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What Drives Credit Growth in Emerging Asia?

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Abstract

This paper seeks to uncover the main drivers of credit growth in emerging Asia using a multi-country structural vector autoregressive (SVAR) model. Taking a novel approach, we developed a two-block SVAR whereby shocks *within* blocks are identified using sign restrictions, whereas shocks *across* the blocks are identified using a recursive (block-) Cholesky structure. We find that domestic factors are more dominant than external factors in driving rapid credit growth in emerging Asia. This is particularly true for domestic monetary policy, which can play a pivotal role in terms of managing rapid credit growth in emerging Asia.

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EXECUTIVE SUMMARY

This paper seeks to uncover the main drivers of real credit growth in emerging Asia using a structural empirical model. The paper proposes a novel way to identify and disentangle the main factors influencing emerging Asia's real credit growth. The model is used to generate quantitative results, which yield several insightful policy implications.

We contribute to the literature by proposing a novel identification strategy in the context of multi-country structural vector autoregressive (SVAR) models. In particular, a two-country SVAR model is presented whereby shocks *within* the blocks are identified using sign restrictions, whereas shocks *across* the blocks are identified using a recursive (block-Cholesky) structure. Specifically, underpinned by a three-equation New Keynesian framework, a monetary policy, aggregate demand, and aggregate supply shock are identified *within* each block using sign restrictions. However, the classical recursive (block-Cholesky) structure is imposed to identify shocks *across* the two blocks consisting of (i) emerging Asia and (ii) the United States and euro area. Therefore, while one block can affect the other contemporaneously, feedback in the opposite direction occurs with a one-period lag. Such feedback is important because it is not realistic to posit emerging Asia (which includes economies such as China, India, Indonesia, Korea, Hong Kong SAR, and Singapore) as a small open economy.

A subtle contribution of our proposed identification scheme is that it is not necessarily computationally taxing. This is important because it facilitates the utilization of the Fry and Pagan (2010) median target method needed to resolve the multiple models problem, which is required in order to generate meaningful quantitative results.

In terms of policy implications, the main conclusions of this paper are as follows: first, domestic factors are more dominant than external factors in driving rapid credit growth in Asia. This is particularly true for domestic monetary policy, which plays a pivotal role in terms of guiding credit growth. Second, greater exchange rate flexibility could also promote financial stability as it reduces the role of external factors affecting domestic credit dynamics. Third, a pause in monetary tightening may be appropriate for some economies in view of the current exceptionally uncertain global growth prospects relevant at the time of writing, but policymakers need to keep in mind the possibility of lingering financial imbalances over the medium term.

I. INTRODUCTION

Periods of rapid credit growth often tend to be associated with mounting financial and macroeconomic instability. In this context, especially since 2010, credit growth has been rapid in many emerging economies despite some recent easing. This is particularly the case across many emerging Asian economies, where credit growth is still elevated (**Figure 1**).

Credit can grow rapidly for at least three reasons: financial deepening (shown to support growth), normal cyclical upswings (the demand and availability of credit tends to increase during recoveries), and excessive cyclical fluctuations (credit booms). Episodes of rapid credit growth, credit booms in particular, tend to be linked to growing financial imbalances, and typically end abruptly, often in the form of financial crises. In fact, as shown in Elekdag and Wu (2011), Asian credit booms have been characterized by a higher incidence of crises (dates are based on Reinhart and Rogoff, 2009) relative to all other emerging economies, including banking, currency, and debt crises (**Figure 2**).

Periods of rapid credit growth, are influenced by both domestic and external factors. For example, domestic monetary policy rates tend to be low as credit booms build (Elekdag and Wu, 2011). By contrast, international interest rates (which serve as a proxy for global liquidity) tend to be quite stable during these periods of rapid credit growth (Gourinchas, Valdes, and Landerretche, 2001; Tornell and Westermann, 2002). At the same time, periods of rapid credit growth have been preceded by episodes of large capital inflows (Mendoza and Terrones, 2008; Elekdag and Wu, 2011).

