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The impact of Chinese monetary policy shocks on East Asia

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Tomasz Koźluk and Aaron Mehrotra

The impact of Chinese monetary policy shocks on East Asia

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All opinions expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

Tomasz Koźluk[a] and Aaron Mehrotra [b]

The impact of Chinese monetary policy shocks on East Asia

Abstract

We study the effects of Chinese monetary policy shocks on China's major trading partners in East Asia by estimating structural vector autoregressive (SVAR) models for six economies in the region. We find that a monetary expansion in Mainland China leads to an increase in real GDP (temporary) and the price level (permanent) in a number of economies in our sample, most notably in Hong Kong and the Philippines. The impact could result from intertemporal substitution present in a general equilibrium framework which allows for positive domestic impacts of foreign monetary expansions. Our results emphasize the growing importance of China for its neighboring economies and the significance of Chinese shocks for the design of monetary policy in Asian economies.

Keywords: Monetary policy shocks, Asian production chain, SVAR, East Asia, China
JEL Classification: E52; F42.

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Tomasz Koźluk and Aaron Mehrotra

The impact of Chinese monetary policy shocks on East Asia

Tiivistelmä

Tässä tutkimuksessa tarkastellaan Kiinan rahapolitiikkasokkien vaikutusta maan kuuteen tärkeään kauppakumppanitalouteen Itä-Aasiassa. Tutkimusmenetelmänä käytetään rakenteellisia vektoriautoregressiivisiä malleja. Tulosten mukaan rahapoliittinen ekspansio Manner-Kiinassa johtaa reaalisen BKT:n (väliaikaiseen) kasvuun ja hintatason (pysyvään) nousuun monessa tutkimuksen taloudessa ja erityisesti Hongkongissa ja Filippiineillä. Vaikutus saattaa olla seurausta yleisen tasapainon malleissa esiintyvästä intertemporaalisesta substituutiosta, jonka vuoksi ulkomainen ekspansiivinen rahapolitiikkasokki johtaa positiivisiin vaikutuksiin kotimaassa. Tutkimustulokset heijastelevat sitä, että Kiinan vaikutus muihin alueen talouksiin on kasvanut, samoin kuin Kiinan sokkien merkitys muiden Aasian maiden rahapolitiikan kannalta.

Asiasanat**:** Rahapolitiikkasokit, Aasian tuotantoketju, SVAR, Itä-Aasia, Kiina.

1 Introduction

China's regional influence over the centuries is hard to overstate – the Middle Kingdom has had immense impact on the rest of East Asia in terms of culture, science, trade and migration. One can also think of many purely macroeconomic forces that affect the wellbeing of the region. The fear of competition from cheap Chinese, especially labor intensive, products is one, delicate, side of the story. On the other hand, the existence of the Asian production chain means that Chinese intermediate products are inputs for other economies, and foreign intermediate products serve as inputs for Chinese production. Moreover, China's participation in the global and regional economies involves not only millions of workers, but also millions of increasingly wealthy consumers, which creates a demand for imported consumer goods. In this paper we look closely at a small subsection of China's effects on neighboring economies - the cross-border effects of Chinese monetary policy.

Most of the previous discussion on the effects of Chinese policy has centered on the exchange rate, which is not surprising given China's widening current account surpluses in recent years, especially vis-à-vis the US.[1] Nevertheless, macroeconomic theory predicts potentially important impacts of domestic monetary policy on foreign economies. These effects are obtained in the classic Mundell-Fleming model, or in a general equilibrium framework that captures intertemporal effects ignored by the IS-LM model. Given the capital controls in place in the Chinese economy, the effects of Chinese monetary policy shocks are likely to be transmitted through the trade channel, where a domestic monetary expansion increases the demand for imports, and leads to an increase in aggregate output and prices in a foreign economy.

This paper aims to examine the impact of Chinese monetary policy shocks on its important trading partners in East Asia. To this aim, we estimate structural vector autoregression (SVAR) models for six economies in the region: Hong Kong, Korea, Malaysia, Philippines, Singapore and Taiwan. For all of these economies, trade with the Mainland or with Greater China (comprising the Mainland, Hong Kong and Macao SAR) accounts for an important share of overall foreign trade.[2] Previous literature has used similar SVAR

[1] See e.g. García-Herrero and Koivu (2007) and the references within.
[2] Hong Kong is included in our definition of Greater China due to its importance as a trade gateway for the Mainland. Since a similar role is not observed for the Taiwan Province of China we do not include it here. For the countries in our sample, the share of trade (exports + imports) with Greater China ranges from over 13% for Malaysia to 45% for Hong Kong. The share of exports to Greater China relative to total exports

modeling to investigate the impacts of US monetary policy shocks on foreign economies (see e.g. Kim, 2001; Kim and Roubini, 2000), or the effects of Japanese monetary policy on East Asia (Maćkowiak, 2006). To our knowledge, there has been no previous analysis of the cross-border impacts of Chinese monetary policy.

We find that a monetary expansion in Mainland China leads to an increase in domestic real GDP in Hong Kong, the Philippines and Singapore. It also raises the price level in all six economies in our sample except Taiwan. The impact on GDP is transitory, becoming insignificant in the longer term in all economies but the Philippines. The effect on prices is more of a permanent nature and persists also in the long run, meaning that the shocks are finally absorbed in the price levels. These results are robust to including both US and Japanese monetary policy variables in the estimated system, providing evidence that we have indeed identified a Chinese monetary policy shock. Nevertheless, the Chinese shocks still account for only a small share of overall shocks included in our model. The largest shares for the Chinese shocks, when statistically significant, are found for Hong Kong, the Philippines and Singapore. Our results provide evidence of the importance of the Chinese economy in the East Asian region. Importantly, they suggest that there are relevant cross-border impacts of policy beyond the choice of China's exchange rate regime or the level of the yuan exchange rate.

This paper is structured as follows. In the following section, we discuss theoretical matters relevant to our topic and briefly review some of the previous literature on SVAR modeling of cross-border effects of monetary policy. Section 3 presents the structural model employed and the important data issues. The model is estimated and the results discussed in Section 4. The final section gives a summary of our findings and some implications for policy.

2 Theoretical aspects and previous literature

The standard Mundell-Fleming framework (ISLM BP model) enables evaluation of the effects of a monetary expansion on the domestic economy and its foreign partners.[3] In a

ranges from 13% for Malaysia, just under 20% for the Philippines and Singapore to almost 30% for Korea and Taiwan and 45% for Hong Kong (2005, UN COMTRADE).

[3] See Fleming (1962) and Mundell (1968), or the more recent Dornbusch (1980).

small open economy with free capital flows, a monetary expansion shifts the LM curve to the right. In the new instantaneous equilibrium that balances the money and goods markets, output is higher and the interest rate lower than before. The final outcome depends on the degree to which the exchange rate is allowed to float. In the case of a fixed exchange rate, the new instantaneous equilibrium is characterized by a current account deficit. Capital outflows put pressure on the exchange rate. The central bank defends the exchange rate by purchasing the home currency (we assume the monetary authority has sufficient reserves). This reduces the money supply, causing the LM to shift leftward and returns the economy to the original equilibrium. Thus there is no longer term effect of a monetary expansion, aside from a loss of foreign reserves.

At the other extreme, with a fully floating exchange rate, the new instantaneous equilibrium is again characterized by a current account deficit and a capital outflow. This causes the home currency to depreciate, shifting the BP curve to the right and simultaneously increasing the international competitiveness of domestic producers. This causes an improvement in the trade balance and shifts the IS curve out, placing the economy in a new equilibrium with increased output as a result of higher net exports. This expansion through a 'competitive depreciation' is accomplished at the expense of the foreign country and is a 'beggar-thy-neighbor' policy. Various intermediate exchange rate arrangements would result in a sloping BP curve, and thus a combination of the two developments.

