by the Jarque-Bera test. The structural parameters are estimated by maximum likelihood, but it may also be estimated by solving the nonlinear system given by $\Omega = B_0^{-1} D (B_0^{-1})'$.

[11] Since $e = B_0^{-1} u$ and $u = A^{-1} e$, the equality $A = B_0^{-1}$ follows immediately.

[12] Alternatively, note that the matrices B_0 and D cannot have more unknowns than Ω. In this case, since D has n parameters (it is diagonal) and Ω has $n(n+1)/2$ parameters (it is symmetric), this constrains B_0 to have at most $n(n-1)/2$ free parameters.

(continued)

Identifying Restrictions

17. **The restrictions described in the main text can be written as**:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & 0 & 1 & 0 & 0 & 0 & 0 \\ a_{41} & 0 & a_{43} & 1 & 0 & 0 & 0 \\ 0 & 0 & a_{53} & a_{54} & 1 & 0 & a_{57} \\ a_{61} & 0 & a_{63} & a_{64} & 0 & 1 & a_{67} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} p_t^{oil} \\ i_t^* \\ x_t \\ p_t \\ m_t \\ neer_t \\ i_t \end{bmatrix} = B(L) \begin{bmatrix} p_t^{oil} \\ i_t^* \\ x_t \\ p_t \\ m_t \\ neer_t \\ i_t \end{bmatrix} + \begin{bmatrix} u_t^{poil} \\ u_t^{i*} \\ u_t^{x} \\ u_t^{p} \\ u_t^{m} \\ u_t^{neer} \\ u_t^{i} \end{bmatrix}$$

where $B(L) = \sum_{i=1}^{p} B_i(L^i)$ is a matrix polynomial in the lag operator (L) and u_t is the vector of "structural" shocks. In this case, the over-identifying restrictions test is distributed as a *chi-square* with four degrees of freedom. For instance, according to the model above, the empirical policy reaction function is given by:

$$neer_t = -a_{63}x_t + a'_{-x}y_t + B(L)y_t + u_t,$$

where the impact of output shocks on the NEER is given a_{63}, and a'_{-x} is the vector of coefficients excluding that on x. In this baseline specification there are four over-identifying restrictions. Additional zero restrictions are also imposed on a_{61}, a_{43}, and a_{67}. In some cases, the impact of the interest rate on output is larger but is only marginally significant (e.g., when only $a_{43} = 0$ is imposed).

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[13] The standard errors of the impulse responses are calculated by Monte Carlo simulation. They are broadly similar to the probability bands are calculated from a Bayesian method that employs a Gaussian approximation to the posterior of the matrix A (recommended by Sims and Zha (1999) for overidentified models).

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III. Effectiveness of Fiscal Policy in Singapore[1]

Singapore's policy makers have often relied on fiscal policy to counter the impact of adverse external shocks. Against the background of the current uncertain external environment, this chapter analyze the effectiveness of fiscal policy in managing the economic cycle in Singapore. Empirical results based on a structural autoregression framework suggest that fiscal policy can be used as a counter-cyclical tool, but that the impact of fiscal policy is relatively short-lived and cumulatively small. This may reflect a number of factors, including the absence of credit-constrained economic agents, a high propensity to save among households, the use of quasi-fiscal measures not captured in budgetary data, a monetary focus on price stability, and leakages due to the openness of the economy.

A. Introduction

1. **The effectiveness of fiscal policy as a counter-cyclical tool is the subject of a longstanding debate among economists**.[2] Supporters of an active role for fiscal policy suggest that economies lack an efficient mechanism to return to full potential. Critics, on the other hand, argue that economic agents could offset the impact of fiscal policy on aggregate demand through changes in their savings behavior. A middle-of-the-road view holds that fiscal policy can be effective provided certain conditions hold, including sound macroeconomic fundamentals, nominal wage and price stickiness, imperfect competition, and/or economic agents with finite horizons and liquidity constraints.

