EUROPEAN CENTRAL BANK
EUROSYSTEM

WORKING PAPER SERIES
NO 715 / JANUARY 2007

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HOW AUTONOMOUS ARE BUSINESS CYCLES? [1]

by Rasmus Rüffer [2], Marcelo Sánchez [3] and Jian-Guang Shen [4]

In 2007 all ECB publications feature a motif taken from the €20 banknote.

1 We would like to thank Laurent Clavel for valuable research assistance. This paper has benefited from comments by Balász Vonnák, Julian Morgan, Farshid Vahid and Renee Fry. In addition, we would like to thank participants at presentations at the ECB, the Hong Kong Monetary Authority, the Pacific Rim Conference (Hong Kong, 14-16 January 2005) and the conference "Globalisation and Regionalism" organised by ANU Centre for Applied Macroeconomic Analysis, European Central Bank and Lowy Institute for International Policy. The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank or the IMF. All errors are our responsibility.

2 European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany; e-mail: rasmus.rueffer@ecb.int

3 European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany; e-mail: marcelo.sanchez@ecb.int

4 International Monetary Fund, 700 19th Street, N.W., Washington, D.C. 20431, USA; e-mail: jgshen@imf.org

Address
Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address
Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone
+49 69 1344 0

Internet
http://www.ecb.int

Fax
+49 69 1344 6000

Telex
411 144 ecb d

ISSN 1561-0810 (print)
ISSN 1725-2806 (online)

CONTENTS

Abstract

Against the background of the rapid integration of emerging Asia into the global economy, this paper investigates the role of domestic and external factors in driving individual emerging economies in Asia. We estimate VAR models for ten countries over the period 1979Q1-2003Q4, controlling for external factors, and use sign restrictions to identify structural domestic shocks. Variance decompositions indicate that Asian emerging economies are to a large part driven by external developments, and even more so employing a more recent sample. We analyse to what extent structural domestic shocks exhibit a regional dimension by comparing shocks across countries using correlation and principal component analysis. The extent of regional co-movement between structural shocks is relatively limited. While the principal components analysis indicates a moderate increase in co-movement over time, the correlation analysis finds a decline. This may reflect a broadening of regional integration at the expense of bilateral economic ties.

Keywords: Economic integration; international business cycles; structural shocks; sign restrictions

JEL Codes: F15, F02, F41

Non-technical summary

In recent decades, Asia has become increasingly integrated with the global economy. At the same time, economic integration within Asia has also progressed at an impressive speed. The associated structural changes are likely to have an important effect on growth dynamics of the respective economies. In general, there are three geographical dimensions that are of considerable importance for macroeconomic performance in emerging Asia: global, regional and country-specific. Regarding the global dimension, the considerable strengthening of inter-regional linkages is likely to have resulted in a stronger dependence on developments outside the region. At the same time, the stronger economic links between countries within the region may have strengthened the regional dimension of the business cycle. Lastly, strong growth over a protracted period should have strengthened domestic incomes, thereby potentially increasing the importance of country-specific developments. While the first two "external" dimensions suggest that countries in emerging Asia may have become more integrated with the outside world – either via intra- or inter-regional links – and thus more exposed to external developments, the latter one implies that developments at the country level might have become a more important driver of business cycle fluctuations in individual countries. The main aim of the present paper is to assess the relative importance of these three effects.

This paper extends the existing literature by using an integrated structural approach to identifying the role played in East Asia by external factors (both regional and outside the region) as opposed to impulses originating at the domestic level. To that end we estimate individual VAR models for ten emerging Asian economies. Following previous work by Faust (1998), Canova and De Nicolò (2002) and Uhlig (2004) for advanced economies, we use sign restrictions for cross-products of impulse responses to identify structural shocks from the reduced form model. One advantage of this approach is that it relies on a set of relatively weak identifying restrictions and thus does not suffer from the potential robustness problems of often implausible short-term and long-term exclusion restrictions traditionally employed in the VAR literature.

Based on the structural shock decomposition, we use variance decomposition analysis to disentangle for each country the impact of different types of domestic shocks, on the one hand, and of a set of global variables, on the other, on various domestic aggregates. In addition, we assess the importance of a possible regional dimension by analysing the co-movement of structural domestic shocks through cross-correlations and principal component analysis. If the Asian region is characterised by strong regional dynamics, this is likely to be reflected in significant co-movement in structural shocks across countries, as any co-movement induced by common exposure to global factors is controlled for by the inclusion of the global variables.

Our results can be summarised as follows. Overall, the results show that the East Asian economies are predominantly driven by external factors. On average, across all variables and all countries external factors account for somewhat more than half of the error variance (57%), with the four domestic shocks accounting for similar shares of the remaining fraction. These average results mask, however, interesting differences between countries and variables. The importance of external factors appears to have increased considerably over time, with the share of variance explained by the exogenous variables increasing from 57% to 75% in a more recent sample. Regarding the regional dimension of domestic developments, both the bilateral correlation analysis and the multilateral principal components analysis suggest that the extent of co-movement between structural shocks across the different countries in emerging Asia is relatively limited. The principal components analysis provides some evidence of a moderate increase in co-movement, in particular for demand and monetary shocks. However, if one looks at the correlation analysis co-movement appears to have declined. This difference in results may indicate that the strength of bilateral links between any two countries may have declined in the process of greater Asian regional integration, with the linkages now being spread more broadly across the region, thereby giving rise to a more broad-based increase in regional co-movement of structural shocks.

The increasing fragmentation of the production process, which reduces the domestic value-added content of a country's exports renders the use of traditional measures of trade openness or the external exposure increasingly less useful, with this issue being particularly relevant in the case of Asia. In addition, traditional measures such as trade-to-GDP ratios fail to take into account the different degree of volatility of domestic and external shocks, with a relatively closed economy – traditionally measured – may still be strongly influenced by external developments if the domestic shocks are small relative to external ones. Furthermore, economic integration has been particularly rapid in the area of financial markets, thereby giving rise to non-trade economic linkages between economies, which are note captured by trade-based openness measures. Against this background, the VAR-based methodology presented in this paper offers an attractive alternative measure of an economy's openness and exposure to external developments.

1. Introduction

In recent decades, Asia has become increasingly integrated with the global economy. At the same time, economic integration within Asia has also progressed at an impressive speed. This is evidenced, for example, by the rapid increase in intra-regional trade flows, which partly reflect the increasing internationalisation of the production process, with China emerging as a major assembly and processing centre. The associated structural changes are likely to have an important effect on growth dynamics of the respective economies. In general, there are three geographical dimensions that are of considerable importance for macroeconomic performance in emerging Asia: global, regional and country-specific. Regarding the global dimension, the considerable strengthening of inter-regional linkages, reflecting to some extent outward-oriented growth strategies, is likely to have resulted in a stronger dependence of developments in individual countries in emerging Asia on developments outside the region. At the same time, the stronger economic links between countries within the region may have given rise to a more pronounced regional dimension of the growth process. Lastly, strong growth over a protracted period should have strengthened domestic incomes, thereby potentially increasing the importance of country-specific developments. While the first two "external" dimensions suggest that countries in emerging Asia may have become more integrated with the outside world – either via intra- or inter-regional links – and thus more exposed to external developments, the latter one implies that developments at the country level might have become a more important driver of business cycle fluctuations in individual countries. The main aim of the present paper is to assess the relative importance of these three effects.[3]

The source of emerging Asia's growth dynamics is an important issue for conjunctural analysis. The key question that frequently arises when assessing the economic outlook for the Asian region is: how much of the strong growth momentum evidenced by emerging Asia countries is driven by external factors as opposed to being the result of the autonomous strength of domestic demand. Answering this question is for example crucial for assessing the sustainability of the expansion of Asian countries in the case of a marked slowdown of the global economy. Several studies point to the idea that, while emerging Asia – and, in particular, Chinese – domestic demand helps buffer regional activity from global developments,[4] this

[3] It is beyond the scope of this paper to discuss the implications of this research area for monetary integration prospects in emerging Asia. The interested reader can consult Sánchez (2005), and the references therein.

[4] In this regard, the Asian Development Bank (2003) describes how, at the time of the latest global slowdown in the second half of 2002, exports of emerging Asian economies continued to grow based on strong intra-regional trade. The Monetary Authority of Singapore (2003) estimates that, in the case of East Asia, 36% of total exports are directed to the own region, and 22% of the total satisfy domestic demand of the subregion.

autonomous regional component is constrained by several factors. The latter include, for instance, the high degree of reprocessing in exports,[5] the still relatively small size of emerging Asia economies compared to the world economy, and the region's dependence on global demand of some products – and especially US demand for IT goods.[6]

Descriptive analysis, which is frequently used in that respect, can provide only a very limited understanding of emerging Asia's links to the rest of the world. For example, the direct comparison of domestic and external components of GDP, as is regularly done, ignores important interactions between the two. In particular, from a pure national accounting point of view an increase in investment spending would be considered a domestic demand development. In reality, this investment spending might however be closely linked to positive developments in the export sector. Similarly, private consumption also depends on earnings related to exports. Therefore a deeper understanding of the role played by domestic and external factors requires the use of rigorous econometric techniques, which can disentangle these interdependencies.

This paper extends the existing literature by using an integrated structural approach to identifying the role played in East Asia by external factors (both regional and outside the region) as opposed to impulses originating at the domestic level. To that end we estimate individual VAR models for ten emerging Asian economies. Following previous work by Faust (1998), Canova and De Nicolò (2002) and Uhlig (2004) for advanced economies, we use sign restrictions for cross-products of impulse responses to identify structural shocks from the reduced form model.[7] The identification through sign restrictions avoids imposing implausible and very restrictive exclusion restrictions on the short or long-term impact of various shocks. Furthermore, the concrete sign restrictions applied ensure that the identification strategy is consistent with a large number of macroeconomic models. Based on the structural shock decomposition, we use variance decomposition analysis to disentangle for each country the impact of different types of domestic shocks, on the one hand, and of a set of global variables, on the other, on various domestic aggregates. In addition, we

[5] Estimates of the degree of export reprocessing vary. For China, they range from 50% (Rumbaugh and Blancher, 2004) to 80% (Goldman Sachs, 2003).

[6] US purchases of IT software and equipment is particularly important for countries such as South Korea, Taiwan, Singapore and Malaysia. Zebregs (2004) calculates that the electronics sector has accounted for around half of overall export growth by emerging Asian countries in the period 1998-2001.

[7] Our analysis incorporates four domestic macroeconomic variables and control for a set of external variables including measures of advanced economies' economic activity, world interest rates and stock prices, and oil and non-oil commodity prices. By estimating models for individual Asian countries, we relax the constraint of "common slopes" found in the panel VAR studies reviewed below.

assess the importance of a possible regional dimension by analysing the co-movement of structural domestic shocks through cross-correlations and principal component analysis. If the Asian region is characterised by strong regional dynamics this is likely to be reflected in significant co-movement in structural shocks across countries, as any co-movement induced by common exposure to global factors is controlled for by the inclusion of the global variables. This analysis serves at the same time as a robustness check of the preceding domestic-external decomposition, as domestic shocks may contain an important regional component, rather than being purely domestic in nature. Against the background of the rapid structural changes in the Asian region over recent decades, we also investigate whether this has led to significant changes over time in either the domestic-external decomposition or in the importance of a regional element in growth dynamics.

Our results can be summarised as follows. Overall, the results show that the East Asian economies are predominantly driven by external factors. On average, across all variables and all countries external factors account for somewhat more than half of the error variance (57%), with the four domestic shocks accounting for similar shares of the remaining fraction. These average results mask, however, interesting differences between countries and variables. In terms of countries, Singapore and Malaysia appear to be the countries most influenced by external developments, with a share of variance of around 87% being accounted for by the exogenous variables. On the other end of the spectrum, the Philippines and India seem to be least affected by developments outside the country. The importance of external factors appears to have increased considerably over time, with the share of variance explained by the exogenous variables increasing from 57% to 75% in a more recent sample. Regarding the regional dimension of domestic developments, both the bilateral correlation analysis and the multilateral principal components analysis suggest that the extent of co-movement between structural shocks across the different countries in emerging Asia is relatively limited. The principal components analysis provides some evidence of a moderate increase in co-movement, in particular for demand and monetary shocks. However, if one looks at the correlation analysis co-movement appears to have declined. This difference in results may indicate that the strength of bilateral links between any two countries may have declined in the process of greater Asian regional integration, with the linkages now being spread more broadly across the region, thereby giving rise to a more broad-based increase in regional co-movement of structural shocks.

The remainder of the paper is organised as follows. Section 2 relates the present paper to the existing literature by reviewing relevant previous studies. Section 3 presents the methodology used, examining the identification restrictions employed in the empirical part, the set-up of the vector autoregressive models and the approach to identification. Section 4 briefly describes the data. Section 5 presents the results of the VAR analysis and analyzes the relative contribution of domestic and exogenous shocks to the dynamics of individual Asian countries. Section 6 contains the analysis of a possible regional dimension in the identified domestic shocks at the country level. Finally, section 7 contains some concluding remarks.