However, this simple analysis is not very suitable for China. Although one can claim that China is in some respects an open economy with a fixed exchange rate,[4] the most serious flaw of the above analysis is the existence of capital controls. With strict capital controls, a monetary expansion in China shifts the LM curve to the right, but no straightforward adjustment mechanism follows. Obviously, the effect of using such an expansion to increase output would result in either an overheating of the economy or a rise in inflation expectations or both, and price adjustments would eventually correct the disequilibrium. As the capital flow channel is essentially closed for China, the mechanism by which Chinese monetary policy influences foreign economies is trade.

The simple theoretical framework above has another limitation – the ISLM-BP model has problems in explaining intertemporal issues. This is because expectations and

[4] In 2006 imports and exports together amounted to roughly 65% of GDP. During most of our sample period, the Chinese yuan was either fixed to (1994-mid 2005) or closely tracking the USD, while many Asian economies had their currencies tied to the USD in one way or another.

other determinants of adjustment within the model are assumed to be static. Hence, Svensson and van Wijnbergen (1989) propose a general equilibrium approach in which a foreign monetary expansion may lead to an increase in domestic output. In their framework, the necessary conditions include the effect of foreign (in our case Chinese) monetary policy on foreign output, the assumption that the home market is in an underconsumption regime (not capacity constrained), and that there is some complementarity between foreign and domestic goods. Regarding the first assumption, Chow and Shen (2004) investigate the impact of Chinese monetary shocks on output and prices in the domestic economy, and find similar patterns as in the US.[5] The assumption of an underconsumption regime is reasonable due to the Asian crisis and its aftermath, which led to a decline in GDP in several of China's trading partners during our sample period and subsequent high levels of saving relative to GDP. Finally, the complementarity of foreign and domestic goods is satisfied by the Asian production chain.

When these conditions are fulfilled the foreign monetary expansion will trigger two types of effects. The classical shift from home to foreign goods, which become cheaper because of depreciation of the foreign currency (present in the Mundell-Fleming framework, and previously labeled the 'beggar-thy-neighbor' effect) leads to a decline in home output. The intertemporal effect, in contrast, increases home output. Here, a foreign monetary expansion causes foreign inflation to rise, thus lowering the real interest rate. This leads to intertemporal substitution in favor of current goods, in part current domestic goods. As mentioned in our South-East Asian case, where capital flows between China and S.E. Asian economies are subject to strict controls and there is little *de facto* exchange rate flexibility, we expect the second effect to dominate.

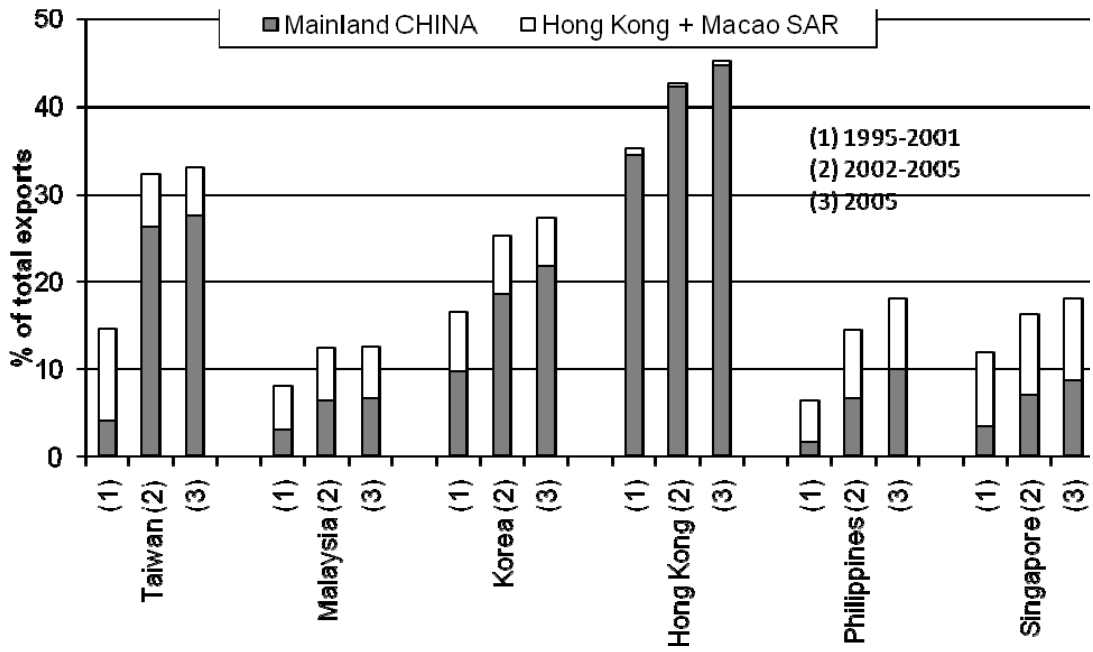
The positive intertemporal effect may obtain further support from a wealth effect. An expansion - monetary or fiscal - will lead to an increase for import demand, via the import elasticity of wealth. As the Chinese economy expands, Chinese consumers feel richer and thus demand more imports while Chinese producers will require more inputs from the Asian production chain. The increase of demand for imports can be expected to have an expansionary effect on foreign producers, raising their output and possibly exerting upward pressure on prices.

[5] Mehrotra (2008) also shows how shocks to real M2 lead to increases in CPI inflation in the Mainland.

How important could these effects be? Over the past decade or so, the importance of the Chinese economy, both globally and regionally (for South East Asia) has increased immensely. The implications of China's entry into the global economy have been discussed extensively.[6] Chinese exports grew on average 18% annually (USD terms) throughout 1995-2005, accelerating to 27% annual growth in 2006, while imports climbed at a slower pace (17% on average) throughout 1995-2005, and accelerating to 20% in 2006. This has caused China's trade to have an impact both globally and regionally. Exports from China as a share of total world exports amounted to 8% in 2006, while imports to China amounted to over 6% of world imports, making it the world's third largest importer and exporter of merchandise. More specifically, for the South East Asian economies, China emerged as an important export destination, as shown in Figure 1. The figure displays both the exports to Mainland China and the sum of exports to Mainland China, Hong Kong SAR and Macao SAR, as shares of total exports. For many years Hong Kong was considered the trade gateway to Mainland China, and even currently a significant amount of trade with the Mainland is done via Hong Kong.[7] Exports to China as a share of total exports roughly doubled in the past decade, making China one of the top export destinations for many of the regional economies. If exports to Mainland China and Hong Kong are combined, China often emerges as the prime export destination (in 2006 this was the case e.g. for Singapore and Taiwan). As most S.E. Asian economies are relatively open, a significant part of domestic production is actually exported to China.[8] For this reason, one can expect the Chinese demand for imports from South East Asia to have a significant effect on output and prices in these economies.

[6] See Winters and Yusuf (2007) for a collection of studies on the implications of China's and India's growth for the world economy.
[7] For instance, the high level of Taiwanese trade with Mainland China via Hong Kong is motivated mainly by political factors.
[8] International Trade Statistics of the WTO provide the following trade-to-GDP ratios for the S.E. Asian economies (2003-2005 averages): Singapore 432%, Hong Kong 364%, Malaysia 218%, Thailand 138%, Taiwan 120%, Philippines 103%, and Korea 80%. Even considering the fact that, especially in the smaller countries, trade statistics are often inflated by imports which are re-exported, the economies are widely regarded as 'open'.