2. **Singapore has often used fiscal policy to counter adverse external shocks**. In the aftermath of the Asian crisis (1998), the bursting of the tech-bubble (2001), and the SARS shock (2003), the authorities used fiscal policy to help cushion the impact on economic activity and vulnerable groups. The fiscal counter-measures focused on relief for both businesses and households, including through tax incentives, tax credits, transfer payments, and various rebates on housing and utilities.

3. **In the context of the current uncertain external environment, the chapter analyzes empirically the effectiveness of fiscal policy in Singapore**. Fiscal multipliers are estimated using a structural vector autoregression (SVAR) framework. The chapter is organized as follows: Section B looks at the cross-country evidence on the effectiveness of fiscal policy; Section C presents the empirical approach (elaborated in the Annex) and results for Singapore; and Section D concludes.

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[1] Prepared by Leif Lybecker Eskesen

[2] See IMF World Economic Outlook, April 2008.

B. Cross-country Evidence on the Effectiveness of Fiscal Policy

4. **The question of the effectiveness of fiscal policy is ultimately empirical**. There is a vast literature on this topic. Studies generally support the role for counter-cyclical measures, but evidence on the size of fiscal multipliers is uneven:

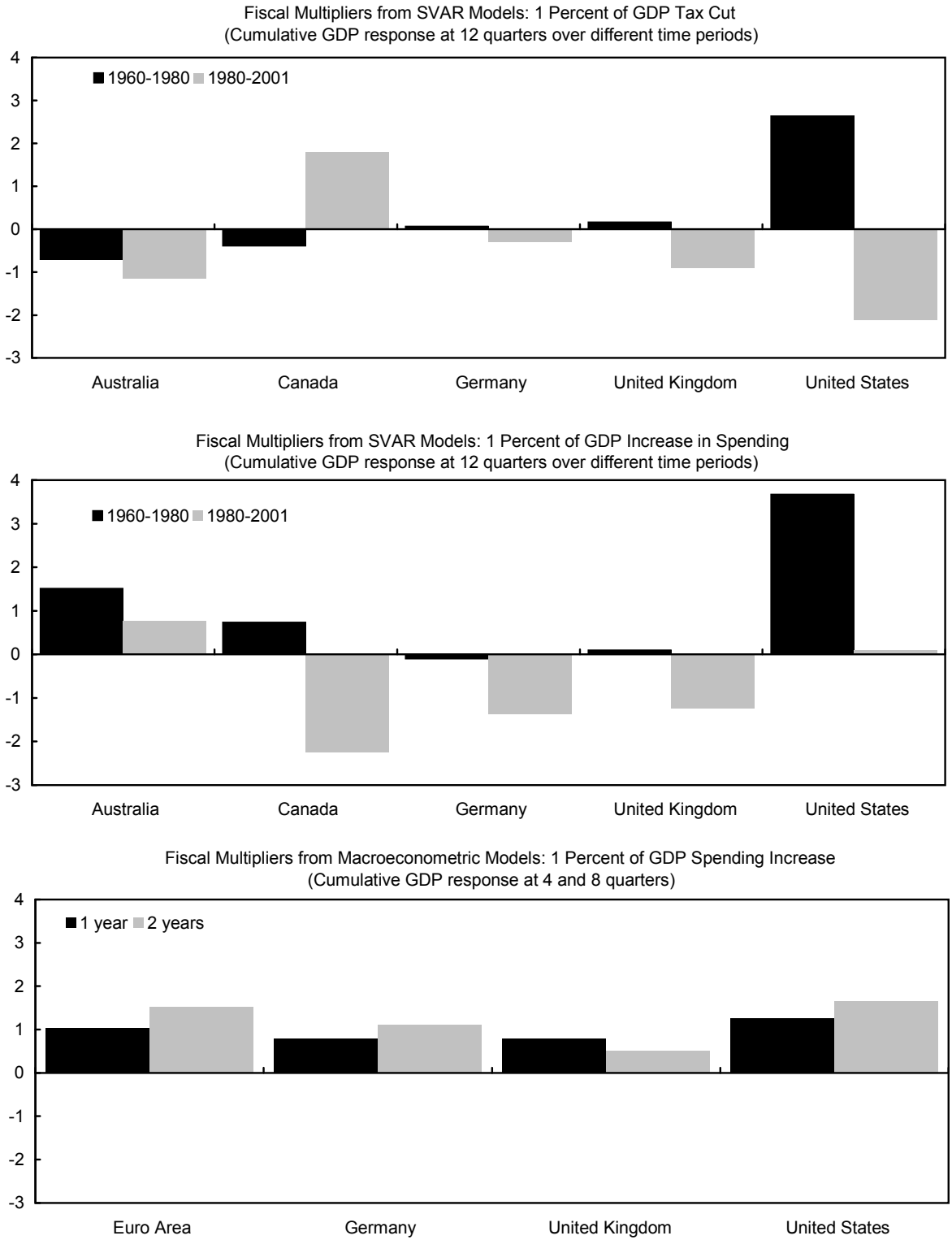
- ***Event-studies*** give mixed results. The 2001 income tax rebates in the United States are generally considered to have been effective in boosting domestic demand, although the impact on output was relatively small with multipliers well below 1 (Shapiro, *et al.* (2002, 2003)). The 1995 stimulus package in Japan is estimated to have been successful in the short term, but it did not have a lasting impact on economic activity (Posen (1998), Mühleisen (2000)). However, Finland's response to the 1991 output shock, by letting automatic stabilizers operate fully, is considered to have been largely ineffective because it raised concerns about fiscal sustainability (Corsetti and Roubini (1996)).