Against this background, this paper focuses on the following questions:

- Are domestic or external factors more important in driving emerging Asian credit growth? How important are domestic versus external monetary policies?
- Can domestic monetary policy be used to manage episodes of rapid credit growth? What other policies could help foster financial stability?
- What are the medium-term financial stability risks that could be associated with a domestic monetary policy stance that is too loose? At this current juncture, what are the monetary policy challenges in terms of navigating near-term macroeconomic uncertainty while recognizing financial stability risks going forward?

The main conclusions of this paper are as follows:

- First, domestic factors are more dominant than external factors in driving rapid credit growth in emerging Asia. This is particularly true for domestic monetary policy, which plays a pivotal role in terms of guiding credit growth.

- Second, greater exchange rate flexibility could also promote financial stability as it reduces the role of external factors affecting domestic credit dynamics.

- Third, in terms of policy implications, a pause in monetary tightening may be appropriate for some economies in view of the current exceptionally uncertain global growth prospects, but policymakers need to keep in mind the possibility of lingering financial imbalances over the medium term.

A structural econometric model is used to generate these conclusions. Specifically, the empirical methodology is based on a two-country (or two-block) structural vector autoregressive (SVAR) model with (i) "emerging Asia" taken as the domestic block and (ii) the United States and euro area taken as the foreign block (henceforth, EMAS and USEUR, respectively). Because EMAS contains populous countries such as China, India, and Indonesia; has made large contributions to global growth (particularly recently during 2009–10); has a large and growing impact on global commodity price fluctuations; and includes some economies that are global financial centers, the EMAS block should *not* be modeled as a small open economy. In the context of a SVAR therefore, a two-country setup, which allows feedback across blocks, is warranted.

In this context, this paper contributes to the literature by proposing a novel identification strategy in the context of multi-country SVAR models. In particular, we present a two-country SVAR whereby shocks *within* the blocks are identified using sign restrictions, whereas shocks *across* the blocks are identified using a recursive (block-Cholesky) structure. Specifically, underpinned, by a three-equation New Keynesian framework along the lines of Woodford (2003), a monetary policy, aggregate demand, and aggregate supply shock are identified *within* each block using sign restrictions as formalized and pioneered by Faust (1998), Uhlig (2005), as well as Canova and De Nicolo (2002). However, the classical recursive (Cholesky) structure as popularized by Sims (1980) is imposed to identify shocks *across* the two blocks.[2] Therefore, under the baseline specification, for example, USEUR shocks can affect the EMAS block contemporaneously, whereas propagation of shocks in the other direction occurs with a one-period lag. This not only intuitively allows for feedback across the blocks, but as discussed next, is computationally less expensive when compared to other two-country SVAR that rely on sign restrictions for shock identification.

In a review of the sign restrictions literature, Fry and Pagan (2010) emphasize a critical issue which they call the *multiple models problem*. Specifically, most of the papers using sign restrictions use the median to summarize the impulse responses satisfying the imposed sign restrictions. The risk, however, is clear from an intuitive example they give, namely that

[2] Other notable studies using sign restrictions include Peersman (2005 and 2011), Canova (2005), Farrant and Peersman (2006), and those listed in Fry and Pagan (2007 and 2010). Bjornland and Halvorsen (2008) also combine sign and short-term (zero) restrictions which we discuss in further detail, along with important differences in methodologies, in Section III.

reporting medians would be similar to presenting the responses to technology shocks from a real business cycle model, and the monetary shocks from a monetary model. This implies that the identified structural shocks may not be uncorrelated thereby making any inferences based on impulse responses and forecast error variance decompositions economically meaningless. To solve this multiple models problem, Fry and Pagan (2010) propose a median target (MT) method by presenting the impulse responses generated from a single set of orthogonal shocks, which are as close to the medians as possible instead of the medians themselves.

Therefore, a subtle contribution of our proposed identification scheme is that despite jointly imposing a combination of sign restrictions with a block-Cholesky recursive structure, it is computationally less expensive than alternative identification schemes using sign restrictions in many two-country SVARs. This is important because it facilitates the utilization of the Fry-Pagan MT method needed for meaningful variance decompositions and impulse response functions.