Figure 1 Share of exports to China (mainland and greater China) in total exports for selected S.E. Asian economies.



A number of papers have adopted the structural VAR approach in order to investigate the cross-border effects of foreign monetary policy on domestic output and prices. The underlying idea is that shocks in a large, important economy spill over to smaller economies through various channels. 9 Among these papers, we can distinguish two basic methodologies. The first involves estimation of the model for the large foreign economy augmented by some external variables for the domestic economy. In the second approach, the model is estimated for the small domestic economy, with additional foreign variables.

The first approach is adopted by Kim (2001) to investigate the mechanism through which U.S. monetary policy shocks are transmitted internationally in a flexible exchange rate environment. The author sets up an SVAR system with both recursive (Cholesky type) and non-recursive contemporaneous identification restrictions. He estimates models, using both monthly and quarterly data, for the U.S and then adds each external (non-U.S. G-6) variable, one-by-one. Among the findings is a positive effect of a U.S. monetary expansion on non-U.S. G-6 output, via the capital market, i.e. through the world interest rate, rather than the trade channel.

[9] Where importance can be defined both in the global or regional sense.

Similarly, Maćkowiak (2006) estimates an SVAR model for Japan to assess the impact of its monetary policy on neighboring economies, in particular its role in the emergence of the Asian crisis. He uses four different identification schemes, one with contemporaneous restrictions, based on Christiano et al. (1999), which assumes that at the moment a monetary policy decision is made, the policy maker does not have the full contemporaneous set of information. The other identification approaches are based on recursive restrictions, where all variables react to monetary policy with a delay; a scheme based on Leeper et al. (1996) which imposes blocks of variables that react 'fast' or 'sluggishly', and sign-restrictions. Maćkowiak (2006) first estimates a six-variable system using quarterly data for Japan only.[10] Secondly, the system is augmented with a selected variable from the set of indicators capturing trade flows and economic conditions in South-East Asian economies. He finds modest effects for Japanese monetary policy on its neighbors, with little support for the beggar-thy-neighbor story. Moreover, although Japanese monetary expansion preceded the Asian crisis, the author finds no evidence it contributed to the crisis.

Another approach – adopted here – is used in Kim and Roubini (2000) to assess the impact of U.S. monetary shocks on macroeconomic variables in the non-U.S. G-7 economies and to address a number of puzzles common to the empirical literature.[11] The authors use an open economy SVAR with monthly observations for 1974-1992. The system consists of the five standard domestic variables, the oil price, and the U.S. Federal Funds Rate. The methodology generally follows Sims and Zha (2006) with a non-recursive identification scheme based on contemporaneous restrictions arising from economic theory. These arise from assumptions on the availability i.e. timing of information for economic agents. Among other things, they find significant effects of U.S. monetary policy shocks on output levels, especially in Canada and to a smaller extent in Germany.

Cushman and Zha (1997) investigate the effects of a foreign (U.S.) monetary policy shock on a small open economy (Canada) with flexible exchange rates. They use monthly data for 1974-1993 in an SVAR system. For identification purposes, they use a block-exogenous approach with restrictions on contemporaneous parameters. They find a large impact of U.S. policy shocks on Canadian output.

[10] The system variables are real GDP, CPI, commodity prices, interest rate, money supply and the USD/JPY exchange rate.
[11] These puzzles include the liquidity puzzle, price puzzle, exchange rate puzzle and forward discount bias puzzle.

In order to achieve identification, the papers discussed above generally propose alternatives to the Cholesky decomposition, which is reported to have the tendency to produce empirical puzzles.[12] These arise from the imposed recursive structure that precludes simultaneous reactions among certain variables. As argued by Cushman and Zha (1997), this shortcoming may be particularly relevant for examining the effects of monetary policy on small open economies.

3 SVAR model and data issues

Our modeling strategy is based on vector autoregressions. A reduced form VAR model, excluding the deterministic terms, can be written as

$$x_t = A_1 x_{t-1} + \ldots + A_p x_{t-p} + u_t . \qquad (1)$$

, p denotes the order of the VAR model. In our system of K endogenous variables, $x_t = (x_{1t}, \ldots, x_{Kt})'$ is a (K×1) random vector and the A_i are fixed (K×K) coefficient matrices. We assume that $u_t = (u_{1t}, \ldots, u_{Kt})'$ follows a K-dimensional white noise process with $E(u_t) = 0$. In order to examine the effects of Chinese monetary policy shocks on the system variables, we employ a structural vector autoregressive model. To achieve identification, we impose contemporaneous restrictions based on theoretical considerations and assumptions on information availability. We write the general structural representation as

$$\mathrm{A}x_t = A_1^* x_{t-1} + \ldots + A_p^* x_{t-p} + \mathrm{B}\varepsilon_t , \qquad (2)$$

where $\varepsilon_t \sim (0, I_K)$. The matrix A allows for modeling of the instantaneous relations. The A_i^*'s (i = 1, ..., p) are (K×K) coefficient matrices, and B is a structural form parameter matrix. The structural shocks, ε_t, are related to the model residuals by linear equations. We assume that the structural shocks are orthogonal. Their connection with the reduced form disturbances is obtained by multiplying (2) by A^{-1}, so that $A_j = \mathrm{A}^{-1} A_j^*$ (j = 1,...,p). This gives us the following relationship between errors of the reduced and structural forms:

[12] See Kim and Roubini (2000) for an explicit reference to the empirical puzzles, or Cushman and Zha (1997) for a detailed exposition.

$$u_t = \mathrm{A}^{-1}\mathrm{B}\varepsilon_t \ . \tag{3}$$

Following the AB-model by Amisano and Giannini (1997), we combine restrictions for A and B, so that the model for innovations becomes $\mathrm{A}u_t = \mathrm{B}\varepsilon_t$. The setting of linear restrictions on the A and B matrices is explained formally in Breitung et al. (2004). As there are altogether $2K^2$ elements in the structural form matrices, and the maximum number of identifiable parameters in these matrices is $K(K+1)/2$, we need $2K^2 - K(K+1)/2$ further restrictions for exact identification. These are discussed below.

Our structural model is comprised of 4 domestic and 2 external endogenous variables. The domestic variables include real output (y_t), price level (p_t), domestic short-term interest rate (i_t), and the exchange rate (e_t). The variables characterized as external are oil price (measured in USD), denoted oil_t and the Chinese money supply, denoted m_t. This yields the reduced form disturbances: u^y_t, u^p_t, u^i_t, u^e_t, u^{oil}_t, u^m_t. The model for innovations, $\mathrm{A}u_t = \mathrm{B}\varepsilon_t$, is specified as

$$\begin{bmatrix} 1 & 0 & 0 & 0 & \mathbf{a}_{15} & 0 \\ 0 & 1 & 0 & 0 & \mathbf{a}_{25} & 0 \\ \mathbf{a}_{31} & \mathbf{a}_{32} & 1 & \mathbf{a}_{34} & \mathbf{a}_{35} & \mathbf{a}_{36} \\ 0 & \mathbf{a}_{42} & 0 & 1 & \mathbf{a}_{45} & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & \mathbf{a}_{63} & \mathbf{a}_{64} & \mathbf{a}_{65} & 1 \end{bmatrix} \begin{bmatrix} u_t^m \\ u_t^y \\ u_t^e \\ u_t^p \\ u_t^{oil} \\ u_t^i \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_t^m \\ \varepsilon_t^y \\ \varepsilon_t^e \\ \varepsilon_t^p \\ \varepsilon_t^{oil} \\ \varepsilon_t^i \end{bmatrix} . \tag{4}$$