- Studies on advanced economies using ***vector autoregressive (VAR) methods*** conclude that fiscal multipliers have declined over time and, in some cases, may even have been negative (see Perotti (2005) for an overview). These results (Figure III.1), which differ widely across countries, likely reflect: (i) more leakage through the trade channel due to increased openness of economies; (ii) a decline in the share of liquidity constrained households due to better access to credit; and (iii) a sharper focus of monetary policy on price stability.

- Estimates from ***macro models***, on the other hand, show that fiscal policy can be quite effective (Figure III.1). Impact multipliers are in the range of 0.3 to 1.2 percent upon impact. Furthermore, expenditure measures appear to have a larger effect than tax measures (Hemming and others 2002, Botman 2006). However, the size of the estimated multiplier depends on assumptions about parameters such as labor supply elasticities and the pervasiveness of liquidity constraints.

5. **Generally, the cross-country evidence suggest that the success of fiscal policy is contingent on a number of factors**. First, the fiscal response needs to be *well-timed*. This will tend to increase the effectiveness of fiscal policy in countries with short implementation lags and/or large automatic stabilizers (the latter being the first line of defense). Second, *strong fundamentals*, including macroeconomic stability and fiscal sustainability, will strengthen multiplier effects by lowering any possible offsets from precautionary savings. Finally, fiscal measures need to be *well-targeted* to ensure the largest possible demand impact.

Figure III.1. Fiscal Multipliers from SVAR and Macroeconometric Models - Cross-country Evidence



Source: Perotti (2005).

C. Effectiveness of Fiscal Policy in Singapore

Empirical Approach

6. **VAR methods are standard in monetary policy analysis, but have only recently been applied to fiscal policy**. This chapter does so by applying the SVAR methodology developed in Blanchard and Perotti (2002).

7. **Intuitively, this methodology utilizes the ("inside") lags in fiscal policy to identify discretionary structural fiscal shocks and their impact on economic activity**:

- Assuming that discretionary fiscal policy decisions take time to be implemented (because of political and legislative requirements), the short-term (i.e., within one quarter) reaction of fiscal variables to current economic developments only reflect "automatic" responses defined by existing laws and regulations.

- Fiscal developments adjusted for these automatic/cyclical responses are, therefore, assumed to represent discretionary *structural* fiscal policy shocks.

- In simulations, these structural shocks are used to quantify the response of real economic variables to discretionary fiscal policy. In the case of Singapore, the focus is on private domestic demand, in part to abstract from first-order leakages.