2. Review of the related literature

The present paper relates to two related strands of the literature. First, the literature on the influence of domestic and external factors on a country's economy, and second, the literature on cross-country linkages. Regarding the former strand, most relevant to the present paper is Canova (2003), who studies how US shocks are transmitted to eight Latin American economies. He uses the procedure of Canova and De Nicolò (2002) to identify US structural shocks by means of sign-restricted vector autoregressive (VAR) models, then following a Bayesian VAR approach to estimate their impact on Latin America. He finds evidence of a significant role of the US in affecting Latin American macroeconomic performance. This role is entirely driven by a financial transmission channel, with a large contribution of US monetary shocks, while US demand and supply shocks do not appear to have a significant impact. In their comparative study of Asian and Latin American countries, Hoffmaister and Roldós (1997) use a panel structural VAR for a number of domestic and external variables with both short-run and long-run identifying restrictions. They report that overall a single domestic shock (namely, the supply shock) dominates the macroeconomic behaviour of both Asia and Latin America, with the latter region being however somewhat more affected by external shocks. Among studies of Asian countries, Genberg (2003) uses a semi-structural VAR to analyse macroeconomic behaviour in Hong Kong. He finds that external factors account for around half of macroeconomic fluctuations in the short-run and become dominant in the medium to long run. In addition, Moon and Jian (1995), in their cointegrated VAR study of South Korea, analyse the behaviour of a series of domestic macroeconomic variables controlling for external variables such as foreign interest rates, prices and output. Both domestic and external factors are found to impact the Korean economy, with the authors stressing that world interest rates play a significantly larger role than domestic rates.

Regarding the second strand of the literature analysing cross-country interdependencies, a number of papers stand out as particularly relevant. Using a

Bayesian dynamic latent factor model, Kose *et al.* (2003) address separate world, regional and country-specific determinants of macroeconomic behaviour for 60 countries. In particular, they find that world factors are important determinants of business cycles, while regional effects appear to play only a limited role. Although their approach is powerful to uncover distinct geographical characteristics, the methodology cannot attach a structural interpretation to the decompositions involved. Ahearne *et al.* (2003) use a panel VAR analysis of export growth for several Asian countries. They find that foreign demand (measured by an average of major trading partners' GDP growth) dominates real exchange rate developments in explaining export dynamics. In addition, they show that Chinese exports have a positive impact on the exports of other Asian countries. Abeysinghe and Forbes (2001) and Abeysinghe and Lu (2003) employ a structural VAR model to study the interrelation between real GDP in Asian countries and foreign demand computed by using trade-weighted foreign GDP. This allows the authors to estimate direct and indirect impacts across countries. They find that China has a larger impact on its neighbours than all other Asian economies except Japan.[8] Using unobserved factor analysis, Zebregs (2004) finds that the common factor in emerging Asia business cycles dominates the country-specific factor, and that this common factor is more correlated with Japan than with the US and EU countries. Pesaran *et al.* (2004) propose a cointegrated VAR model for 26 countries grouped into 11 regions including domestic and foreign variables. These separate models are then linked in a global model identifying "historical" shocks by using generalised impulse responses as proposed by Pesaran and Shin (1998).

Taking the existing literature as a whole, relevant results on the role of domestic and external variables in driving macroeconomic developments in emerging market economies tend to vary. However, on balance, there appears to be some tentative evidence that external factors are of considerable importance, and even dominate domestic factors. For instance, Genberg (2003) finds that they are responsible for over 75% of business cycles in Hong Kong, and Canova (2003) estimates the corresponding share for Latin American countries at almost 90% - 50% being US-driven – on average. [9] Even for larger open economies, results have tended to attach a significant weight to external influences, as is the case in Cushman and Zha's (1997)

[8] Abeysinghe and Lu (2003) also show that the impacts across Asian countries have broadly increased over the period 1986-2000, with propagation from China intensifying the most.

[9] On the opposite side of the spectrum, Hoffmaister and Roldós (1997) find that, at the very maximum, external factors account for 20% and 30% of macroeconomic fluctuations in Asia and Latin America, respectively. However, their use of long-run identification restrictions a la Blanchard and Quah (1989) could be interpreted as biasing upwards the estimate of the share of (domestic) supply factors (see, for example, Faust and Leeper, 1997).

study on Canada. They find that the United States alone contributes over 70% to Canadian business cycle dynamics. Interestingly, deviating from the VARs used in all the studies mentioned in this paragraph, Kose *et al.* (2003) find that in both Asia and Latin America, macroeconomic fluctuations are largely explained by domestic factors, while extra-regional and especially intra-regional developments play a considerably more modest role.

3. Methodology

3.1 Model specification

We model each of the eleven East Asian economies individually using a four-variable VAR model. Concretely, we include industrial production as an activity variable, consumer prices to capture price developments and real money balances to capture the monetary side of the economy. As interest rates in many of the East Asian economies have been or are to some extent regulated, we opted for a quantitative measure of monetary conditions. As a fourth variable we include the real effective exchange rate as a measure of international competitiveness given the strong export orientation of the small open economies of East Asia. In addition, we include a number of exogenous variables in order to control for developments outside each country, which are assumed to affect the country but not vice versa. Concretely, these variables are a measure of economic activity outside East Asia, global interest rates, global equity prices and the price of oil and non-oil commodities.[10]

We can write the estimated reduced form model as follows:

$$y_t = A(L)y_t + G(L)x_t + \varepsilon_t \quad \text{with } \varepsilon_t \overset{D}{\sim} WN(0,\Sigma) \tag{1}$$

where y_t is a $n \times 1$ vector of domestic variables, x_t is a $k \times 1$ vector of exogenous global variables, ε_t is a vector of white noise errors, and $A(L)$ and $G(L)$ are polynomials of orders p and q, respectively.

When trying to model the East Asian economies one has to account in some way for the fact that the dynamics in some of these economies have been significantly affected by the Asian crisis 1997-1998. As commonly done in the literature, we try to capture this affect through the introduction of crisis dummies. We allow for a maximum of

[10] Of course, there are many more variables which might potentially be used to describe external influences. It appears however that these capture the main real, financial and commodities linkages, while at the same time keeping the model specification fairly parsimonious.

five consecutive dummy variables from 1997Q3 to 1998Q3. The selection of p and the set of Asian crisis dummies (if any) entering the VAR model is based on the value of the Akaike information criterion (AIC).[11] In order to preserve degrees of freedom, the exogenous variables enter the system only contemporaneously.[12]

3.2 Identification through sign restrictions

A number of approaches have been proposed to transform the reduced form model into a structural model whose dynamics are determined by economically interpretable shocks. One standard assumption is that these structural shocks are independent from one another. Thus the underlying structural model is:

$$\widetilde{C}y_t = \widetilde{A}(L)y_t + \widetilde{G}(L)x_t + \omega_t \text{ with } \omega_t \overset{D}{\sim} WN(0,\mathrm{I}) \tag{2}$$

From this it is immediately apparent that the two models (1) and (2) are linked as follows: $A(L) = \widetilde{C}^{-1}\widetilde{A}(L)$, $G(L) = \widetilde{C}^{-1}\widetilde{G}(L)$ and $\varepsilon_t = \widetilde{C}^{-1}\omega_t = C\omega_t$. Thus the structural model can be identified by imposing sufficient restrictions on the C matrix, taking into account that $CC^{-1} = CIC^{-1} = CE(\omega_t\omega_t')C^{-1} = E(\varepsilon\varepsilon') = \Sigma$. A common identification approach is to impose short-run impact restrictions on the structural shocks by restricting some coefficients of the C matrix to be zero. In particular, in many cases a recursive structure is assumed by restricting the C matrix to be lower triangular (Choleski decomposition). Existing dynamic macroeconomic theory provides a wealth of restrictions that can be used to identify shocks. Rarely, however, do these restrictions take the form of zero constraints on the impact multipliers. For example, Canova and Pina (1999) argue that the imposition of a zero impact restriction of monetary policy shock on output is inconsistent with a large class of general equilibrium monetary models.

In order to avoid some of these problems, restrictions on the long-run impact have frequently been employed following the seminal paper by Blanchard and Quah (1989). While such restrictions often have a better theoretical foundation, some potential inconsistencies with theory have been noted (e.g. Gali, 1992) and restrictions on the long-run in the presence of short samples can lead to important biases (Faust and Leeper (1997).

More recently, sign restrictions have sometimes been employed to recover the structural model (e.g. Canova, 2005; Uhlig, 2005; Peersman, 2005). While economic

[11] The Schwartz criterion generally suggested including only one lag in the specification.

[12] This choice is generally supported by the information criteria, in particular, the Schwartz criterion.

theory rarely provides zero restrictions, there are a number of fairly robust results regarding the direction of the reaction of various variables to certain shocks. For example, in most models a positive supply shock will result in a simultaneous decline in prices and increase in output.[13] In practice, it is more convenient to impose restrictions on the cross-product or cross-correlation of the responses than on the sign itself. For the case of a supply shock one would therefore restrict the responses of prices and output to be negatively correlated. Restricting the impulse response to structural shocks in such a way implicitly imposes restrictions on the C matrix which links the estimated reduced form shocks with the structural shocks and can thus be used for identification.[14] In contrast to the imposition of short and long-run zero restrictions, this identification approach in general does not lead to a unique identification. This is a reflection of the fact that the imposed restrictions are relatively general and weak, albeit more plausible. Typically, therefore some summary statistics of the set of impulse responses satisfying the sign restrictions are reported, such as the minimum, maximum and mean (or median). The more technical details of the implementation are described in Appendix A.

Concretely, we characterise the dynamics of the economy in terms of responses to the global variables as well as four domestic structural shocks: a supply (or technology) shock, a real demand shock (henceforth simply "demand" shock) and a monetary policy shock. In addition, we also allow for one other shock, but do not restrict the response of the variables to this shock, given the difficulty of coming up with plausible and robust restrictions from theory.[15] For the three identified shocks we impose the sign restrictions on the cross-products of the impulse responses. We build from previous work by Faust (1998), Canova and De Nicolò (2002) and Uhlig (2004) for advanced economies. A domestic supply shock yields negative co-movements between domestic output and domestic inflation while domestic demand and monetary shocks produce positive co-movements in domestic output and domestic inflation. We disentangle demand from monetary shocks by requiring that they

[13] Other features of the impulse response function can of course also be used for identification. For example, Peersman (2005) uses the restriction that the impact effect of an oil price shock on oil prices is stronger than that of a supply shock, thereby disentangling oil and supply shocks which otherwise share the same identifying sign restrictions.

[14] The sign-restriction approach is sometimes confronted with the criticism of circularity, as any analysis of the impulse responses of the identified system are seen as just reflecting the identification assumptions imposed for the purpose of identification. This is an issue for any identification scheme and is not particular to the sign restriction approach. For instance, it appears in the context of short-run restrictions, which are a priori assumed to be zero in some cases. It is worth saying that, in the case of sign-restricted VARs, one can still address the issue of magnitude of response, shape of the response and even the sign of the response in the case where no restrictions have been imposed on certain shocks and/or variables. Moreover, the data is allowed to reject the restrictions used, in which case no identification will be achieved.

[15] One could possibly interpret this shock as an exchange rate or competitiveness shock. It is however not clear how the other variables in the system should react to such a shock. We therefore let the data determine these responses and impose only a minimum set of plausible and robust identifying assumptions on the system.

produce negative and positive co-movements between real money balances and inflation, respectively. As theory is less clear on the effect of structural shocks on exchange rate fluctuations, we do not impose any restrictions on the response of the real effective exchange rate.

The sign restrictions referred to in the previous paragraph are in line with standard macroeconomic models. They do not only reflect the conventional wisdom as represented in macroeconomics textbooks (e.g. AS-AD framework), but also align with major strands of modern dynamic general equilibrium models. The restrictions are for example consistent with the theoretical impulse responses obtained from standard New Keynesian DSGE models. For example, Peersman and Straub (2006) set up a fully specified New Keynesian DSGE model with Calvo-type price and wage setting, wage and price indexation, habit persistence in consumption, capital adjustment costs and variable capacity utilisation. This model basically represents the widely used model by Christiano et al. (2005) and Smets and Wouters (2003). For the simulation of the impulse responses from this model the authors carefully select parameter values based on the existing empirical literature and check the robustness of their findings by varying the parameter values within reasonable ranges. The model dynamics are driven by seven different structural shocks: 3 real demand shocks (preference, government spending, investment), 3 supply shocks (price mark-up, technology, labour supply) and a monetary shock. All three supply shocks produce the negative correlation between the price and output response assumed for identification in the present paper. Furthermore the three demand shocks and the monetary shocks all produce equally signed impulse responses for output and prices. The real demand shocks and the monetary policy shock can be distinguished by the response of nominal interest rates, with the former three resulting in an increase, while the monetary shock is associated with a decrease.