In (4), the structural shocks are Chinese monetary policy shocks ε mt, output shocks ε yt, exchange rate shocks ε et, price shocks ε pt, oil price shocks ε oilt, and domestic monetary policy shocks ε^i_t. Our identification scheme is very similar to Kim and Roubini (2000), although we allow for some departures from their specification due to specific characteristics of the Chinese economy and the quarterly frequency of our data. An important issue in our case is identification of the Chinese monetary policy shocks, specified in the first row of (4). We assume that the People's Bank of China (PBoC) sets its money supply observing, and potentially reacting to, the current value of the world price of oil but not taking into account the contemporaneous values of the other variables in the model. We argue that monetary base is an appropriate variable to capture Chinese monetary policy shocks, as

interest rates have not yet assumed a role in the transmission mechanism comparable to that in developed economies.[13] In his survey of Chinese monetary policy targets and instruments, Geiger (2006) confirms the importance of monetary base targeting and the prominent role of money supply in the conduct of monetary policy. The Chinese monetary authority has specified intermediate targets in terms of annual money supply growth since 1994. According to the PBoC, an appropriate rate of money growth would promote "economic growth positively and contribute to preventing both inflation and deflation" (PBoC, 2005). Xie (2004) also argues that while inflation and economic growth are the ultimate objectives of Chinese monetary policy, it targets the money supply, and open market operations are used as the primary instrument to control the money base. Mehrotra (2007) provides empirical evidence that interest rate shocks did not significantly influence output and price developments in 1996-2004 in the Mainland. Moreover, Chow and Shen (2004) identify monetary policy shocks in Mainland China as shocks to narrow money M1, and find very similar dynamics as in the US economy. [14] Despite the US dollar peg that prevailed during our sample period (January 1994-July 2005), capital controls have allowed for a relatively independent monetary policy. Persistent current account surpluses have drawn US dollars and other major international currencies into the Chinese economy - which must be subsequently exchanged for renminbi. The PBoC has had little difficulty in sterilizing this increase in liquidity by selling bonds to state-owned commercial banks. Green (2005) points out that, due to extremely low or negative sterilization costs in China, the USD peg has proved quite profitable for the PBoC.

The second and fourth rows in (4) describe the goods market equilibrium. Real output can only respond to monetary policy and exchange rate shocks with a lag, due to significant inertia in economic activity, as in Sims and Zha (2006), but it can react to oil prices within the same quarter, as a result of a mark-up rule that creates a link between input costs, output and output prices. The third row is an arbitrage equation for the foreign exchange market, whereby the exchange rate is allowed to react contemporaneously to any shock hitting the system. In our system, prices react sluggishly to monetary policy and ex-

[13] We use the "reserve money" variable reported in the PBoC's Quarterly Statistical Bulletin, which includes currency issue, and deposits of financial institutions and non-financial corporations at the PBoC.
[14] Yu (1997) finds that monetary aggregates in China outperform bank credit in forecasting future economic activity, providing support for the use of monetary aggregates as a major policy target for the PBoC. Dickinson and Liu (2007) identify monetary policy shocks using the central bank lending rate and the quantity of credit as the monetary policy variables for China.

change rate shocks, as is commonly assumed in reduced form modeling of monetary policy. This is shown in the fourth row of (4). The slow adjustment of prices is in line with the canonical pricing scheme by Calvo (1983), where prices are changed at exogenous random intervals. Because prices do not react contemporaneously to an interest rate shock, the real interest rate rises and brings on the monetary contraction.

The fifth row describes the oil price shock. The oil price is exogenously determined to the extent that it does not react contemporaneously to any other shock hitting the system, although we do allow for lagged effects. The last row of (4) is the monetary policy reaction function of the domestic central bank. We generally assume that the monetary authority sets the interest rate on the basis of the current price level – emphasizing the focus on price stability – but can also take into account the contemporaneous oil price. For Hong Kong, however, we restrict the coefficient a_{64} on prices to zero due to the currency board mechanism that limits independent domestic monetary policy. The interest rate in Hong Kong is therefore dependent to an extent on movements in the exchange rate. As the US dollar is the anchor currency in Hong Kong, and the US Federal Reserve can be assumed to pay attention to the oil price in its policy setting,[15] we leave the coefficient on oil price a_{65} unrestricted.

The data are quarterly and span the period 1990Q1-2006Q4. The primary data sources are the IFS and CEIC databases. For output, we use real GDP for all economies. The price series is the consumer price index. As the short-term interest rate, we use the overnight interbank rate for Taiwan and Malaysia, the money market rate for Hong Kong, Korea and the Philippines, and the three-month interbank rate for Singapore. The exchange rate against the US dollar is used for all other economies except Hong Kong and Malaysia. For these two, we use the nominal effective exchange rate, due to the currency board in the former and the tight US dollar peg for part of the sample in the latter economy. The oil price is the average crude price in US dollars, and monetary base ("reserve money") is used for the Chinese money supply. The series for real GDP, CPI, and Chinese base money are seasonally adjusted using the TRAMO-SEATS procedure. Finally, all variables except the interest rate are in logarithms.

[15] See, for instance, Kim and Roubini (2000).

4 Estimation results

We estimate the reduced form VAR models first by OLS in first differences to ensure stationarity.[16] We then construct subset models by utilizing a procedure that at each step checks and possibly eliminates the regressor with the lowest *t*-value from the estimated system. In the final models for all countries, only parameters with *t*-values exceeding the threshold of 1.00 are included. This ensures more significant estimates in our relatively large VAR models featuring many statistically insignificant coefficients. The lag length is based on tests for misspecification, with the primary aim of removing autocorrelation and ARCH-effects from the residuals. This results in 3 lags for Korea, Hong Kong and Malaysia, and 4 lags for Philippines, Taiwan and Singapore. The models perform relatively satisfactorily in the misspecification tests; there are, however, signs of ARCH-effects for Malaysia and very weak evidence (at 10% level) of autocorrelation for Singapore and Malaysia in the LM test.[17]

We acknowledge the fact that where the variables are cointegrated, the reduced form VAR models in first differences are misspecified. However, the results from cointegration tests were generally unsatisfactory, as few robust results on the cointegrating rank of the systems were found. In particular, small changes in the testing procedure, such as in the number of lags, yield different results for the cointegrating rank. Importantly, estimating the model in stationary first differences allows for subset modeling, which substantially improves system performance in misspecification tests.

The structural VAR models are estimated by maximum likelihood, using the variance-covariance matrix of the reduced form model and the restrictions imposed for the structural form. The maximization was done by numerical optimization methods using a scoring algorithm (see Breitung et al., 2004). The system (4) is overidentified with three overidentifying restrictions, with the exception of Hong Kong where four overidentifying restrictions are used, due to the currency board regime. A formal likelihood ratio test does

[16] ADF tests formally confirm stationarity of the first-differenced time series, as the null hypothesis of unit root is rejected at 5% level, when the Schwarz information criterion is used to determine the lag length. Only for Hong Kong is there evidence that the price level series could actually be I(2). For Malaysia, a unit root for CPI inflation is weakly rejected (10% level).

[17] In order to remove residual outliers, some of the estimated models include impulse dummy (obtaining a value of one for a specific quarter and zero otherwise) and shift dummy variables (obtaining a value of one for several quarters and zero otherwise). The model for Korea includes an impulse dummy for 98Q1. For

not reject the overidentified models for any economy at 5% level, as shown in Table 1. But the restrictions are weakly rejected (at 10%) for Malaysia and Singapore.