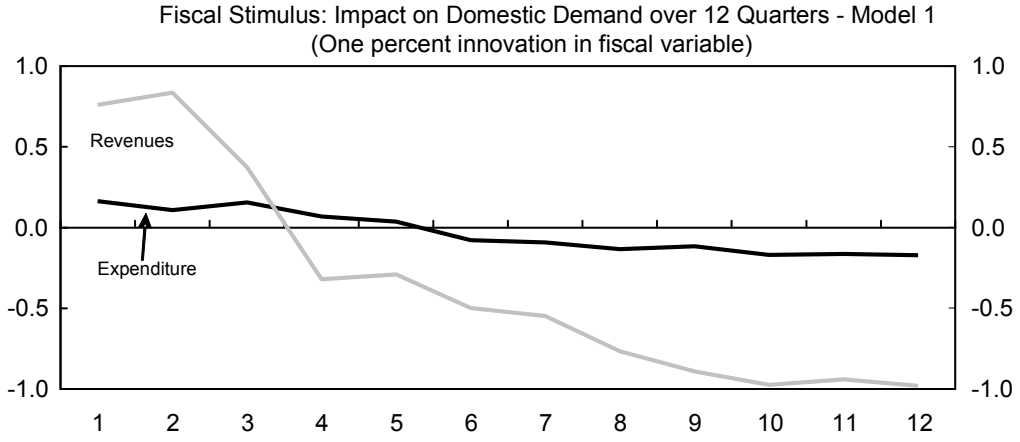
A technical description of the methodology is presented in the Annex to this chapter.