Although we do not include interest rates into our specifications due to the special financial structure of the emerging Asian economies, we include real money balances as alternative measure of monetary conditions. An easing of monetary conditions is associated with an increase in money balances – also implied by a simple money demand function in response to a decline in interest rates – giving rise to a positive correlation between the impulse response to prices, output and money in the case of a monetary shock. In contrast, a positive real demand shock would result in a negative correlation between real money balances and both prices and output. This correlation pattern is confirmed by the limited participation model developed by Canova and De Nicolò (2002). In addition, it is also implied by Lucas' (1972) misperception model, New Keynesian models with micro-founded nominal rigidities as described in Clarida *et al.* (1999) and Woodford (2003), other limited participation models inspired in Christiano *et al.* (1997), and models of indeterminacy *à la* Farmer (2000).[16]

4. Data description

Our database consists of quarterly series for ten emerging Asia countries over the period 1979Q1-2003Q4. Appendix B contains a description of the data sources. The emerging Asia countries under study are China, Hong Kong, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand. Due to data availability constraints, these countries have different maximum sample periods (see Appendix C).

As mentioned in section 3, we use the following endogenous variables for each Asian country: industrial production as a measure of economic activity, CPI as a measure of domestic prices, M1/CPI as a measure of real money balances, and the real effective exchange rate. The exogenous variables that we use to capture global effects outside the emerging Asia region include indicators of world economic activity and interest rates, the MSCI global equity price index, as the price of Brent crude oil and an index for non-oil commodity prices. For global economic activity and interest rates, we use the G7 real GDP index computed by the OECD and US 10-year Treasury bill rates, respectively. We follow Canova and De Nicolò (2002) in detrending and seasonally adjusting all series using a linear regression on a linear time trend and seasonal dummies.[17] We do not model long-run relationships explicitly, even if they should be present in the data. We follow instead the now common practice of estimating the model in its level specification, while allowing – as mentioned above – for a sufficiently large number of lags. This can be justified on the ground that the alternative approaches of transforming the model to stationary form by differencing or imposing long-run relationships to handle stochastic trends may be unnecessary or even inappropriate (see e.g. Sims *et al.*, 1990).

[16] For further discussion, see, for example, the discussions in Canova and De Nicolò (2002) and (2003), and Canova and Pina (1999). Canova and Sala (2006) deal in some detail with the issue that a number of state-of-the-art models deliver similar predictions in terms of impulse responses to key structural shocks.

[17] The usefulness of more formal tests for non-stationarity is limited due to the short sample available for many countries. This is supported by the actual outcomes from formal unit root tests which we conducted. While tests based on the null hypothesis of non-stationary (e.g. augmented Dickey-Fuller, Phillips-Perron, Elliot-Rothenberg-Stock and Ng-Perron) fail to reject the null hypothesis for most variables, the Kwiatkowski-Phillips-Schnidt-Shin test, which is based on the null hypothesis of stationarity, fails to reject the null hypothesis as well for each individual variable. Thus the test results prove inconclusive as a result of the limited power of unit root tests. Visual inspection suggests that there is no compelling evidence of stochastic non-stationarity in the series employed.

5. The relative importance of domestic and exogenous shocks

We start by estimating the reduced form of the VAR model in (1) for each Asian economy. We then identify structural shocks using the approach outlined in section 3. Charts of the impulse response functions for the different countries (mean as well as 10% and 90% percentile) are shown in Appendix C. In order to assess the relative importance of external and domestic shocks for the evolution of the various variables, we perform a variance decomposition analysis.

With regard to estimation, the lag selection tests suggest optimal values of *p* equal to 2 in most cases. In the case of India and Indonesia 1 lag appears to be sufficient. In addition, we test for the significance of up to five dummies to capture the effect of the Asian crisis. The results depend crucially on the country considered, with no dummy being significant in the case of Hong Kong, India, the Philippines and Singapore, while, for example, in the case of Korea and Thailand four crisis dummies prove to be statistically significant (see Appendix C for details).

The results presented below cover two different sample periods for which the estimation is conducted, namely, a "full" sample period and a "recent" sample period. The reason for this distinction is that we want to assess whether our results are robust to the sample period used in the estimations. In particular, we are interested to see whether Asian countries have become more or less dependent on external factors over time. The "full" sample period is simply based on the maximum available for each country (see Appendix C). In general, the "recent" sample period starts in 1990Q1. Only in the case of China, Indonesia and Thailand the sample starts in 1996Q4, as otherwise the difference between the full and recent sample would have been too small.

The variance decomposition results for the maximum sample available for each country are reported in Table 1 in Appendix D. The variance decomposition is calculated at a horizon of 12 quarters. Overall, the results show that the East Asian economies are predominantly driven by external factors. On average, across all variables and all countries external factors account for somewhat more than half of the error variance (57%). The four domestic shocks account each for a similar share of around 10-11%. These average results mask, however, interesting differences between countries and variables.

In terms of countries, Singapore and Malaysia appear to be the countries most influenced by external developments, with a share of variance of around 87% being accounted for by the exogenous variables. On the other end of the spectrum, the Philippines and India seem to be least affected by developments outside the country, with shares below 40%. These results conform to some extent with *a priori* expectations given Singapore's and Malaysia's strong export orientation and India's status as a large and relatively closed economy and the relatively low degree of integration into the global economy of the Philippines, at least in the early part of the sample. In general, there appears to be however only a very loose connection between traditional measures of external dependence and the share of variance explained by external factors. Nonetheless, the correlation between the ratio of exports to GDP, one such measure, and the share of variance attributed to external variables is relatively high (almost 70%). For a number of countries however some notable differences arise. For example, in the case of Taiwan the export-to-GDP ratio would suggest a relatively high external dependence, broadly in line with that of Thailand. However, while the average variance explained by external factors is around 55% in the case of Thailand they account for "only" 42% in the case of Taiwan, making it one of the countries least dependent on external developments.

A number of factors may help to account for such differences between identified VAR-based measures of external dependence and more traditional trade ratios. First, a considerable share of trade by Asian countries is processing trade with the actual value added contained in exports being only a fraction of the overall export value. Thus a large share of exports does not necessarily imply a strong dependence of the economy on external factors. Second, measures of trade openness narrowly focus on trade as the main link through which a country interacts with the rest of the world. In comparison, the present methodology includes a number of other factors such as financial linkages and indirect effects through commodity prices, thus providing a more comprehensive measure of external dependence. Third, measures of trade openness basically assume similar volatility of external and domestic shocks. However, in the case that domestic shocks have a high variance relative to external shocks even a country with a high trade-to-GDP ratio may be heavily dependent on domestic factors in explaining shorter-term business cycle fluctuations. Lastly, the validity of the structural VAR analysis depends of course crucially on the quality of the underlying data. This may for example be a relevant issue in the case of China, whose dependence on external shocks is relatively large compared to the ratio of exports to GDP or other measures of the countries openness. In general, it seems however that a VAR-based analysis of dependence on external developments can provide a much more comprehensive and accurate measure of the relative importance of external and domestic factors for a country's cyclical dynamics.

Regarding the different variables, the importance of external factors appears to be particularly relevant for the CPI, with the average share of variance being close to 70%. External factors are on average least relevant for the dynamics of real GDP, although even in this case they explain slightly more than half of the forecast variance.

The importance of external factors appears to have increased considerably over time, as suggested by the estimation results for the recent sub-sample (see Table 2 in Appendix D). The share of variance explained by the exogenous variables – averaged over all countries and all endogenous variables – increases from 57% to 75%. The increase has been relatively similar for the different variables, with that for the CPI being somewhat less pronounced, reflecting perhaps the already high level for the full sample.

Regarding the different countries, the increase has been particularly pronounced in the case of Indonesia, Korea, the Philippines and Thailand, with the share of variance explained by external factors increasing in all cases by more than 30 percentage points. In contrast, the increases have been relatively small in the case of Malaysia, Singapore and Taiwan. In the case of Malaysia and Singapore this could perhaps be explained by the already high values for the external dependence in the full sample, leaving less room for large increases in any sub-sample. In the case of Taiwan the relative small increase might in part explained by the relatively high level of development and integration into the global economy reached already at the beginning of the full sample. Interestingly, the overall correlation between the share of variance explained by external factors and the export-to-GDP ratio declines significantly – to 37% - in the more recent sub-sample. This increased de-coupling of the two indicators suggests that structural changes have reduced the information content of trade-based openness indicators even further, possibly reflecting the increasing importance of other channels of international transmission or the increasing prevalence of processing trade in the Asian region.

6. The regional dimension of domestic shocks

The external variables included in the preceding analysis were largely global variables or variables capturing developments outside the Asian region. As increasing intra-regional integration may increase the exposure of individual countries to developments specific to the region, such effects may be important and increasing over time. In order to assess whether Asian countries are affected by regional factors, we analyse the domestic shocks in greater detail. In particular, we are interested in the co-movement between structural shocks across different countries in the region. Increasing integration may, for example, imply that domestic demand shocks may be shared by a number of countries. Concretely we analyse co-movement on a bilateral basis (correlation analysis) and a multilateral basis (principal component analysis). This analysis is conducted for different time periods in order document how co-movement has changed over time. This analysis also provides a robustness test of whether the shocks that have been identified as domestic in the preceding analysis are truly domestic or whether they contain in addition a significant regional element. This approach is related to the strand of the empirical literature on optimal currency areas initiated by Bayoumi and Eichengreen (1992), which uses the correlation of identified structural shocks obtained from identified VAR models to assess the suitability of a common currency for groups of countries. While we do not intend to make any inferences about optimal currency areas, we use a similar methodology to detect regional dimensions in structural shocks from country-level VARs, with the important improvement of rendering the results more robust by using a less restrictive identification scheme.

Given the differences in data availability (and lag structures) we analyse different sample periods for different groups of countries. The longest time period starting in 1980:3 is available only for four countries: India, Korea, Malaysia and Taiwan. Restricting the sample to start in 1986:3 Hong Kong, Indonesia and the Philippines can be added, resulting in a sample of 7 countries. The sample of the entire cross-section of 10 countries is available only starting in 1991:4, the starting date of the Chinese data. In addition to these "full" sample results we also consider shorter and more recent samples, starting in 1991:1 for the 7-country sample and in 1996:1 for the 10-country sample.[18] The results for the cross-country correlation between the three identified structural shocks (demand, supply and monetary) are contained in Appendix E, with correlation coefficients that are significant at the 5% level highlighted in bold and italics.[19]

Regarding supply shocks (Tables E1 and E2), it appears that cross-country correlation is relatively limited and declining over time.[20] Malaysian supply shocks are

[18] We do not include an additional short sample for the long 4-country sample as such results are in effect contained in the long and short samples of the larger cross-section samples.

[19] In Tables E1 to E6 we only report results for correlation among the same shocks, i.e. supply-supply, demand-demand and monetary-monetary. Our main conclusions are not affected by also looking at cross-country correlations across different shocks – e.g. between supply shocks in country A and demand shocks in country B. These results are available upon request.

[20] A relatively limited cross-country correlation between supply shocks is consistent with the structural differences documented in Sánchez (2005) for emerging East Asian countries, including rather diverse conditions in production structures, technological development and commodity composition of international trade.

significantly and positively correlated with supply shocks in India, Taiwan, the Philippines and Indonesia. The correlation becomes however insignificant over time. Supply shocks in the Philippines also show significant correlation with those in several other countries (India Malaysia, and Korea), with the correlation pattern however not being stable over time. Concentrating on the newly industrialised economies, we find very little significant correlation. Supply shocks in Korea and Taiwan are negatively correlated, possibly reflecting the competitive relationship between the two economies. In the short sample encompassing all countries, only one correlation coefficient remains significant (between the Philippines and Indonesia).

Turning to demand shocks, again the prevalence of significant cross-country correlation seems to be relatively low. However, in contrast to the case of supply shocks the importance of such correlation appears to have increased somewhat over time. In the case of the longest sample of four countries no correlation coefficient proves significant. For a few countries significant correlation is found with more than one other country: Indonesia (with Taiwan, the Philippines, Hong Kong and Singapore), Taiwan (with Malaysia, Korea, the Philippines, Indonesia, Singapore) and Singapore (with India, Taiwan and Indonesia). Demand shocks in China exhibit significant (positive) correlation only with those in one other country, Korea, possibly reflecting the strong production links between the two countries.

Monetary shocks exhibit relatively little cross-country correlation, with no clear trend over time. Only monetary shocks in China, India and Taiwan are significantly correlated with monetary shocks in more than one other country, but this significance is not robust to changes in the sample length. The only significant correlation that lends itself to a reasonable interpretation might be the positive one between monetary shocks in Taiwan and Korea, reflecting perhaps the focus on exchange rate developments and the close link with the US dollar which results in similar monetary policy reactions. Perhaps somewhat surprisingly this effect disappears in the shorter samples. One might also have expected to find some stronger links between monetary policy shocks given the widespread use in the region of the US dollar as an anchor. This is however possibly reflected more in the systematic component of monetary policy which is not captured by the structural shocks.