Table 1 Test for three overidentifying restrictions

Economy	Likelihood ratio test
Hong Kong (four restrictions)	LR= 4.68 (0.32)
Korea	LR= 1.81 (0.61)
Malaysia	LR= 6.49 (0.09)*
Philippines	LR= 6.04 (0.11)
Singapore	LR= 7.19 (0.07)*
Taiwan	LR= 4.48 (0.21)

Note: *, ** and *** denote statistical significance at 10%, 5%, and 1% levels, respectively.

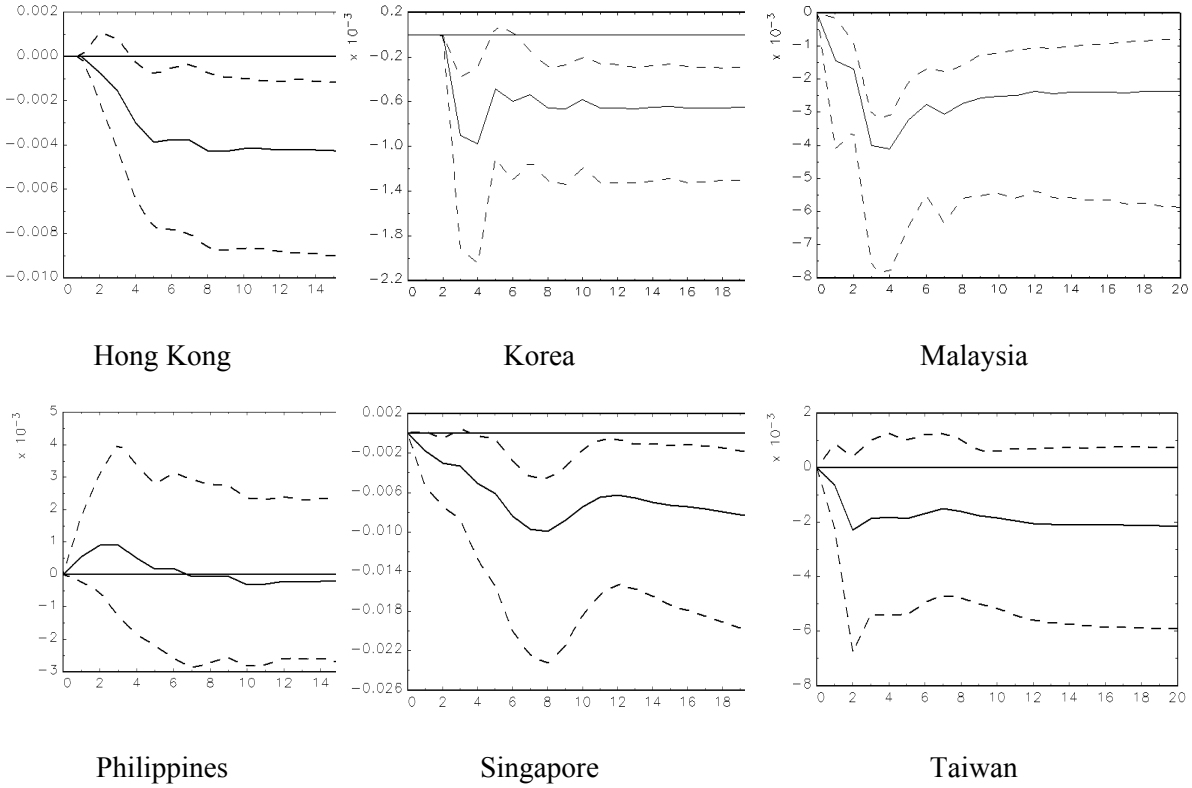
We commence investigation of model dynamics by looking at impulse responses within the estimated structural systems. The focus of the analysis is on the effects of Chinese monetary policy shocks on output and prices in the South East Asian economies. However, it is important to examine whether our models in general provide sensible dynamics, apart from the impacts of the Chinese shocks on neighboring economies. First, to analyze whether the domestic monetary policy shocks make sense, we look at the effects of interest rate shocks on real GDP and the price level. Where we have managed to identify a monetary contraction, we would expect real GDP and the price level to fall after a positive interest rate shock. Figure 2 displays the impact of the domestic monetary policy shock on domestic real GDP, while the impact of the domestic monetary policy shock on the interest rate itself is shown in Appendix A. All impulse responses are accumulated in order to focus on the impacts on the levels of the variables. The 90% Hall percentile confidence intervals for the impulse responses are obtained by bootstrapping methods, with 1,000 replications.

Figure 2 shows that for most countries in our sample, real GDP falls in response to a domestic monetary policy shock. The result is not statistically significant for the Philippines. For Taiwan, the accumulated impact is clearly negative even if the zero line falls inside the confidence intervals. The peak impact is generally obtained after one year following the shock, which seems reasonable. If we use 95% confidence intervals instead, we see that the effect is not significant in the longer run for Hong Kong and Singapore, which is in line with the neutrality of monetary policy, i.e. the lack of a long run effect on real

Malaysia, we include a shift dummy for the year 1998 and an impulse dummy for 97Q4. Finally, for both Philippines and Taiwan we include an impulse dummy for 94Q3.

variables. However, in the case of Korea and Malaysia, the real effects of monetary policy shocks appear quite persistent. Investigating the impact of a domestic monetary policy shock on the price level (not displayed), we find little evidence of a price puzzle – the price level falls in five of the six economies examined.[18] These results suggest that we have indeed managed to identify a domestic monetary policy shock within our system.

Figure 2 Response of real GDP to a domestic monetary policy shock



We then move on to investigate the effects of a Chinese monetary expansion on real GDP and price level for the economies under study. These are shown in Figures 3 and 4. The exact dynamics of the Chinese monetary policy shock on China's money supply are displayed in Appendix A.

Figure 3 shows that an expansionary monetary policy shock in China leads to an increase in domestic output in many of the economies studied. This result is in line with our theoretical framework, whereby a foreign monetary expansion can, through the trade chan-

[18] For Malaysia the effect is mildly positive, though statistically insignificant.

nel, lead to an expansion in a major trading partner. The result is not statistically significant for Korea and is weakly significant in Taiwan. However, in all countries but Malaysia and the Philippines, the effect becomes insignificant in the longer term, which indicates that the effect of Chinese monetary policy on GDP is of a temporary nature. We then examine the multiplier,[19] obtained as the maximum real GDP impact over 20 quarters of the initial Chinese money supply shock, for those economies where a clearly statistically significant impact is found. The multiplier is highest in Singapore (0.4), and lowest in the Philippines and Hong Kong (both 0.2), although the confidence bands are quite large.