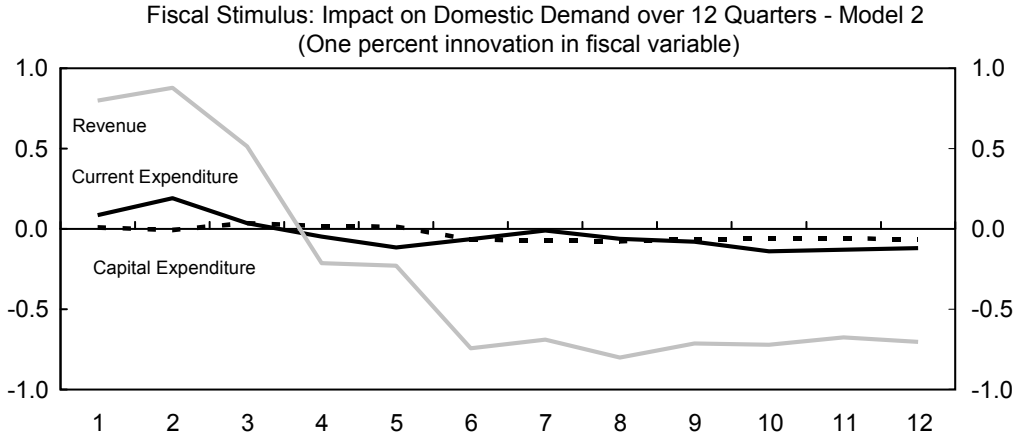
Empirical Results

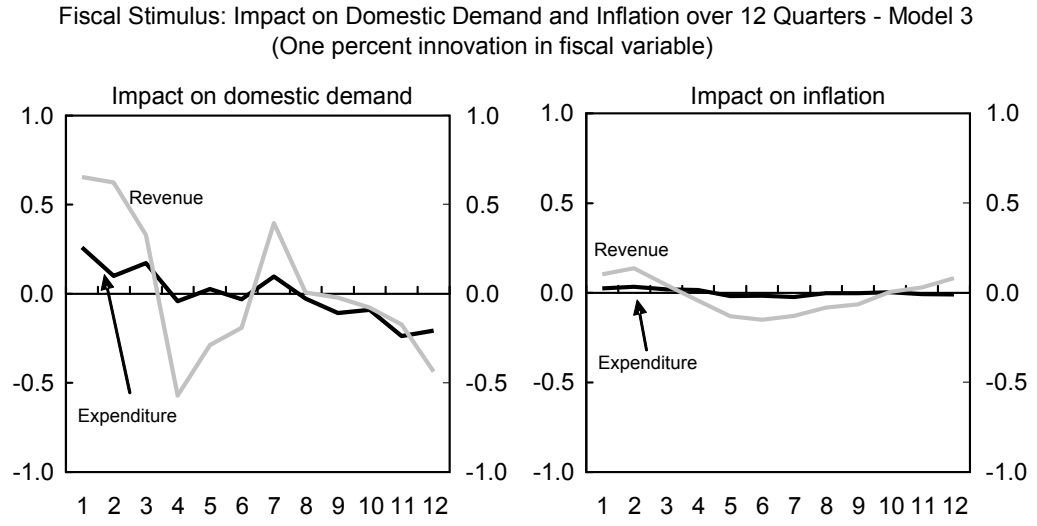
8. **Empirical results suggest that discretionary fiscal policy can have an immediate impact on private domestic demand and play a role as a counter-cyclical tool**. However, the impact drops off quickly and eventually turns negative (Figure III.2 and III.3), leaving the cumulative effect relatively small compared to other countries. The estimated impulses are generally not significant past the fourth quarter. By aggregate demand component, the estimated impulse response functions (not shown here) suggest fiscal policy appears to have a larger impact on private investment than on private consumption. This may reflect a high precautionary savings-motive among Singaporean households and a government strategy of partly focusing discretionary measures on strengthening household savings.

9. **Changes in revenues are estimated to have the largest impact-effect on private demand, but that impact fizzles out quickly**. This is in contrast to results obtained for a number of other industrial countries, which tend to show a larger multiplier for expenditure measures. However, the puzzle could in part be explained by the narrower definition of government expenditure used here, which excludes key income transfers for lack of *quarterly* data.

Figure III.2. Singapore: Fiscal Multipliers in Singapore - SVAR Results

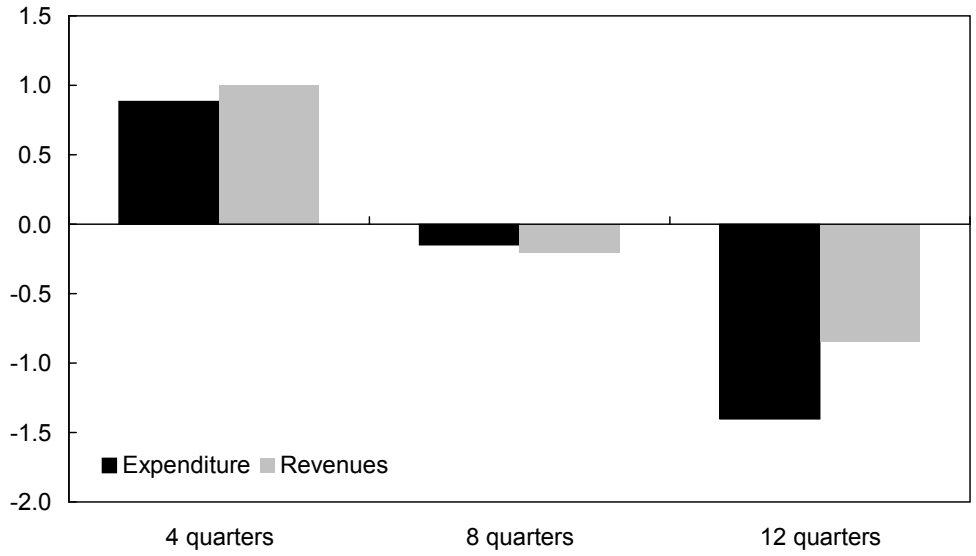






Source: Staff estimates

Figure III.3: Cumulative Multipliers - Model 1
- Cumulative impact on private demand from a fiscal expansion of 1 S$



Note: The cumulative multiplier at a given quarter equals the ratio of the cumulative response of private demand and the cumulative response of the fiscal variable.

10. **Among expenditure components, the simulations show that changes in government current spending provides more stimulus than changes in public investment**. Indeed, the estimates for investment multipliers are generally insignificant. This may reflect some crowding out of private investment activity.