As with some other notable studies in the literature, this paper attempts to shed light on credit dynamics. For example, Gourinchas and others (2001), Tornell and Westermann (2002), Mendoza and Terrones (2008), and Barajas and others (2011), study episodes of excessive credit growth, that is “credit booms”. Extending the work in these three papers, Elekdag and Wu (2011) argue that both domestic factors (including domestic monetary policy) and external factors (for example, international interest rates—a proxy for global liquidity conditions) drive credit growth. However, because they do not employ a structural model, they are not able to offer any causal statements and are limited in terms of their quantitative findings.

VAR models have also been used to better comprehend credit dynamics. Noteworthy papers include Helbling and others (2010), which find that credit shocks (identified using sign restrictions) have been influential in driving global activity. Also employing a VAR, Meeks (2009) concentrates on the United States and argues that credit shocks play an important role during financial crises, but that they have a lesser role during more tranquil periods. However, while these studies use SVAR to uncover how credit shocks affect business cycle dynamics, this paper presents a novel identification scheme to address how domestic (including monetary policy) and external shocks after real credit growth in emerging Asia. The structure of the rest of the paper is fairly standard. The next two sections discuss the data and the methodological contribution of this paper, while Section IV discusses the results, and the last section concludes.

II. Data

The sample covers the period spanning 1989:Q1–2010:Q4 and includes the following country blocks: the foreign block consists of the (PPP-weighted average of the) United States and the euro area (USEUR), while emerging Asia (EMAS) comprises China, India, Hong Kong SAR, Korea, Singapore, Taiwan Province of China, Indonesia, Malaysia, Thailand, and the Philippines. The database includes quarterly real GDP, CPI, short-term interest rates for all of the countries, but credit only for EMAS. As with the foreign block (USEUR), individual emerging Asian time series were combined using PPP-GDP weights to form the EMAS aggregates.

The quarterly logarithmic growth rates of real GDP, CPI, and real credit, along with the level of short-term interest rates are used in the SVAR. First differencing is quite standard, but following, for example, Clarida and Gali (1994), and Peersman (2005), the level of interest rates are used. Real credit is defined as the stock of credit scaled by CPI. The credit series are from the IMF's IFS database (IFS line 22d and line 42d, when a sufficiently long time series was available). This corresponds to the aggregate claims on the private sector by deposit money banks and is quite standard in other studies (see, for example, Elekdag and Wu, 2011). The rest of the series are also quite standard and were compiled from the IMF's WEO and IFS databases and Haver Analytics.

III. Methodology

The empirical methodology is based on a structural vector autoregressive (SVAR) model. In particular, this paper contributes to the literature by proposing a novel identification strategy in the context of multi-country SVAR models. As a preview of what is to follow, we present a two-country SVAR whereby shocks *within* countries are identified using sign restrictions, whereas shocks *across* countries (blocks) are identified using a recursive (block Cholesky) structure. Not only does this allow for an intuitive approach to identify structural shocks, but also allows for feedback across blocks in a computationally inexpensive manner, which, as discussed below, would be crucial for obtaining meaningful quantitative results.

A. Emerging Asia Should Not Be Considered a Small-Open Economy

Before continuing, it should be emphasized that the emerging Asia (EMAS) block is *not* modeled as a small open economy. This is because this region (block) contains populous countries such as China, India, and Indonesia, has made large contributions to global growth (particularly during 2009–10); has a large and growing impact on global commodity price fluctuations; and includes some economies that are global financial centers. In the context of a VAR, therefore, a two-country (block) setup that allows feedback across blocks is appropriate. For our purposes, the conceptual framework is a global economy with two blocks: EMAS and the rest of the world (initially assumed to be adequately summarized by the USEUR block), whereby shocks originating in the two blocks can be transmitted to each other.