Figure 3 Response of real GDP to Chinese monetary policy shock

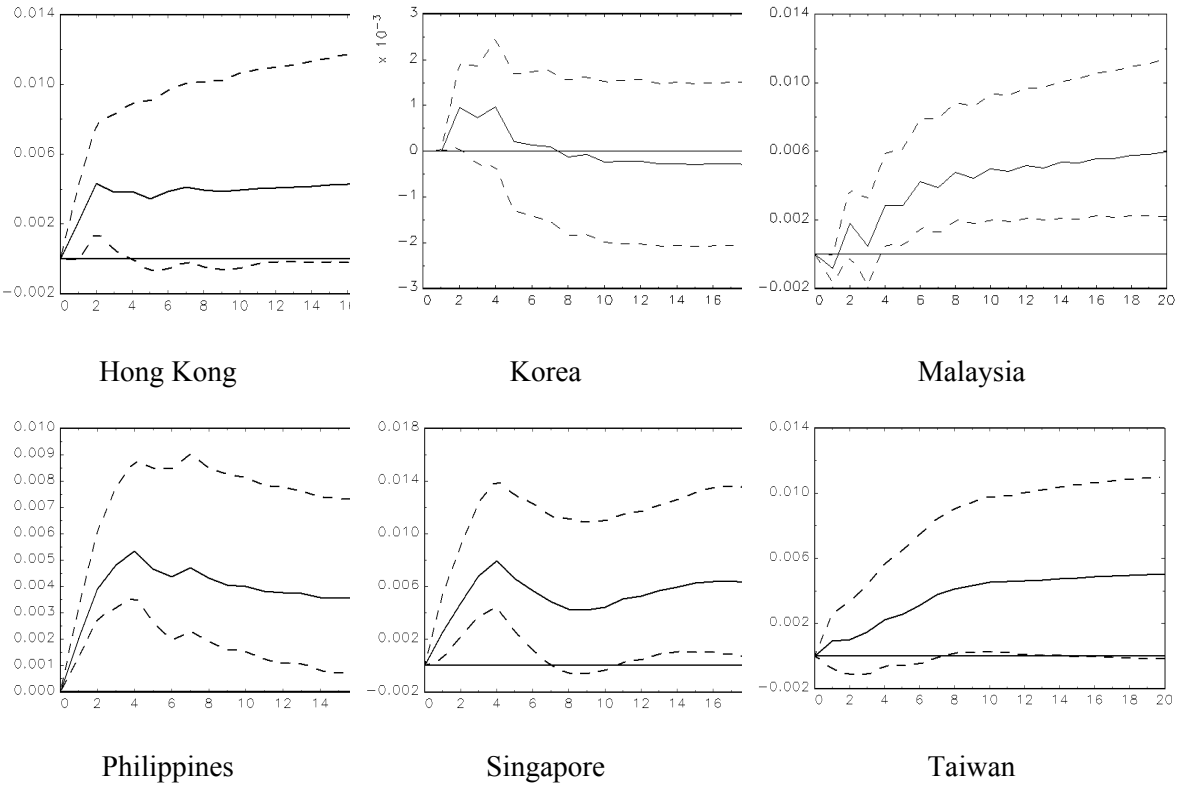
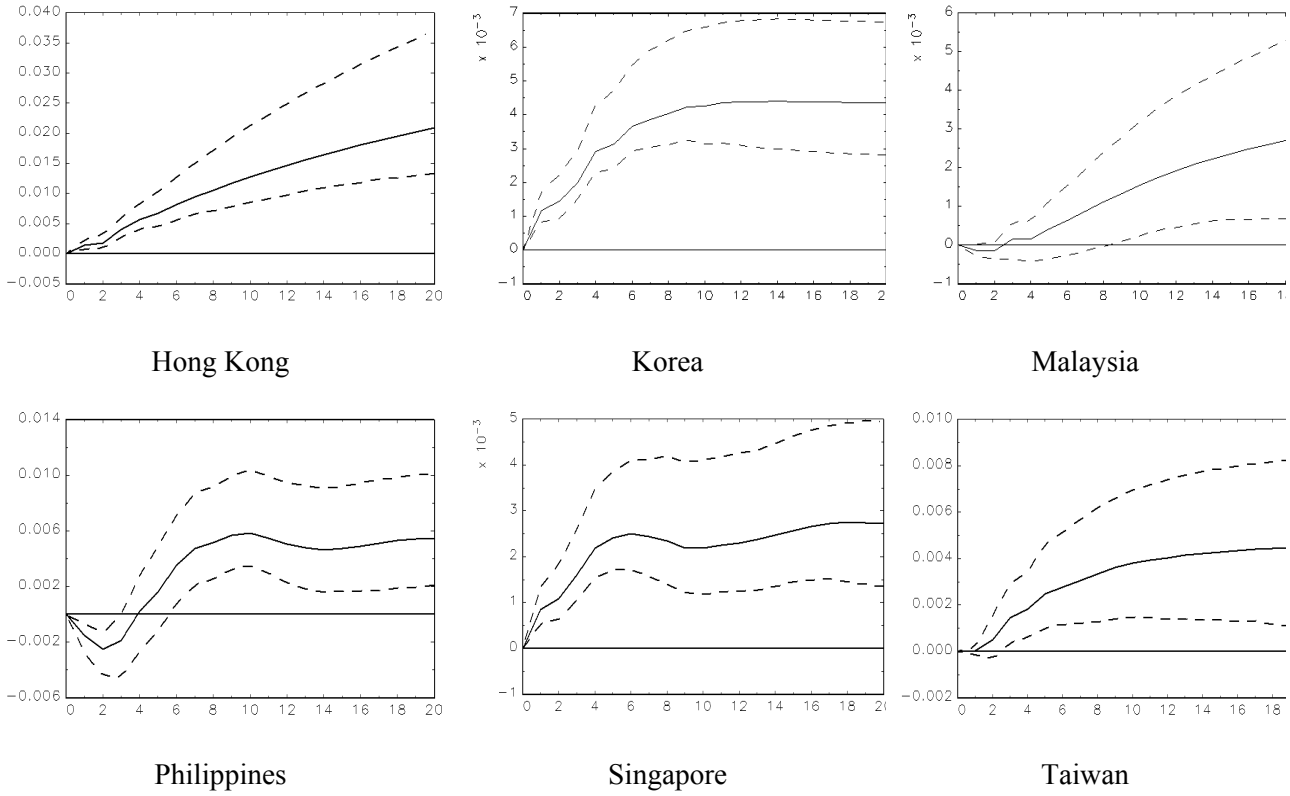


Figure 4 shows that a Chinese monetary expansion leads to an increase in the price level in the long run in all countries studied. Again focusing on the economies where we see a clearly statistically significant impact, the multiplier is now highest in Hong Kong (0.8) and lowest in Singapore (0.1), both with quite wide confidence bands.

[19] The multiplier is the ratio of the maximum accumulated effect on the outcome variable (e.g. output, prices) to the magnitude of the initial shock to the Chinese monetary policy variable.

Figure 4 Response of price level to a Chinese monetary policy shock



In order to be sure that we have actually identified Chinese monetary policy shocks we must be confident that these shocks do not capture other regionally important disturbances, e.g. shocks in U.S. or Japanese monetary policy.[20] To avoid the identification of more than one external monetary shock, we include the two monetary policy variables, one-at-a-time, as exogenous variables in the models for the East Asian economies. To capture U.S. monetary policy, we use a short-term interest rate. However, regarding Japanese policy, due to the fact that the zero interest rate floor was binding for part of our sample period and actual policy focused on quantitative easing by increasing money supply, we use the Japanese monetary base as the policy variable for that economy.[21] We argue that the Japanese and U.S. monetary authorities, in making policy decisions, do not react to domestic South East Asian variables.[22] The robustness of the results is confirmed for most countries, as the in-

[20] Both U.S. and Japanese shocks may be of global importance; moreover the two countries also constitute major trading partners of South East Asian economies.
[21] For each country we include the same number of lags of the U.S. interest rate or Japanese monetary base, as well as the contemporaneous lag, as we do for the endogenous variables.
[22] We acknowledge that they could, however, react to the oil price.

clusion of neither U.S. short-term interest rate nor the Japanese monetary base affects the significance of output and price responses to Chinese monetary policy. Exceptions are Malaysia (output) and Taiwan (prices).

Even if Chinese monetary policy shocks have statistically significant impacts on some economies in the region, their importance may still be small, in case they were to account for only a minor share of all shocks affecting these countries. To investigate this issue, we perform a forecast error variance decomposition. Here, we want to see how large a share of variation in output and prices can be explained by a structural Chinese monetary policy shock, relative to other shocks. These results are shown in Tables 2 and 3. We investigate the importance of the shock up to 20 quarters ahead.