11. **A fiscal expansion has a positive but limited impact on inflation**. The largest impact is related to changes in taxes, which is consistent with the estimated larger impact on private demand (and hence inflation pressures) from changes in government revenues. Government spending, on the other hand, does not appear to have a significant impact on prices.

D. Concluding Remarks

12. **Singapore's large fiscal reserves provides ample scope to use fiscal policy to counter adverse external shocks**. Given Singapore's relatively small automatic stabilizers, a counter-cyclical response—when needed—would have to be primarily discretionary.[3] However, the short fiscal lags allow for a fast response to changing economic conditions. In an uncertain external environment such as today's, this flexibility provides some insurance against further negative spillovers from a more pronounced deterioration in the global economy.

[3] Singapore does not have a comprehensive unemployment benefit scheme and corporate taxes are assessed based on previous year's income.

13. **Preliminary results suggest that fiscal policy in Singapore can serve as a tool for demand management, but cumulative fiscal multipliers are generally found to be small**. This may reflect a number of factors, including:

- The absence of credit-constrained households, leading to a somewhat lower consumption response, on the margin, to changes in disposable incomes;

- A high propensity to save among households—possibly, in part, reflecting the absence of a more comprehensive social safety net;

- The use of nonbudgetary measures, including changes in contributions to the mandatory public savings scheme (CPF), to stimulate activity. These are not captured in the fiscal variables used in this study;

- Strong monetary focus on price stability, which may partly offset the effect of fiscal stimulus;

- Significant leakages through trade as well as remittances (nonresident workers account for around 30 percent of the labor force), which may weaken the dynamic interrelations between domestic demand components.

14. **This analysis could be expanded.** It could be useful in future research to analyze the impact of more disaggregated fiscal measures on private demand and its sub-components, which could help strengthen fiscal design. A study of the impact of income transfers would be particularly desirable, since they are often used as a counter-cyclical as well as redistributive tool. Finally, the results could be subjected to sensitivity analysis, including with respect to the assumed expenditure and revenue elasticities. All these potential extensions remain on the research agenda.

Annex III.1. Technical Description of the Fiscal SVAR Framework

The basic VAR specification is:

(1) $z_t = \Gamma(L)z_{t-1} + u_t$

where z_t is a *nx1* vector of endogenous variables, $\Gamma(L)$ is a *nxn* matrix of lag polynomials in the lag operator L and u_t is a *nx1* vector of reduced-form innovations, which are independent and identically distributed. The relation between the reduced-form innovations u_t and the objects of ultimate interest, the structural shocks v_t, can be represented as:

(2) $Au_t = Bv_t$

where the *nxn* matrices A and B describe (i) the instantaneous relation between the variables and (ii) the linear relationship between the structural shocks and the reduced form residuals, respectively. The structural shocks are assumed to be orthogonal, which allows for impact analysis of an isolated shock. The structural form of the VAR can be obtained by multiplying (1) by A and using the relation defined in (2):

(3) $Az_t = A\Gamma(L)z_{t-1} + Au_t = A\Gamma(L)z_{t-1} + Bv_t$

Solving (3) for z_t yields the structural specification:

(4) $z_t = [I - \Gamma(L)L]^{-1}A^{-1}Bv_t$

Where I is a *nxn* identity matrix. In the simplest specification used in this study, $z_t = [y_t \;\; e_t \;\; r_t]$ consists of three variables for Singapore: real private domestic demand, y_t; real government expenditure (consumption and investment), e_t; and real current government revenue, r_t.[4] The data used are seasonally adjusted and at a high frequency (quarterly) in order to identify the structural shocks. The VAR is estimated in log levels with a constant, time dummies, and G7 growth added as exogenous explanatory variables. The number of lags chosen is five as suggested by Akaike and other information criteria.[5]

[4] Quarterly data for special transfers were unfortunately not available and are, therefore, not included in the expenditure data.

[5] The models specified in this paper are robust to alternative specifications and residuals do not appear to suffer from autocorrelation. Tests for normality of error terms suggest there is not an issue with skewedness, but they cannot reject the hypothesis that there may be an issue with kurtosis.