B. Methodological Contribution: An Overview

This paper proposes a simple intuitive shock identification strategy within the context of two-country VAR models. Specifically, *within* each block, sign restrictions are employed, however, *across* blocks, a recursive causal structure (block-Cholesky) is assumed. Shock identification is jointly imposed, but nonetheless is computationally less expensive than some other recent approaches using sign restrictions to identify shocks in two-country SVARs. As would be discussed later below, a lighter computational burden can be critical in that it facilitates quantitative results that are economically meaningful.

The proposed identification strategy is summarized in **Table 1**, with the details as follows:

- *Sign restrictions are used to identify shocks* ***within*** *each block.* As discussed earlier, using sign restrictions to identify shocks in VARs was pioneered by Faust (1998), Uhlig (2005), Canova and De Nicolo (2002), and Canova (2005). Consider the foreign USEUR block comprising of three equations determining the dynamics of real GDP growth, CPI inflation, and the level of the short-term interest rate. Underpinned by a three-equation New Keynesian framework along the lines of Woodford (2003), a monetary policy, aggregate demand, and aggregate supply shock are identified. Specifically, while an aggregate demand shock implies a positive comovement of output and prices, the opposite is true for the aggregate supply shock in line with the standard textbook aggregate supply-aggregate demand model. In the case of monetary policy, the reaction of short-term interest rates would be used to differentiate from the aggregate demand shock. In particular, while the short-run interest rates are used to stabilize the economy in face of an aggregate demand shock, these rates are increased in light of macroeconomic overheating using monetary policy shocks (see, for example, Peersman 2005). It should also be noted that under the baseline specification EMAS real credit growth is assumed to be procyclical.

- *A recursive (block-Cholesky) structure is imposed to identify shocks* ***across*** *the two blocks.* Recursive identification was popularized by Sims (1980). In the baseline specification, it is assumed that shocks from the foreign USEUR block can affect the EMAS block contemporaneously, whereas propagation of shocks in the other direction occurs with a one period lag. As discussed in Section IV, sensitivity analysis indicates that our main conclusions do not depend on this ordering.
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Overall, using sign restrictions *within* blocks, and the block-Cholesky recursive structure *across* blocks, implies that EMAS would not only be affected by external shocks, but can in turn influence the economic dynamics of the foreign (USEUR) block.

Addressing the Multiple Models Problem

In a review of the sign restrictions literature, Fry and Pagan (2010) emphasize a critical issue that they call the *multiple models problem*. Specifically, most of the papers using sign restrictions use the median (and/or various percentiles) to summarize the impulse responses satisfying the imposed sign restrictions. However, the risk is clear from an example that Fry and Pagan (2010) provide—namely that reporting medians would be similar to presenting the responses to technology shocks from a real business cycle model and the monetary shocks from a monetary model. This implies that the identified structural shocks may not be uncorrelated; thereby distorting any inferences gleaned via impulse responses and variance decompositions.

To solve this multiple models problem, Fry and Pagan (2010) propose a median target (MT) method by presenting the impulse responses generated from a single set of orthogonal shocks, which are as close to the medians as possible instead of the medians themselves. We follow the advice of Fry and Pagan (MT), and when presenting impulse responses and in addition to 90 percent bands and the median, we also provide the median computed using their MT method. For variance decompositions, we only present the results using the MT method when identification is sought via sign restrictions.

Does a Computational Less Expensive Method Matter?

A subtle contribution of our proposed identification scheme is that it is computationally less expensive than some alternative identification schemes using sign restrictions. To assess the robustness of our results, we follow Peersman (2005) and posit an alternative identification method shown in **Table 2**. As discussed further below, however, we show that this strategy is computationally very expensive, specifically numerous attempts (measured in days) yield about seven valid draws out of over 10 million (to be clear, an acceptance rate of less than 0.0001 percent). This is striking because the model under development is quite parsimonious with seven variables in a two-country system (and with sign restrictions imposed only in the first period in the baseline specification). As can be seen, even small-to-medium-scale VAR model identified using sign restrictions can quickly become computationally overbearing. Furthermore, it begs the question of whether even attempting to use the Fry-Pagan MT method even makes sense in this situation. This highlights why the computational gains from our proposed identification scheme (which yields runs in about an hour or two, rather than a day or two) is potentially so important. Combining sign restrictions with a block-Cholesky recursive structure also facilitates the utilization of the Fry-Pagan MT method needed for meaningful variance decompositions and impulse response functions.