In general, the correlation results suggest that the degree of bilateral co-movement among country-specific structural shocks in Asia is relatively low. Comparing the different shocks it seems that cross-country correlation is most important in the case of demand and supply shocks, with the co-movement of monetary shocks being significantly less pronounced. However, even in the case of demand and supply shocks the importance of co-movement appears to be declining over time, especially in the case of supply shocks.

While cross-country correlation can identify co-movements between pairs of countries, it is not well-suited to study the general co-movement within the region as a whole. We therefore perform a principal component analysis for the different structural shocks. We conduct the analysis for a large cross-section sample, including all countries except China with a sample period from 1989:3 to 2003:4.[21] In addition, we also consider a smaller cross-section including Hong Kong, India, Malaysia, the Philippines, Korea and Taiwan, for which the sample period extends from 1982:3 to 2003:4. In order to study again possible changes over time, we use also shorter samples in both cases starting in 1996:1 and 1992:4, respectively.

Overall the results from the principal components analysis suggest that the degree of co-movement among structural shocks within Asia is relatively low (see Chart 1). Between 20% to 30% of the variance of the structural shocks is explained by the first factor, going up to around 40% for the first two factors cumulated. This compares to a share of variance explained by the first component of over 30% for the eleven euro area countries analysed by Bayoumi and Eichengreen (1992) and of around 50% for the U.S. regions. The difference between the various structural shocks is relatively small. Regional co-movement appears most important in the case of supply shocks followed by demand shocks and monetary shocks (see Chart 1a). The importance of co-movement in the case of supply shocks is confirmed in the longer sample with the more restrictive country coverage. However, the relative ordering of monetary and demand shocks is reversed with demand shock exhibiting the lowest degree of co-movement.

Regarding possible changes over time Charts 1b to 1d depict the cumulative variance explained by the principal components for the three identified structural shocks over the long and the short sample period for the extensive country coverage. It appears that co-movement has declined somewhat in the case of supply shocks, as the share of variance explained by the first component drops from almost 30% to 22%. However, in the case of the more restrictive country sample extending back to 1982 this result is overturned, with the degree of co-movement increasing marginally over time. In contrast co-movement appears to have increased over time for demand and monetary

[21] We exclude China, as its inclusion would have been too costly in terms of the number of observations foregone. In addition, the dynamics of the Chinese economy are *a priori* believed to be relatively independent from the other countries in the region, as for example also suggested by the correlation analysis.

shocks, with the result being robust across the different samples, although somewhat less pronounced in the smaller country sample.

Chart 1: Principal components analysis of structural shocks (cumulative variance proportion explained)

Chart 1a: Supply, demand and monetary shocks – long sample

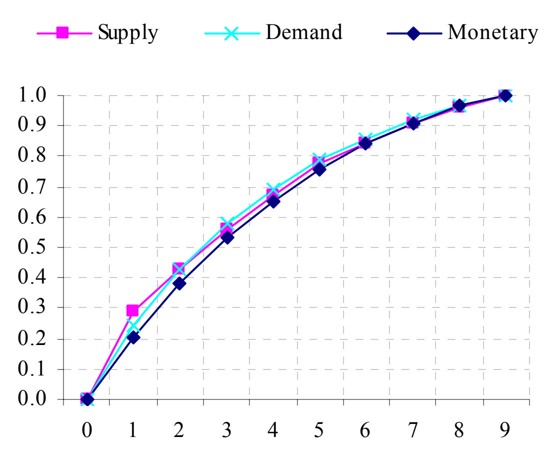


Chart 1b: Supply shocks – different sample periods

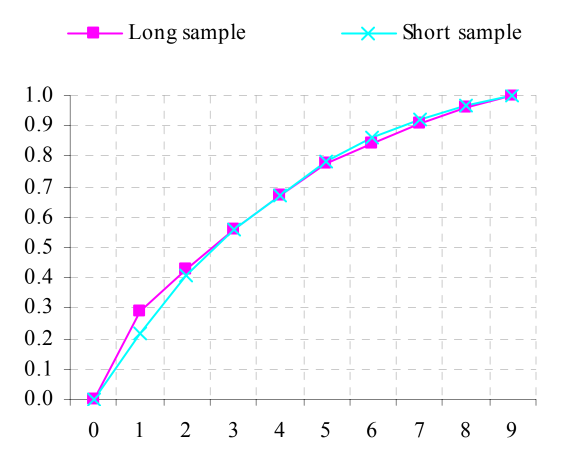


Chart 1c: Demand shocks – different sample periods

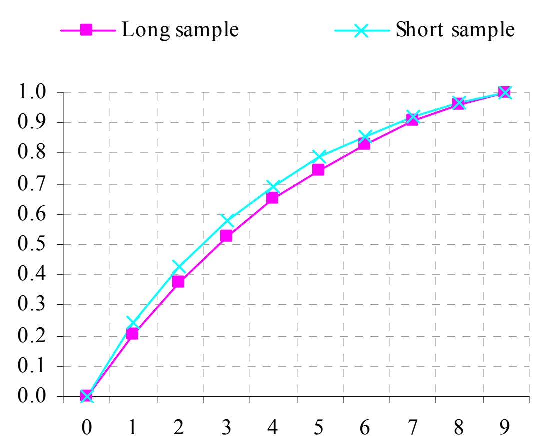
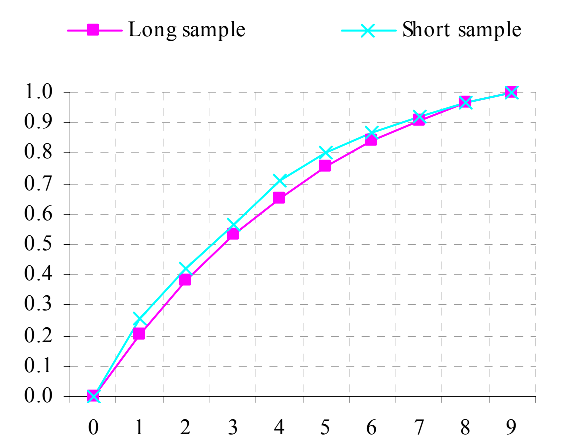


Chart 1d: Monetary shocks – different sample periods



Note: The sample consists of all countries except China. The long sample is 1989:3 to 2003:4 and the short sample is 1996:1 to 2003:4.

Overall, both the bilateral correlation analysis and the multilateral principal components analysis of suggest that the extent of co-movement between structural shocks across the different countries in emerging Asia is relatively limited. The principal components analysis provides some evidence of a moderate increase in co-movement, in particular for demand and monetary shocks. However, if one looks at the correlation analysis co-movement appears to have declined. This difference in results may indicate that the strength of bilateral links between any two countries may have declined in the process of greater Asian regional integration, with the linkages now being spread more broadly across the region, thereby giving rise to a more broad-based increase in regional co-movement of structural shocks. These results also confirm that the domestic structural shocks that we have identified are indeed primarily true domestic shocks, exhibiting only a relatively small regional component.

7. Concluding remarks

The analysis in this paper shows that the dynamics of the individual Asian economies are largely determined by developments outside the region, with the dependence on external factors having, in fact, even increased over time. Although the impressive growth record of Asian countries over recent decades is likely to have strengthened domestic demand in the region, which therefore may have become a more important driver of these economies, this strengthening has not been sufficient to offset the even stronger increase in the exposure to developments outside the region that took place in the context of the concomitant rapid integration of Asia into the global economy. This finding may reflect the particular developments strategy of many of these economies, relying on strong export growth supported by stable and, in some cases, undervalued exchange rates. Efforts by various governments in the region to shift to a more domestic demand led growth strategy do not appear to have shown any tangible results yet or may have been too recent as to affect the estimation results significantly. These results therefore also cast some doubt on the proposition that Asia may be able to become an important engine of growth for the global economy, as the regional fortunes still appear to be mainly determined by what is happening elsewhere rather than the other way around.

The role of Asia as potential global growth engine would be strengthened, if the regional economies exhibited a strong inherent tendency to move in unison, given the still relatively small economic size – relative to the global economy – of many of the Asian countries individually, with the exceptions of China and India of course. However, as the correlation and principal component analysis of structural shocks has shown, there is only limited co-movement between domestic shocks. Thus the significant regional co-movement of economic activity, which has been found by a number of empirical studies, appears to be largely the result of the synchronising effect of common external shocks, rather than regional shocks or spill-overs which might alternatively explain such co-movement. This interpretation is also consistent with the study by Moneta and Rüffer (2006), which finds that Asian synchronisation is mainly explained by common shocks and only to a much smaller extent by inter-regional spill-over effects.

The increasing fragmentation of the production process, which reduces the domestic value-added content of a country's exports renders the use of traditional measures of trade openness or the external exposure increasingly less useful, with this issue being particularly relevant in the case of Asia. In addition, traditional measures such as trade-to-GDP ratios fail to take into account the different degree of volatility of domestic and external shocks, with a relatively closed economy – traditionally measured – may still be strongly influenced by external developments if the domestic shocks are small relative to external ones. Furthermore, economic integration has been particularly rapid in the area of financial markets, thereby giving rise to non-trade economic linkages between economies, which are note captured by trade-based openness measures. Against this background, the VAR-based methodology presented in this paper offers an attractive alternative measure for the relative importance of domestic and external shocks. The present methodology which employs sign restrictions to identify structural shocks appears particularly useful, as it relies on a set of relatively weak identifying restrictions and thus does not suffer from the potential robustness problems of often implausible short-term and long-term exclusion restrictions traditionally employed.

A number of avenues for further research on the drivers of Asian growth dynamics can be envisaged. At a rather general level, other measures of domestic and global macroeconomic behaviour could be used. For example, it would be worth employing alternative and possibly broader measures of domestic economic activity, including real GDP developments in those countries for which data availability over a reasonably long period is not an issue. Still at the domestic level, other monetary aggregates and interest rate data could be used to alternatively gauge the characteristics of the monetary transmission process. At the global level, alternative measures of economic activity could be employed, including trade-weighted real GDP using country-specific and time-varying weights in the computation. Although the degree of co-movement among structural shocks appears to be relatively low, it would be interesting to study the regional aspects in more detail, for example, by including cross-country interactions directly into the modelling strategy. In addition, it would be interesting to study the similarity of responses to the various structural shocks and possible changes therein over time.

Appendix A. Identification algorithm and decomposition choice

This appendix provides some more technical background information on the identification method. The basic problem in applying sign restrictions for identification purposes is that one has to search for structural models which satisfy the sign restrictions among all structural models consistent with the reduced form model. In principle, there is an infinite number of such structural models. If C satisfies $CC' = \Sigma$, then the same holds true for $\hat{C} = CJ$, with J being any orthogonal matrix, since $CJJ'C' = CIC = CC' = \Sigma$.

All applications of the sign restriction methodology use a parametrisation of the space of possible decompositions. Starting with any arbitrary structural decomposition C_{start}, such as a Choleski decomposition, one can span the entire decomposition space with the matrix $C_{start} J(\Theta)$, where Θ is a $\left(\frac{n(n-1)}{2} \times 1\right)$-vector of parameters θ_i and n being the dimension of the VAR.[22] In the case of a four-variable VAR the following holds:

$$J(\Theta) = \prod_{a,b} J_{a,b}(\theta) = J_{12}(\theta_1) \times J_{13}(\theta_2) \times J_{14}(\theta_3) \times J_{23}(\theta_4) \times J_{24}(\theta_5) \times J_{34}(\theta_6),$$

where $J_{ab}(\theta)$ is defined as:

$$J_{ab}(\theta) = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & \cos\theta & 0 & -\sin\theta & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & 1 & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & \sin\theta & 0 & \cos\theta & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

where (a,b), a ≠ b, denote the rows (or columns) of J and $\theta \in [0;2\pi[$. $J_{ab}(\theta)$ represents a bivariate rotation of the J matrix where rows a and b are rotated by the angle θ_i. By varying the different angles θ_i simultaneously it is possible to span the entire space of decompositions.

In order to implement this approach in practice, one needs to restrict attention to a countable – but sufficiently large - subset of all possible decompositions and find

[22] See Press (1997).

those for which the associated impulse response functions satisfy the sign restrictions. There are two popular approaches for this. One approach, followed by Canova (2005) and Peersman (2005) is to divide the interval $[0;2\pi[$ into a grid of fixed width. The other approach is to randomly draw parameter values from a uniform distribution for the individual θ_i.[23] In this paper we follow the first approach, choosing the fineness of the search grid such that a sufficiently large number of decompositions with the desired sign properties for the associated impulse responses is found. We explore a minimum of 15625 (=5^6) and a maximum of 2985984 (=12^6) rotations.