Table 2 Importance of a Chinese monetary policy shock for domestic output

Horizon	Hong Kong	Korea	Malaysia
1	**0**	0	0.00
5	**0.05**	0.02	0.09
10	**0.05**	0.03	0.11
20	**0.05**	0.03	0.11
	Philippines	Singapore	Taiwan
1	**0**	**0**	0
5	**0.23**	**0.06**	0.02
10	**0.24**	**0.06**	0.03
20	**0.24**	**0.06**	0.03

Note: Column marked in bold if corresponding impulse response dynamic is statistically significant and remains robust to inclusion of U.S. and Japanese monetary policy variables.

Table 3 Importance of a Chinese monetary policy shock for domestic price level

Horizon	Hong Kong	Korea	Malaysia
1	**0**	**0**	**0.00**
5	**0.20**	**0.13**	**0.01**
10	**0.19**	**0.14**	**0.04**
20	**0.19**	**0.14**	**0.06**
	Philippines	Singapore	Taiwan
1	**0**	**0**	0
5	**0.11**	**0.16**	0.04
10	**0.17**	**0.14**	0.06
20	**0.17**	**0.14**	0.06

Note: As in Table 2.

The tables suggest that a Chinese monetary policy shock does not constitute a major source of variation in any of the economies. The smallest shares of movement in output

explained by such a shock are for Korea and Taiwan (3% of overall shocks after 5 years), while its importance for GDP is notably higher for the Philippines (24% after 5 years). Regarding the impact on prices, we see that the share of Chinese monetary policy shock is of minor importance only in Taiwan (6%) and notably higher in the other economies (14-21%). Combining results from Tables 2 and 3, the importance of Chinese monetary policy is generally greater for prices than for GDP. We recall that for all countries we found a significant, persistent effect of Chinese policy on prices in the impulse response analysis, confirming that the effect on prices is the main channel through which Asian economies adjust to Chinese shocks. Moreover, the quantitative impact of a shock, when significant, is found to be highest in our sample for Hong Kong (prices) and Singapore (output).

5 Conclusion

In this paper we analyze the direction and magnitude of the effect of Chinese monetary policy shocks on East Asian economies. In an SVAR framework with contemporaneous, non-recursive restrictions we estimate models for six economies of the region, including measures of output, prices, exchange rates, and interest rates, augmented by the world oil price and the money supply as an indicator of Chinese monetary policy.

With the adopted identification scheme we are able to identify reasonable responses of variables to domestic monetary shocks. Moreover, we can confidently identify both domestic and Chinese monetary policy shocks. We find significant positive effects of Chinese monetary expansion on output in Hong Kong, Philippines and Singapore in the short term. The effect tends to disappear as the time horizon increases. Moreover we find a positive, significant and persistent effect of Chinese monetary expansion on prices in Hong Kong, Korea, Malaysia, the Philippines and Singapore. These results are robust to the inclusion of Japanese and U.S. monetary policy variables.

Finally, in line with our expectations, the forecast-error variance decomposition results show that Chinese shocks were not the primary driving force of output and price fluctuations in East Asian economies in 1990-2006. However, in some countries Chinese monetary policy shocks were able to explain a notable share of movements in output (Philippines) and prices (all countries except Taiwan). Our findings are consistent with the Mundell-Fleming framework with restricted capital flows and intertemporal open macro mo-

dels, though they mainly emphasize the role of the trade channel, be it because of Chinese consumers' increasing demand for consumption goods or the existence of the Asian production chain.

An important implication of the findings is that if monetary authorities in East Asia aim to stabilize short run output fluctuations and/or prices, they ought to pay attention to developments in Chinese monetary policy. This is especially true in countries where Chinese shocks determine at least 10% of the variance in prices (all except Taiwan) and/or output. Although the effect is large also in Hong Kong, the implications do not straightforwardly extend to its monetary policy, which because of the currency board arrangement is practically determined in the U.S. However, as regards the question of whether Hong Kong should maintain the currency board arrangement with the U.S. dollar, the fact that about a fifth of the variation in its prices is determined by decisions of the People's Bank of China, i.e. actually more than by U.S. policy shocks, may prove to be an important consideration.

It must be noted, however, that the main channel through which we expect Chinese shocks to affect neighboring economies is the trade channel, due mainly to strict capital controls. There have been capital flows in the form of foreign direct investment to China (close to USD 70 billion in 2006), but these movements are typically motivated by factors other than exchange rate changes and interest rate differentials. Yet, once capital controls are liberalized the capital channel may prevail. According to the standard Mundell-Fleming framework, this could result in substantial changes in the magnitude and even direction of effects. If exchange rates between China and East Asian economies were relatively fixed, we would expect there would be little room for any effect, due to arbitrage. On the other hand, with relatively flexible exchange rates, the beggar-thy-neighbor effect might dominate the positive trade effect, leading to a negative impact of a Chinese monetary expansion on East Asian economies. Although the future dynamics are yet to be seen, our paper provides evidence that Chinese monetary policy shocks have spilled over borders to neighboring countries.

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Appendix A

Table A1 Misspecification tests

Taiwan	Philippines
Q(16)= 433.15 [1.00]	Q(16)= 469.47 [0.79]
LM(5)= 184.48 [0.39] LM(4)= 138.45 [0.61]	LM(5)= - LM(4)= 123.57 [0.89]
LM(1)= 19.52 [0.99]	LM(1)= 28.06 [0.82]
$ARCH_1$(16)= 9.20 [0.91]	$ARCH_2$ (16)= 16.06 [0.45]
$ARCH_2$(16)= 11.66 [0.77]	$ARCH_5$ (16)= 7.73 [0.96]
$ARCH_3$(16)= 15.28 [0.50]	$ARCH_3$ (16)= 15.59 [0.48]
$ARCH_4$(16)= 8.40 [0.94]	$ARCH_1$ (16)= 1.26 [1.00]
$ARCH_5$(16)= 10.01 [0.87]	$ARCH_6$ (16)= 11.35 [0.79]
$ARCH_6$(16)= 11.65 [0.77]	$ARCH_4$ (16)= 21.68 [0.15]
Korea	**Singapore**
Q(16)=535.31 [0.36]	Q(16)= 454.61 [0.79]
LM(5)=185.22 [0.38] LM(4)=158.97 [0.19]	LM(5)= 200.21[0.14] LM(4)= 168.70 [0.08]*
LM(1)= 37.33[0.41]	LM(1)= 25.40 [0.91]
$ARCH_1$ (16)=18.45 [0.30]	$ARCH_1$ (16)= 10.22 [0.85]
$ARCH_2$ (16)= 12.88 [0.15]	$ARCH_2$ (16)= 9.68 [0.88]
$ARCH_3$ (16)=2.15 [1.00]	$ARCH_3$ (16)= 4.52 [1.00]
$ARCH_4$ (16)=16.26 [0.44]	$ARCH_4$ (16)= 13.77 [0.62]
$ARCH_5$ (16)=9.60 [0.89]	$ARCH_5$ (16)= 15.63 [0.48]
$ARCH_6$ (16)=11.59 [0.77]	$ARCH_6$ (16)= 5.56 [0.99]
Hong Kong	**Malaysia**
Q(16)= 503.77 [0.73]	Q(16)= 484.70 [0.80]
LM(5)= 204.33 [0.10] LM(4)= 156.95 [0.22]	LM(5)= 186.54 [0.35] LM(4)= 144.70 [0.47]
LM(1)= 18.44 [0.99]	LM(1)= 48.30 [0.08]*
$ARCH_1$ (16)= 9.43 [0.89]	$ARCH_1$ (16)= 13.23 [0.66]
$ARCH_2$ (16)= 15.30[0.50]	$ARCH_2$ (16)= 4.07 [1.00]
$ARCH_3$ (16)= 17.99 [0.32]	$ARCH_3$ (16)= 20.99 [0.18]
$ARCH_4$ (16)= 13.36 [0.65]	$ARCH_4$ (16)= 19.44 [0.25]
$ARCH_5$ (16)= 15.52 [0.49]	$ARCH_5$ (16)= 10.68 [0.83]
$ARCH_6$ (16)= 9.57 [0.89]	$ARCH_6$ (16)= 28.53 [0.03]**

Q and LM denote Portmanteau test and LM test for autocorrelation; ARCH is a Lagrange multiplier test for autoregressive conditional heteroskedasticity for the six system equations; *p*-values in brackets; number of lags in parentheses. *, ** and *** denote statistical significance at 10%, 5%, and 1% levels, respectively. The LM(5) test is not reported for the Philippines due to computational problems.