Estimation basically proceeds in four steps. In the ***first step***, the reduced form VAR is estimated, yielding the reduced form residuals $u_t = \begin{bmatrix} u_t^y & u_t^e & u_t^r \end{bmatrix}$:[6]

$$u_t^y = \alpha_e^y u_t^e + \alpha_r^y u_t^r + v_t^y \tag{5}$$

$$u_t^e = \alpha_y^e u_t^y + \beta_r^e v_t^e + v_t^e \tag{6}$$

$$u_t^r = \alpha_y^r u_t^y + \beta_e^r v_t^e + v_t^r \tag{7}$$

As suggested by Perotti (2005), the innovations in u_t^e and u_t^r can be thought of as linear combinations of three types of shocks: (i) the automatic or cyclical response of expenditures and revenues to innovations in private domestic demand; (ii) the systematic response of fiscal policy to same-period macro shocks; and (iii) discretionary fiscal policy shocks, which are the *structural shocks* we are interested in identifying. This gives the following representation of the reduced form residuals for the fiscal variables:

$$u_t^e = \alpha_y^e u_t^y + \beta_r^e v_t^e + v_t^e \tag{8}$$

$$u_t^r = \alpha_y^r u_t^y + \beta_e^r v_t^e + v_t^r \tag{9}$$

where v_t^e and v_t^r are the structural shocks to government expenditure and revenues, respectively. Since fiscal policy is implemented with a lag, systematic discretionary responses to macro shocks (i.e., item (ii) in the previous paragraph) are absent in quarterly data. As a consequence, the coefficients α_y^e and α_y^r in (8) and (9) only capture the *automatic/cyclical* response of fiscal variables to economic activity.

Given that the reduced form residuals are correlated with the structural shocks, exogenous elasticities are used to estimate the automatic/cyclical response of the fiscal variables.[7] With these, one can then construct the cyclically adjusted fiscal shocks, which constitutes the ***second step*** of the estimation procedure:

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[6] Representation of the exogenous variables are excluded here to allow for a simplistic illustration of the model.

[7] For Singapore, the elasticity of expenditures with respect to changes in economic activity is assumed to be close to zero within the quarter, as commonly assumed in many other empirical studies. The elasticity of revenues is estimated at around ½ percent within the quarter. The relatively low number partly reflects that corporate taxes are based on past year's rather than contemporaneous earnings, leaving taxes less responsive to contemporaneous changes in economic activity. While the parameterization is plausible, the magnitude has implications for the estimated multipliers.

(10) $$u_t^{e,adj.} \equiv u_t^e - \alpha_y^e u_t^y = \beta_r^e v_t^r + v_t^e$$

(11) $$u_t^{r,adj.} \equiv u_t^r - \alpha_y^r u_t^y = \beta_e^r v_t^e + v_t^r$$

In the ***third step***, the structural fiscal shocks are determined. Assuming that structural revenue shocks have no impact on structural spending shocks, (10) and (11) become:

(12) $$u_t^{e,adj.} = v_t^e$$

(13) $$u_t^{r,adj.} = \beta_e^r v_t^e + v_t^r$$

The structurally adjusted expenditure shock is, consequently, equal to the cyclically adjusted expenditure shock. With this, it is now possible to estimate the response of revenues to structural expenditure shocks, β_e^r, using simple OLS.

In the ***fourth and final step***, the coefficients in the equation for private domestic demand residuals (5) can be determined. Combined, the four steps, which are effectively done simultaneously, allow us to estimate the *A* and *B* matrices presented in (2):

$$\begin{bmatrix} 1 & -\alpha_e^y & \alpha_r^y \\ -\alpha_y^e & 1 & 0 \\ -\alpha_y^r & 0 & 1 \end{bmatrix} \begin{bmatrix} u_t^y \\ u_t^e \\ u_t^r \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & \beta_e^r & 1 \end{bmatrix} \begin{bmatrix} v_t^y \\ v_t^e \\ v_t^r \end{bmatrix}$$

In turn, these are used to compute the structural impulse responses of private domestic demand to discretionary expenditure and revenue shocks.

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