We use the eigenvector-eigenvalue decomposition of the estimation variance-covariance matrix as starting matrix C_{start}. Let P be a matrix of eigenvectors of Σ and D a diagonal matrix of eigenvalues. We can then write $PDP' = \Sigma$. Given that Σ is real symmetric positive definite, there exist a unique P and a unique matrix D with positive entries along the principal diagonal. D defines a unique diagonalisation of Σ into an orthonormal base of eigenvectors. A further step produces $PD^{1/2}D^{1/2}P' = PD^{1/2}\left(D^{1/2}\right)'P' = PD^{1/2}\left(PD^{1/2}\right)' = \Sigma$, where decomposition $C_{start} = PD^{1/2}$ yields uncorrelated shocks without imposing any zero restrictions.

For each of the computed decompositions, we check whether the associated impulse response functions satisfy the sign restrictions on the cross products. This yields decompositions with an economically interpretable supply, demand and money shock. The fourth shock generally is a shock for which the sign restrictions do not hold. In some cases the fourth shock, however, turns out to also satisfy the same restrictions as one of the other structural shocks. Thus in some relatively rare cases the dynamics of the system are determined by two uncorrelated supply, demand or monetary shocks. In generally, we impose the sign restrictions on the first six quarters of response and decrease, if necessary, the grid size in order to generate a sufficient number of rotations satisfying the sign restrictions. In those cases where the maximum number of rotations of almost 3 million is not sufficient to generate enough meaningful results, which the case mainly for the short sample period, we reduce the number of periods for which the sign restrictions have to hold until we obtain a satisfactory number of identified rotations.

[23] As the sample size is increased – either through increasing the number of draws or by using a finer grid – the two results generated with the two methods become increasingly similar.

Table A.1. Identification of structural shocks – key parameters

	Full sample			Sub-sample		
	Grid	Periods	Rotations	Grid	Period	Rotations
China	8	6	110	11	3	143
Hong Kong	5	6	290	9	6	138
India	7	6	169	11	5	99
Indonesia	10	6	172	12	3	706
Korea	5	6	622	7	3	533
Malaysia	8	6	126	12	3	1650
Philippines	6	6	540	12	3	126
Singapore	12	4	98	5	3	316
Taiwan	5	6	1369	9	5	222
Thailand	5	6	157	12	3	70

Note: The grid specifies the number of intervals into which the range from 0 to 2/ is divided; the periods specify the number of quarters over which the correlation patterns is expected to hold; the rotations is the number of rotations satisfying the sign restrictions over the specified number of periods and using the given grid.

To characterise the identified set of impulse responses we report the mean/median response and the 10% and 90% percentile of the responses. As the summary statistics are calculated separately for each variable and each horizon, the reported impulse responses do not necessarily correspond to any concrete rotation and the corresponding errors are not necessarily uncorrelated. Although the reported responses provide nonetheless a useful description of the entire set of responses, an alternative approach needs to be chosen for the purpose of calculating the shock correlations in Section 5. For that purpose some type of criterion function needs to be chosen for selecting a particular rotation (see e.g. Uhlig, 2005). We adopt the approach recently proposed by Fry and Pagan (2005) who suggest using the rotation which produces that minimum squared deviation of the impulse response from the "hypothetical" mean or median response. In general, these turn out to be fairly close to the mean or median response.

Appendix B. Data sources and samples used for different countries

We measure economic activity in emerging Asia countries by using industrial production data, which is available for all of them and obtained from IFS except for China, Hong Kong and Taiwan (national statistics). CPI is from IFS except for China, Hong Kong and Taiwan (national statistics). Real effective exchange rate series are from IFS for China, Malaysia, Philippines, and Singapore. For the other countries they are not available in IFS, so we take them from JP Morgan. For money supply, we use M1 series from IFS except for China where we use OECD's *Main Economic Indicators*. We do not consider M1 data for Hong Kong and Taiwan because they are not available for a long enough period. Moreover, we employ M2 data from national statistics. Concerning global variables, world economic activity is measured in terms of G7 real GDP index from OECD quarterly national accounts. Brent oil prices in US dollars are from IFS. Non-oil commodity prices in US dollars are from the Hamburg Institute of International Economics (HWWA), and are computed using OECD countries' weights. The MSCI equity price index is provided by Morgan Stanley Capital International.

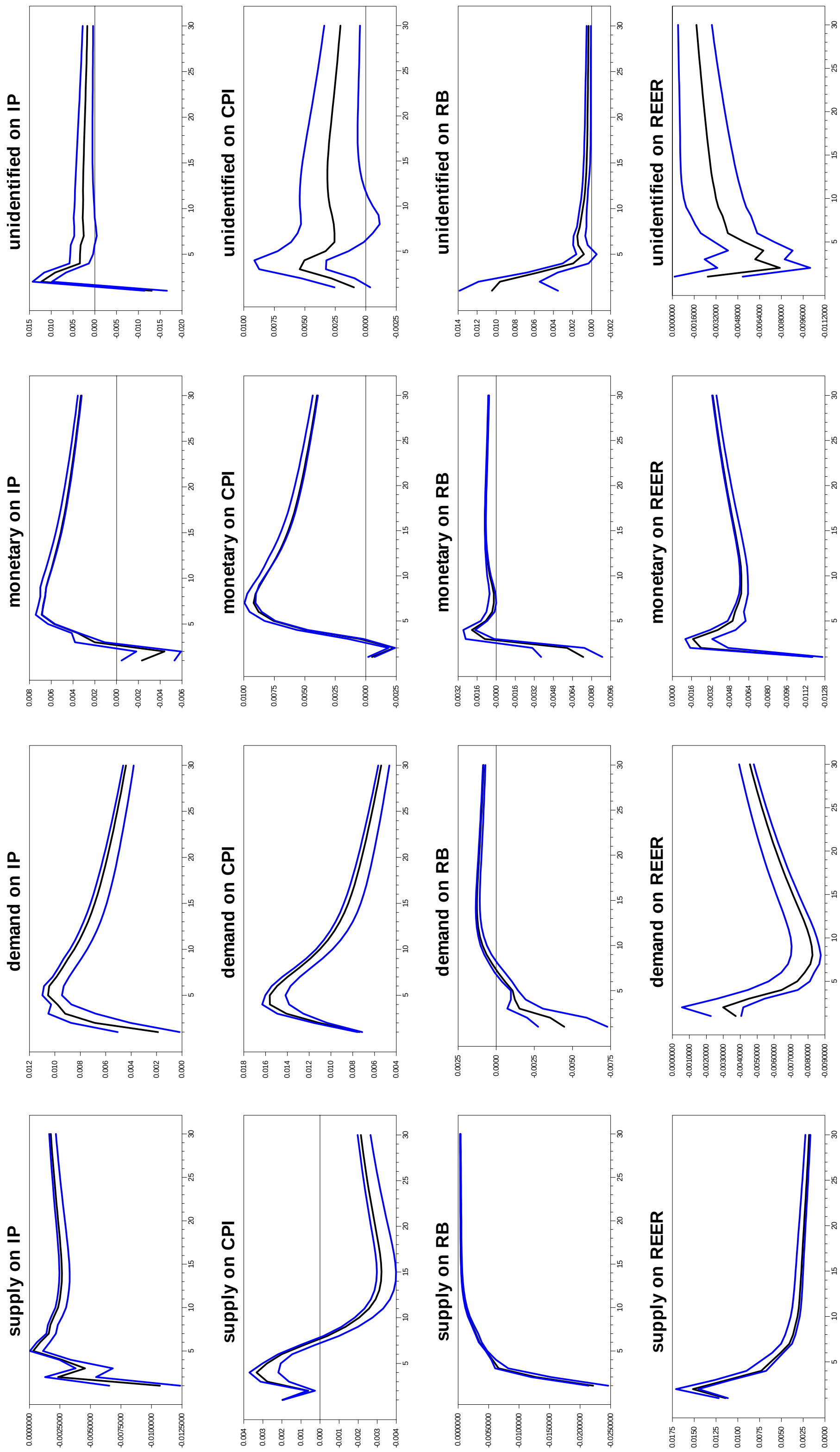
Appendix C. Samples used for different countries and impulse response functions

Given that not all countries offer the same data availability over the period 1979Q1-2003Q4, we work with a shorter sample size for most countries (see Table C.1 below).

Table C.1. Sample period and VAR specification for each Asian country

	Sample period	Lags	Crisis dummy				
			1997Q3	1997Q4	1998Q1	1998Q2	1998Q3
China	1991Q1-2003Q4	2			x		
Hong Kong	1982Q1-2003Q4	2					
India	1979Q1-2003Q4	1					
Indonesia	1986Q1-2003Q4	1	x		x		x
Korea	1982Q1-2003Q4	2		x	x	x	x
Malaysia	1979Q1-2003Q4	2		x	x		x
Philippines	1981Q1-2003Q4	2					
Singapore	1980Q1-2003Q4	2				x	
Taiwan	1979Q1-2003Q4	2					
Thailand	1987Q1-2003Q4	2	x		x	x	x

China



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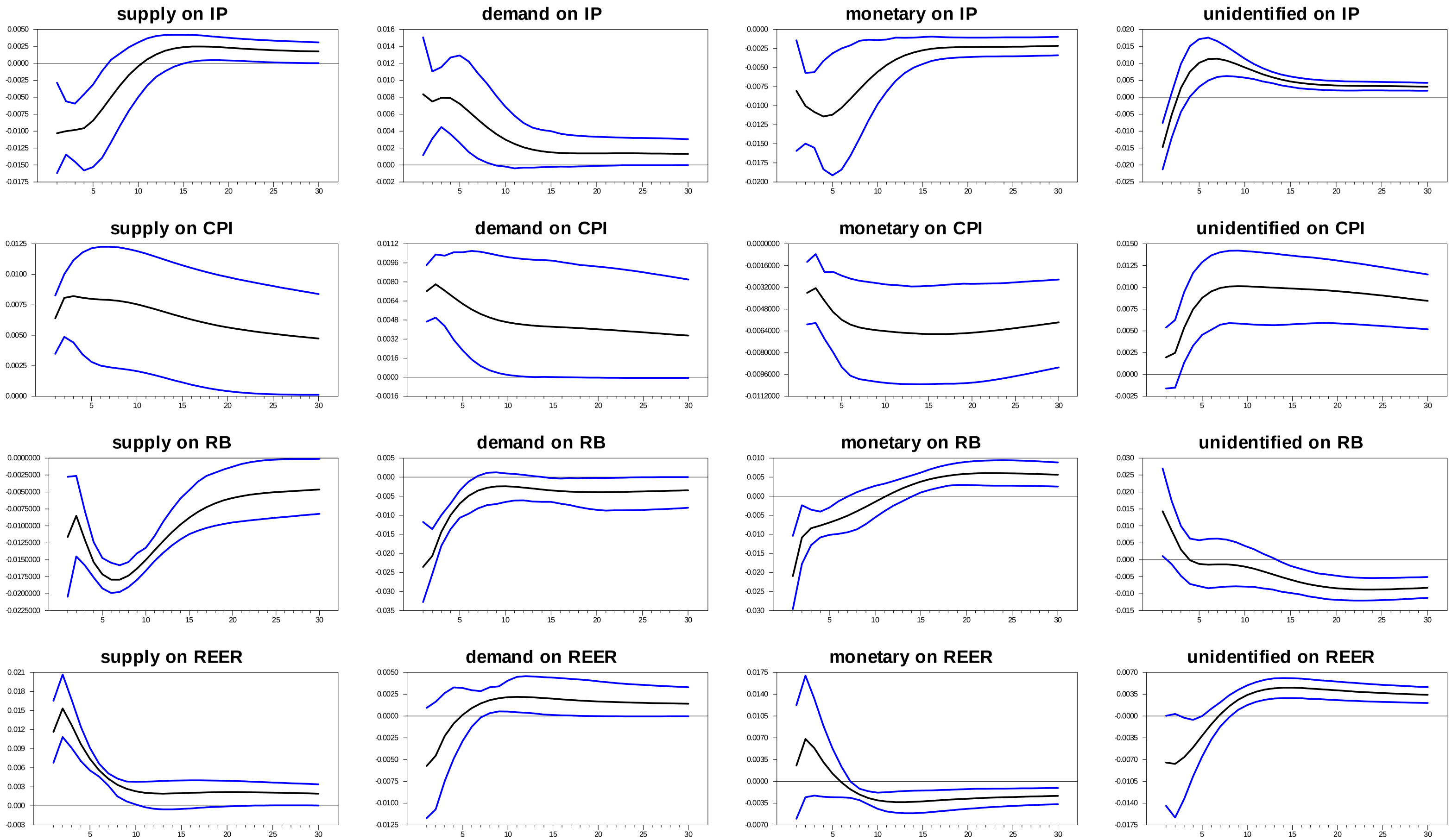