Figure A1 Response of interest rate to domestic monetary policy shock

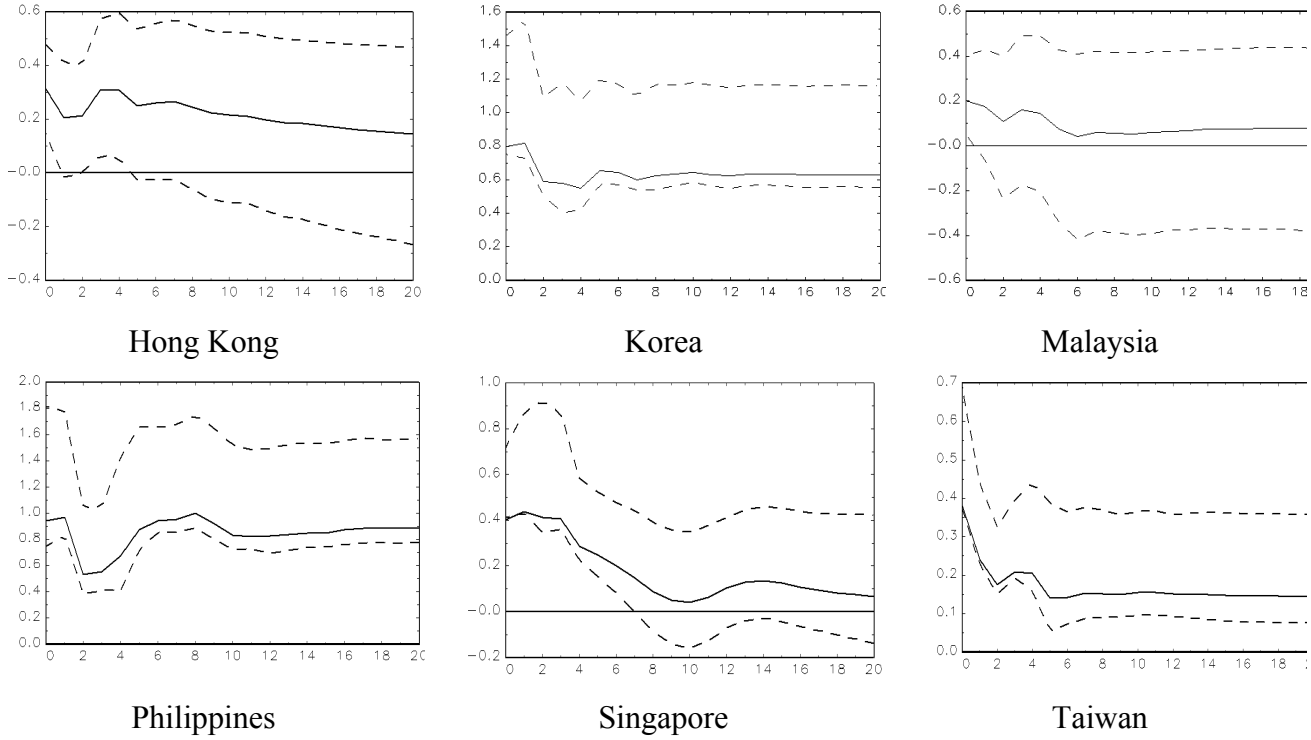
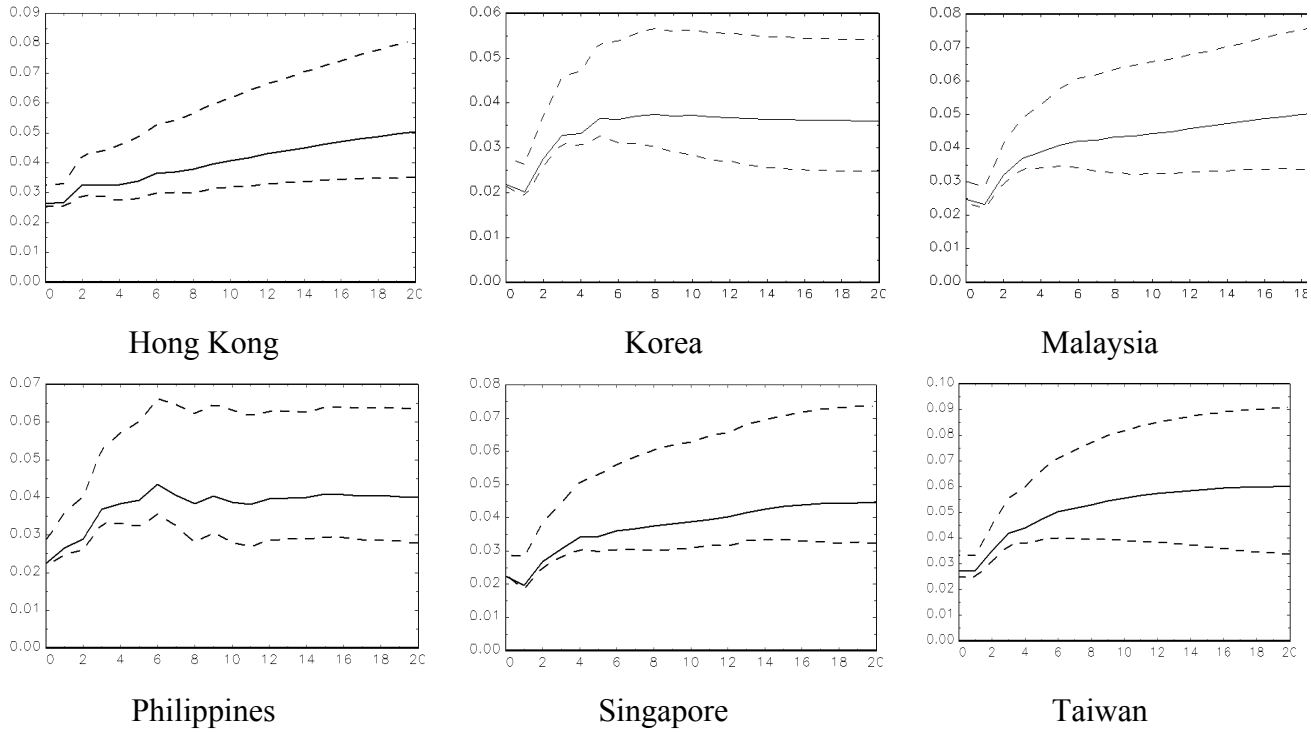


Figure A2 Response of China's money supply to Chinese monetary policy shock in different SVAR systems



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