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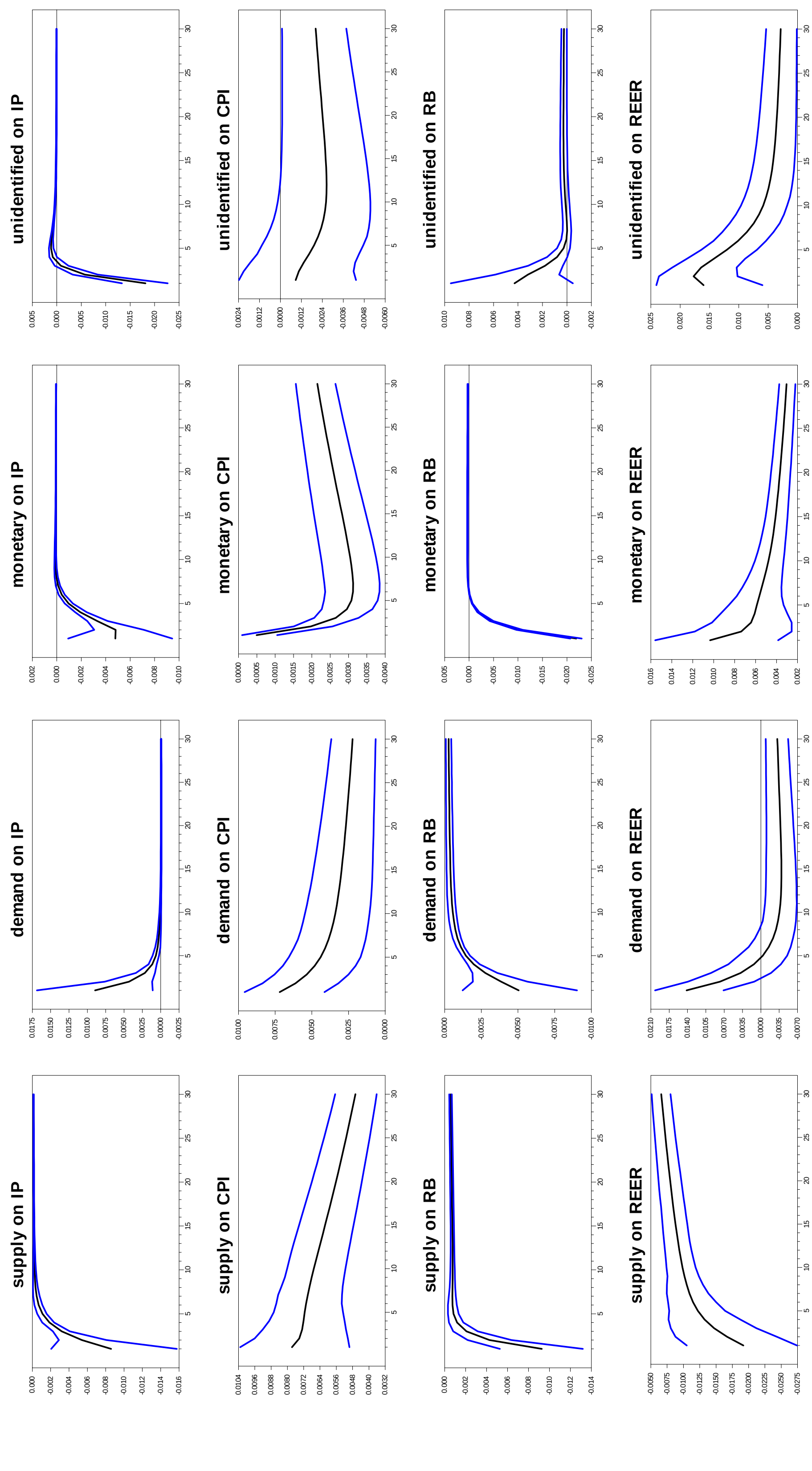
India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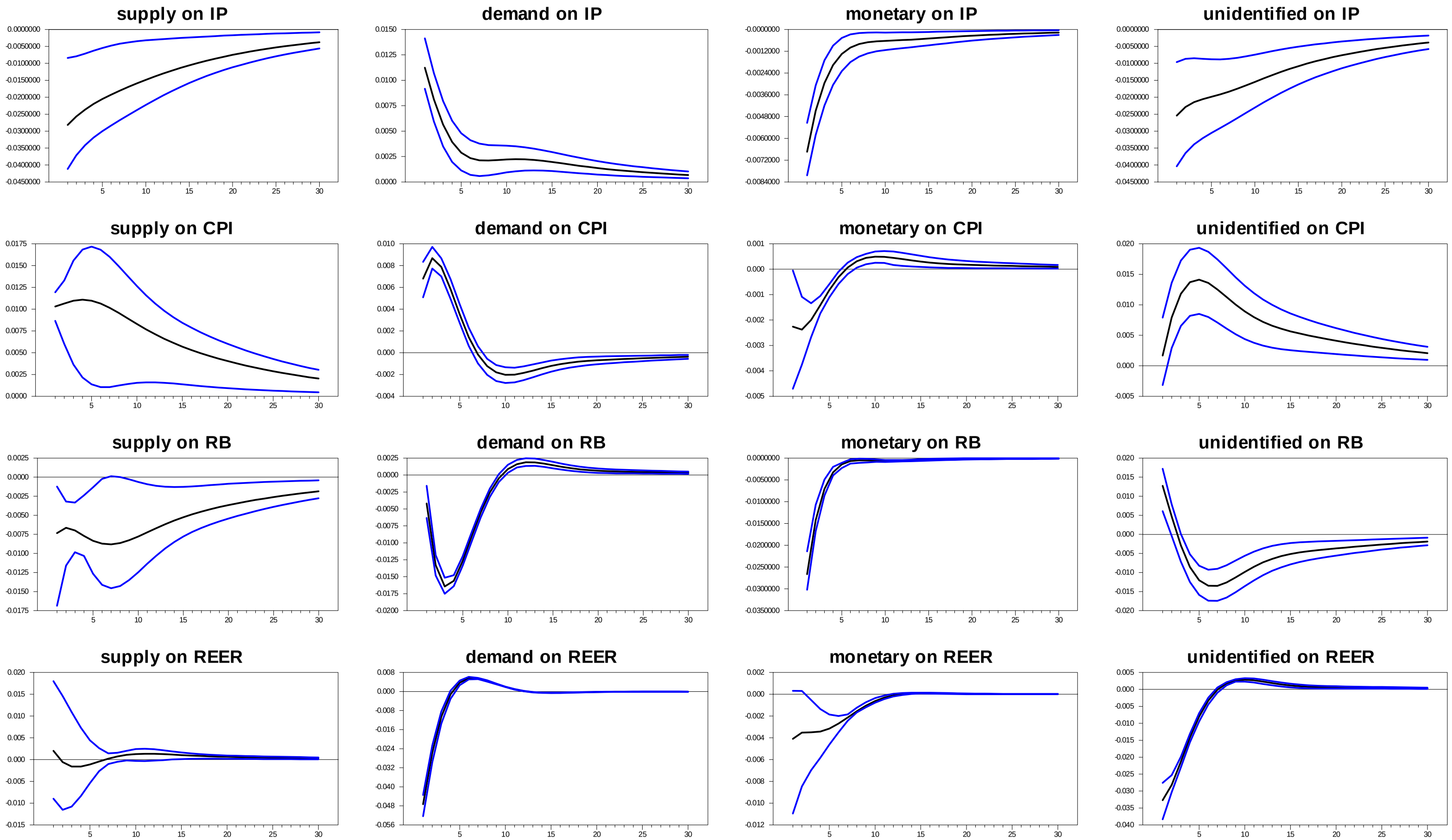
Indonesia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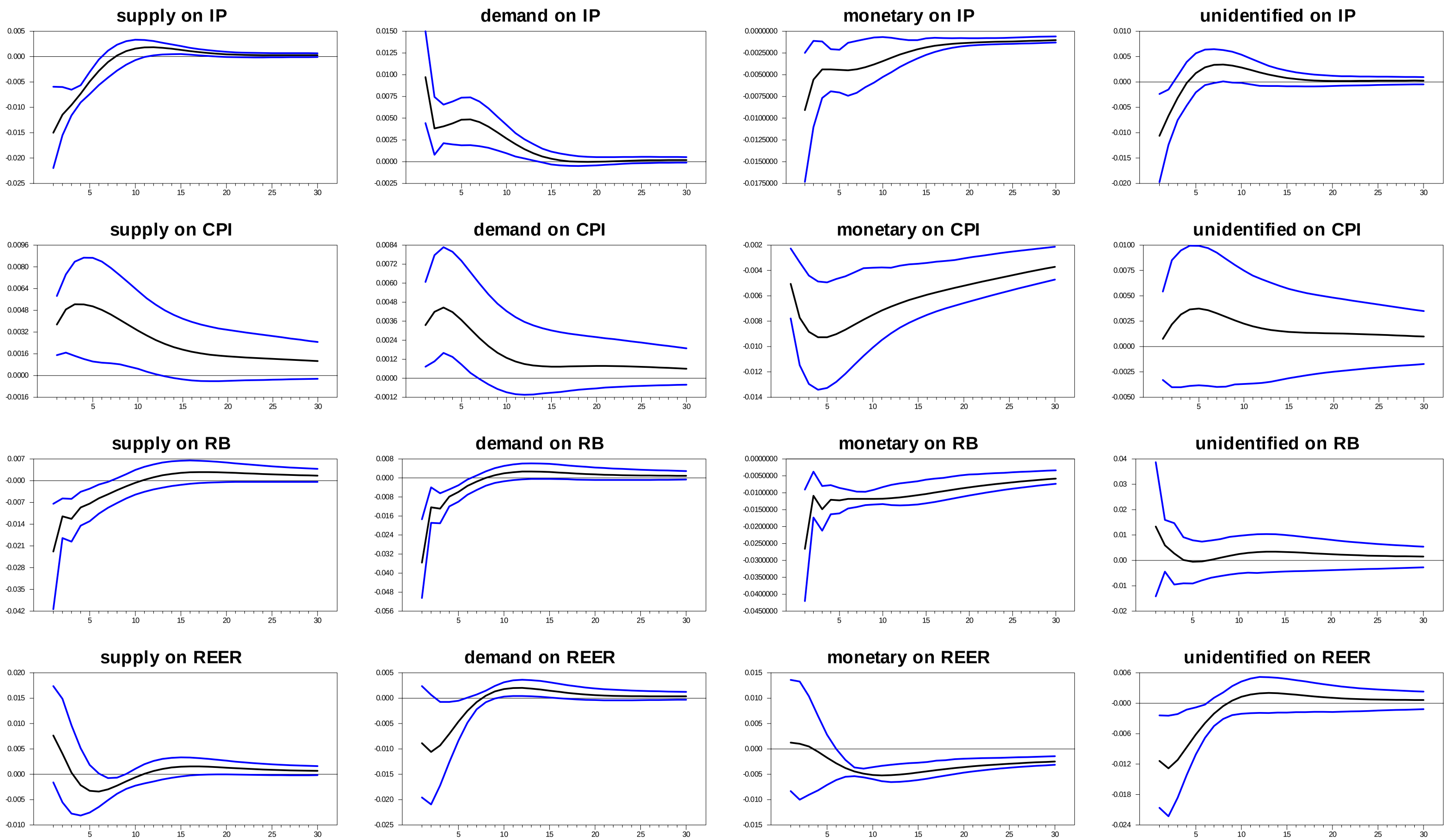
Korea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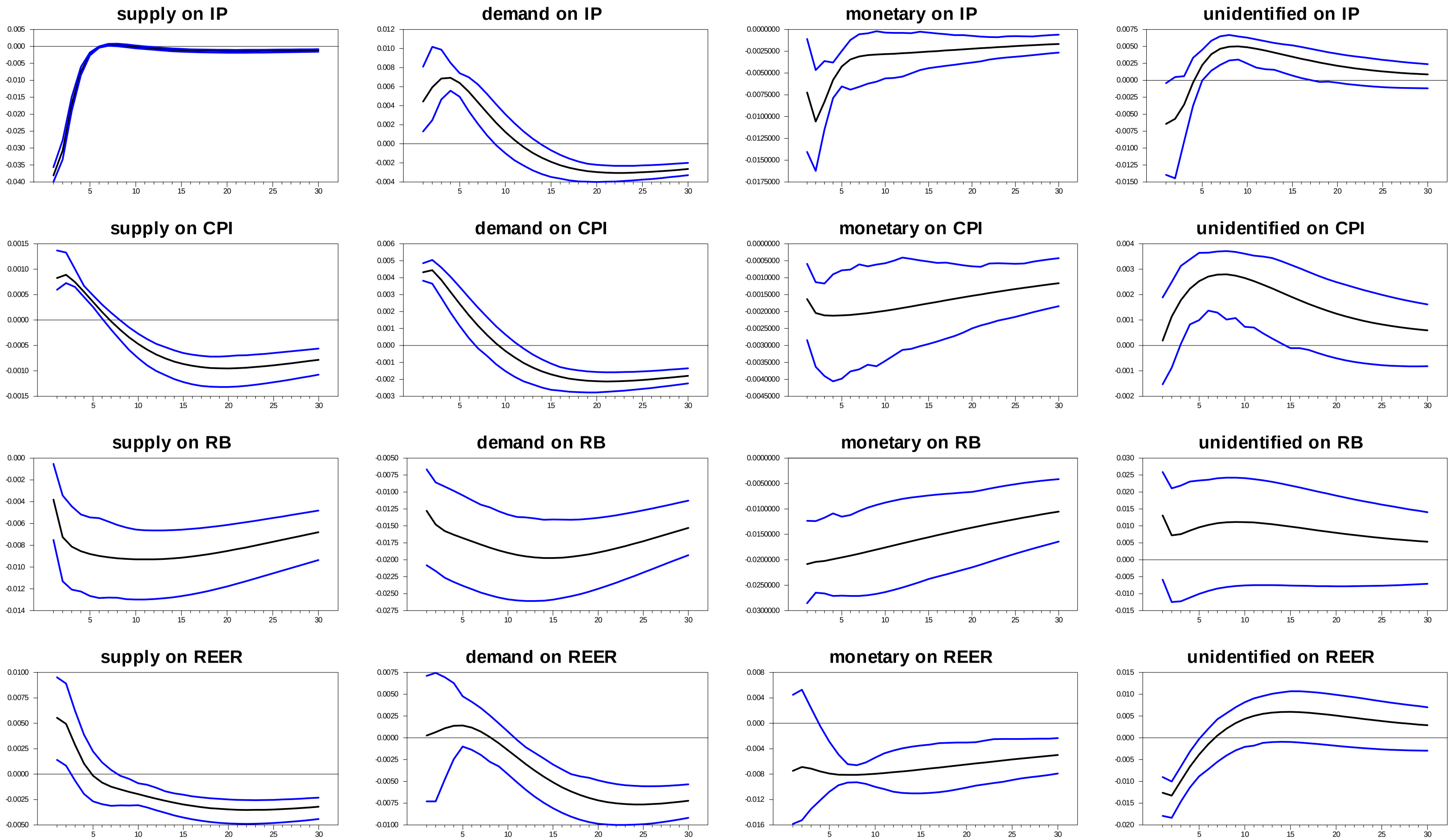
Malaysia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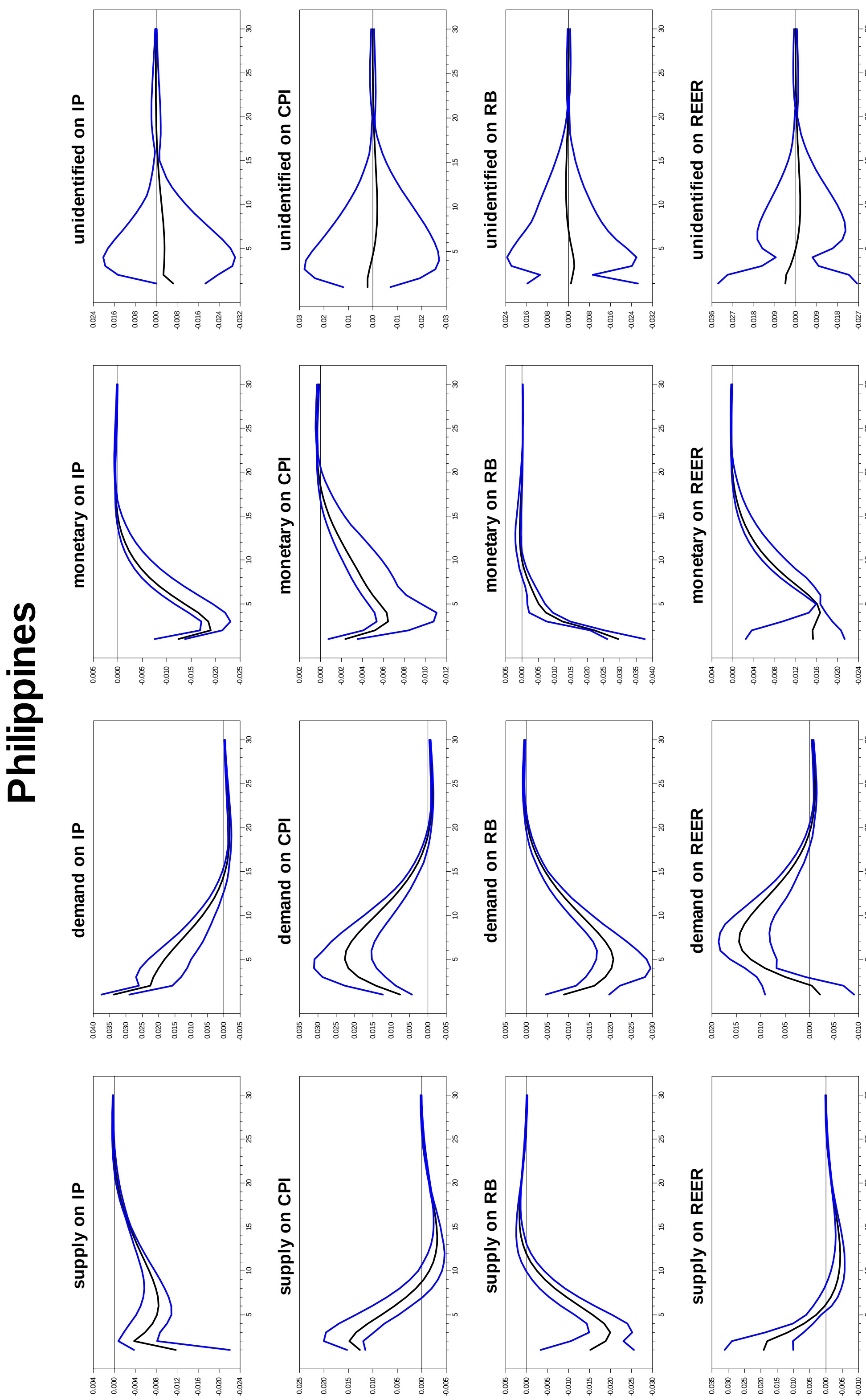
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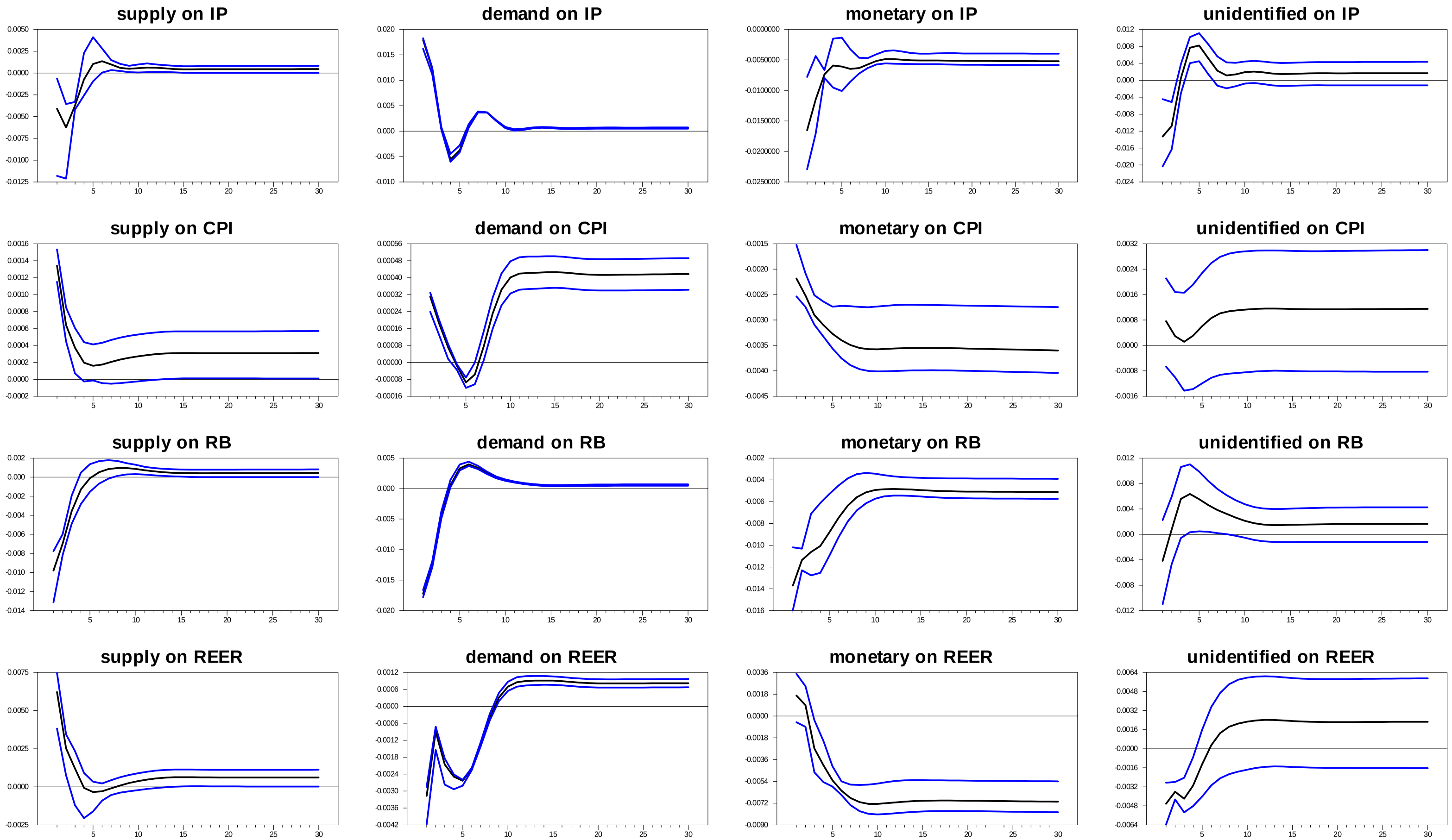
Singapore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Appendix D: Estimation results – Variance decomposition

Table D1. Variance decompositions (full sample results)

A. Variance decomposition of real GDP (in %)

	Demand shock	Supply shock	Monetary shock	Unidentified	External
China	9.1	4.7	6.8	10.7	68.7
Hong Kong	10.4	6.4	13.3	10.3	59.6
India	17.6	13.5	12.1	24.4	32.4
Indonesia	8.7	28.9	24.3	16.1	22.0
Korea	13.8	18.4	9.4	13.6	44.8
Malaysia	8.7	4.2	3.1	2.9	81.1
Philippines	16.0	16.1	19.8	13.9	34.2
Singapore	9.6	8.8	2.6	4.0	75.0
Taiwan	14.2	13.4	14.3	15.9	42.2
Thailand	8.4	13.0	12.5	13.7	52.4

B. Variance decomposition of consumer prices (in %)

	Demand shock	Supply shock	Monetary shock	Unidentified	External
China	9.0	5.4	7.1	5.1	73.4
Hong Kong	8.7	9.1	7.7	9.2	65.3
India	17.2	14.4	9.1	9.1	50.2
Indonesia	4.8	6.4	3.5	5.7	79.6
Korea	8.3	9.3	13.2	9.1	60.1
Malaysia	2.3	1.5	1.6	1.7	92.9
Philippines	17.8	14.5	11.0	16.7	40.0
Singapore	1.1	1.4	1.4	1.5	94.6
Taiwan	13.8	14.5	14.5	11.9	45.3
Thailand	10.9	10.4	10.3	10.3	58.1

C. Variance decomposition of real money balances (in %)

	Demand shock	Supply shock	Monetary shock	Unidentified	External
China	3.4	11.0	7.2	7.8	70.6
Hong Kong	11.8	12.1	12.3	8.0	55.8
India	14.1	12.0	27.4	12.5	34.0
Indonesia	19.4	11.1	19.4	12.7	37.4
Korea	15.4	9.5	12.2	12.7	50.2
Malaysia	4.4	3.4	5.1	2.4	84.7
Philippines	16.5	17.4	16.4	14.3	35.4
Singapore	7.4	2.3	1.8	1.6	86.9
Taiwan	16.0	15.4	14.5	14.2	39.9
Thailand	14.5	11.2	11.1	11.5	51.7

D. Variance decomposition of real effective exchange rates (in %)

	Demand shock	Supply shock	Monetary shock	Unidentified	External
China	6.5	7.7	9.2	7.0	69.6
Hong Kong	7.5	12.8	9.1	9	61.6
India	11.3	18.8	15.4	20.6	33.9
Indonesia	25.3	10.4	17.8	15.6	30.9
Korea	12.0	9.4	11.6	14.3	52.7
Malaysia	4.5	2.9	3.5	2.5	86.6
Philippines	11.0	17.2	18.7	17.3	35.8
Singapore	3.0	1.6	2.3	1.6	91.5
Taiwan	12.8	12.7	15.9	16.8	41.8
Thailand	9.9	10.9	9.6	13.2	56.4

Table D2. Variance decompositions (recent sample results)

A. Variance decomposition of real GDP (in %)

	Demand shock	Supply shock	Monetary shock	Unidentified	External
China	3.5	4.8	4.7	4.3	82.7
Hong Kong	9.6	7.1	8.8	12.0	62.5
India	5.4	11.6	9.2	13.6	60.2
Indonesia	4.3	4.6	4.5	7.5	79.1
Korea	3.6	3.8	6.3	4.0	82.3
Malaysia	4.9	4.7	1.8	6.1	82.5
Philippines	8.0	20.9	20.3	13.6	37.2
Singapore	4.8	4.8	2.1	4.5	83.8
Taiwan	11.4	13.1	14.9	12.9	47.7
Thailand	3.5	3.3	3.2	3.4	86.6

B. Variance decomposition of consumer prices (in %)

	Demand shock	Supply shock	Monetary shock	Unidentified	External
China	3.6	3.2	3.8	3.3	86.1
Hong Kong	7.2	4.5	4.0	6.7	77.6
India	9.1	8.0	11.5	9.0	62.4
Indonesia	3.0	4.5	2.6	3.9	86.0
Korea	2.4	2.4	2.6	3.8	88.8
Malaysia	1.5	1.8	1.5	1.2	94.0
Philippines	5.4	4.6	2.0	4.6	83.4
Singapore	1.4	1.3	1.5	1.9	93.9
Taiwan	14.8	15.4	14.1	10.9	44.8
Thailand	1.1	1.0	1	1.1	95.8

C. Variance decomposition of real money balances (in %)

	Demand shock	Supply shock	Monetary shock	Unidentified	External
China	5.4	5.0	3.8	5.5	80.3
Hong Kong	5.4	9.5	5.0	3.8	76.3
India	12.9	15.9	5.7	9.1	56.4
Indonesia	8.2	5.1	9.1	4.5	73.1
Korea	3.2	6.3	5.2	3.7	81.6
Malaysia	3.1	2.0	8.8	1.6	84.5
Philippines	3.6	2.9	10.2	4.4	78.9
Singapore	3.4	4.0	3.5	1.8	87.3
Taiwan	13.6	12.9	11.9	10.0	51.6
Thailand	5.4	4.7	5.2	5.2	79.5

D. Variance decomposition of real effective exchange rates (in %)

	Demand shock	Supply shock	Monetary shock	Unidentified	External
China	4.6	4.9	3.8	4.3	82.4
Hong Kong	3.8	5.8	6.4	2.6	81.4
India	24.5	5.0	12.3	9.2	49.0
Indonesia	10.8	8.1	8.9	5.4	66.8
Korea	6.3	2.8	4.1	3.0	83.8
Malaysia	4.8	2.6	3.2	3.1	86.3
Philippines	4.7	3.1	11.4	3.5	77.3
Singapore	2.4	3.7	2.7	3.6	87.6
Taiwan	9.6	10.4	9.5	21.4	49.1
Thailand	3.6	3.3	3.3	3.5	86.3

Note: The sample period is shortened to 1990:1-2003:4 in all cases but China, Indonesia and Thailand, for which the sample period is shortened to 1996:1-2003:4.

Appendix E: Cross-country correlation of structural shocks

Table E1. Cross-country correlation coefficients for supply shocks (full sample)

A. Period 1980:3 - 2003:4

	India	Malaysia	Taiwan	Korea	Average
India	1.000	***0.194***	0.067	-0.121	0.047
Malaysia		1.000	***0.234***	-0.171	0.086
Taiwan			1.000	***-0.257***	0.015
Korea				1.000	-0.183

B. Period 1986:3 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Average
India	1.000	***0.245***	0.048	-0.152	***-0.284***	-0.002	0.227	0.014
Malaysia		1.000	***0.252***	-0.145	***-0.305***	0.088	***0.352***	0.081
Taiwan			1.000	***-0.289***	-0.156	***0.276***	-0.011	0.020
Korea				1.000	***0.229***	0.014	-0.132	-0.079
Philippines					1.000	-0.096	0.067	-0.091
Hong Kong						1.000	-0.206	0.012
Indonesia							1.000	0.050

C. Period 1991:4 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Thailand	Singapore	China	Average
India	1.000	***0.258***	0.043	-0.073	***-0.303***	0.073	0.012	-0.216	0.021	0.226	0.005
Malaysia		1.000	0.060	0.153	-0.168	0.168	0.142	0.057	-0.064	0.170	0.086
Taiwan			1.000	***-0.347***	-0.134	0.099	0.086	-0.151	0.090	0.084	-0.019
Korea				1.000	0.157	0.152	0.110	0.199	0.090	0.213	0.073
Philippines					1.000	-0.092	0.282	0.207	-0.131	0.042	-0.016
Hong Kong						1.000	-0.112	0.008	-0.010	0.227	0.057
Indonesia							1.000	-0.118	0.044	0.190	0.071
Thailand								1.000	-0.108	0.074	-0.005
Singapore									1.000	0.003	-0.007
China										1.000	0.136

Table E2. Cross-country correlation coefficients for supply shocks (short sample)

A. Period 1991:1 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Average
India	1.000	***0.311***	0.121	-0.119	***-0.326***	0.068	0.114	0.028
Malaysia		1.000	***0.342***	-0.127	-0.191	0.173	***0.430***	0.156
Taiwan			1.000	***-0.430***	-0.169	0.116	***0.277***	0.043
Korea				1.000	0.163	0.099	-0.052	-0.078
Philippines					1.000	-0.065	0.161	-0.071
Hong Kong						1.000	-0.083	0.051
Indonesia							1.000	0.141

B. Period 1996:1 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Thailand	Singapore	China	Average
India	1.000	0.258	0.043	-0.073	-0.303	0.073	0.012	-0.216	0.021	0.226	0.005
Malaysia		1.000	0.163	0.230	0.027	0.171	0.240	0.171	-0.002	0.094	0.150
Taiwan			1.000	-0.132	-0.014	0.047	-0.036	0.025	-0.010	0.236	0.036
Korea				1.000	-0.049	0.100	0.147	-0.136	0.115	0.044	0.027
Philippines					1.000	-0.149	***0.505***	0.206	-0.170	0.119	0.019
Hong Kong						1.000	-0.332	0.058	0.017	0.158	0.016
Indonesia							1.000	-0.094	0.264	0.026	0.081
Thailand								1.000	-0.163	-0.308	-0.051
Singapore									1.000	-0.103	-0.003
China										1.000	0.055

Table E3. Cross-country correlation coefficients for demand shocks (full sample)

A. Period 1980:3 - 2003:4

	India	Malaysia	Taiwan	Korea	Average
India	1.000	-0.172	0.104	-0.047	-0.039
Malaysia		1.000	0.191	-0.069	-0.017
Taiwan			1.000	0.110	0.135
Korea				1.000	-0.002

B. Period 1986:3 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Average
India	1.000	-0.014	0.112	-0.057	-0.095	-0.119	-0.025	-0.033
Malaysia		1.000	0.010	-0.053	0.113	0.163	-0.044	0.029
Taiwan			1.000	0.182	***-0.202***	0.111	***-0.284***	-0.012
Korea				1.000	0.035	-0.020	-0.006	0.013
Philippines					1.000	-0.126	***0.265***	-0.002
Hong Kong						1.000	***-0.239***	-0.038
Indonesia							1.000	-0.055

C. Period 1991:4 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Thailand	Singapore	China	Average
India	1.000	0.050	0.124	0.077	-0.173	-0.084	-0.206	-0.224	***0.258***	-0.066	-0.027
Malaysia		1.000	***0.238***	-0.008	0.086	0.040	-0.108	-0.193	0.217	0.276	0.066
Taiwan			1.000	***0.224***	***-0.329***	0.182	***-0.410***	0.149	***0.497***	0.089	0.085
Korea				1.000	0.138	-0.112	-0.021	0.050	0.203	***0.328***	0.098
Philippines					1.000	-0.161	***0.262***	-0.060	-0.123	0.058	-0.034
Hong Kong						1.000	***-0.329***	0.025	-0.067	0.059	-0.050
Indonesia							1.000	-0.108	***-0.310***	-0.160	-0.154
Thailand								1.000	-0.131	-0.013	-0.056
Singapore									1.000	0.104	0.072
China										1.000	0.075

Table E4. Cross-country correlation coefficients for demand shocks (short sample)

A. Period 1991:1 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Average
India	1.000	0.075	0.212	-0.002	-0.107	-0.057	-0.138	-0.003
Malaysia		1.000	0.193	-0.015	0.125	0.075	-0.064	0.065
Taiwan			1.000	0.174	-0.314	0.156	***-0.389***	0.005
Korea				1.000	0.122	-0.113	-0.033	0.022
Philippines					1.000	-0.133	***0.284***	-0.004
Hong Kong						1.000	***-0.299***	-0.062
Indonesia							1.000	-0.107

B. Period 1996:1 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Thailand	Singapore	China	Average
India	1.000	***0.050***	0.124	0.077	-0.173	-0.084	-0.206	-0.224	0.258	-0.066	-0.027
Malaysia		1.000	0.245	-0.129	0.058	0.325	-0.173	-0.269	0.188	0.064	0.040
Taiwan			1.000	0.193	-0.222	0.238	***-0.394***	0.189	***0.558***	0.110	0.115
Korea				1.000	0.082	-0.104	0.002	-0.012	0.290	***0.424***	0.091
Philippines					1.000	-0.066	0.110	-0.089	-0.214	-0.094	-0.068
Hong Kong						1.000	-0.205	-0.128	-0.106	0.207	0.009
Indonesia							1.000	-0.145	***-0.378***	-0.273	-0.185
Thailand								1.000	-0.138	-0.091	-0.101
Singapore									1.000	0.179	0.071
China										1.000	0.051

Table E5. Cross-country correlation coefficients for monetary shocks (full sample)

A. Period 1980:3 - 2003:4

	India	Malaysia	Taiwan	Korea	Average
India	1.000	-0.105	0.004	0.009	-0.031
Malaysia			-0.198	-0.048	-0.117
Taiwan				***0.240***	0.015
Korea					0.067

B. Period 1986:3 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Average
India	1.000	-0.085	-0.162	-0.145	0.091	***-0.271***	0.010	-0.094
Malaysia		1.000	-0.259	-0.029	***0.219***	0.058	0.113	0.003
Taiwan			1.000	0.155	0.106	0.067	0.105	0.002
Korea				1.000	-0.045	0.090	0.047	0.012
Philippines					1.000	-0.147	0.088	0.052
Hong Kong						1.000	-0.011	-0.036
Indonesia							1.000	0.059

C. Period 1991:4 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Thailand	Singapore	China	Average
India	1.000	-0.149	-0.080	***-0.295***	0.101	***-0.400***	0.100	-0.165	0.047	0.046	-0.088
Malaysia		1.000	***-0.269***	-0.067	0.111	0.008	0.204	-0.212	-0.036	-0.237	-0.072
Taiwan			1.000	***0.209***	0.076	0.187	0.012	0.142	-0.219	-0.127	-0.008
Korea				1.000	-0.044	0.100	0.145	***0.364***	0.002	-0.213	0.022
Philippines					1.000	-0.206	0.098	-0.325	0.149	-0.063	-0.012
Hong Kong						1.000	-0.161	0.175	-0.150	-0.144	-0.066
Indonesia							1.000	-0.151	-0.048	0.027	0.025
Thailand								1.000	0.016	-0.164	-0.036
Singapore									1.000	***0.366***	0.014
China										1.000	-0.056

Table E6. Cross-country correlation coefficients for monetary shocks (short sample)

A. Period 1991:1 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Average
India	1.000	-0.140	-0.073	-0.266	0.100	***-0.401***	0.102	-0.113
Malaysia		1.000	-0.255	-0.038	0.111	-0.011	0.206	-0.021
Taiwan			1.000	0.220	0.075	0.162	0.015	0.024
Korea				1.000	-0.030	0.081	0.136	0.017
Philippines					1.000	-0.192	0.095	0.027
Hong Kong						1.000	-0.169	-0.089
Indonesia							1.000	0.064

B. Period 1996:1 - 2003:4

	India	Malaysia	Taiwan	Korea	Philippines	Hong Kong	Indonesia	Thailand	Singapore	China	Average
India	1.000	0.929	0.495	-0.837	0.992	0.636	0.802	-1.558	-0.691	-1.170	-0.088
Malaysia		1.000	-0.312	-0.296	0.131	-0.257	0.279	-0.135	-0.073	-0.238	-0.117
Taiwan			1.000	0.007	0.060	0.317	-0.270	0.216	-0.085	***-0.354***	-0.056
Korea				1.000	-0.147	0.088	0.166	***0.488***	0.124	-0.138	0.000
Philippines					1.000	-0.237	0.082	***-0.356***	0.267	0.089	-0.001
Hong Kong						1.000	-0.292	0.267	-0.163	-0.137	-0.090
Indonesia							1.000	-0.137	0.029	0.047	0.000
Thailand								1.000	0.208	-0.153	0.026
Singapore									1.000	***0.357***	0.079
China										1.000	-0.053

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