To further underscore the potential importance of computational savings allowed for under our proposed identification strategy, consider Peersman (2011). This recent paper develops a two-country SVAR with seven variables and seven structural shocks identified using 45 sign restrictions. We conjecture from the paper that there were very few valid draws when all the sign restrictions were imposed jointly, and this is why the shocks are identified one by one in the paper. Namely, if the impulse responses to an individual shock are consistent with the imposed sign restrictions for a shock, then the results for the specific shock are accepted (in contrast to Peersman, 2005). This is critical because to apply the Fry and Pagan (2007 and 2010) MT method, that is to find a single set of orthogonal shocks, they need to be identified *simultaneously*, which in the case of Peersman (2011) seems virtually infeasible. This would imply that the structural shocks used for impulse response functions and variance decompositions would likely *not* be uncorrelated, and therefore such quantitative findings may not be economically meaningful. The shortcoming in the example above highlights the value of the computational savings as it facilitates the use of the MT method, thereby allowing for economically meaningful quantitative inferences.

Three Other Noteworthy Points

- First, during the final drafting stages of this paper, we came across a study by Bjornland and Halvorsen (2008) who also combine sign restrictions and short-term (zero) restrictions. In the broadest terms, we both innovate by proposing that sign restrictions be combined with a recursive ordering. We can, however, differentiate our paper in several dimensions: (i) we use a two-country setup that could be seen as a more natural case when sign restrictions are combined with a recursive structure, (ii) relatedly, our recursive ordering is across blocks seems natural given the two-country setup, and that is why we have used the term block-Cholesky, (iii) the Fry-Pagan MT method underpins our quantitative results (in contrast to many in the literature), and (iv) in this regard, we have emphasized the computational savings gained by combining a block-Cholesky recursive structure along with popular sign restrictions that facilitate the Fry-Pagan MT method needed for meaningful quantitative results.

- Second, as in Uhlig (2005) and Helbling and others (2011), this paper initially identifies less shocks than there are equations in the systems. Indeed, while a seven-equation system is estimated, only six shocks are initially identified. While some sort of financial, exchange rate, or capital inflows shock could have been proposed, in the parsimonious specification discussed further below, it is not clear how such a shock would be linked to a domestic or external source. Recall that this paper will attempt to uncover whether domestic or external factors are more important in driving emerging Asian credit growth. Therefore in the baseline, the seventh shock is not identified. It should also be noted that exchange rate dynamics are partially captured by the interest rate differential between domestic and international short-term rates (as discussed in Clarida and Gali, 1994). However, when discussing robustness, we show that using a recursive structure (which by definition identifies all seven shocks) reinforces our main results.

- Third, previous studies have used VARs to model two-country setups. Clarida and Gali (1994) popularized a two-country framework whereby each variable include in the VAR is measured in relative terms. Farrant and Peersman (2006) present a modern incarnation of this idea using sign restrictions. A shortcoming of such an approach is that estimation using relative variables implies the same propagation mechanism for shocks originating in both blocks is assumed. Moreover, using relative variables does not provide any information about the relevance of shocks for the *level* variables, in the case of this paper, for example, credit. Similarly, Peersman (2011) elaborates on Mountford (2005) and Farrant and Peersman (2006) and models a two-country VAR using symmetric and asymmetric shocks. One issue with this setup is that a purely common shock, for example a hike in global commodity prices, may have opposite effects depending on whether a country is a net commodity importer or exporter. Furthermore, because there are a few important net exporters of key global commodities (for example, Indonesia and Malaysia) within emerging Asia, this would make the interpretation of symmetric versus asymmetric shocks even more difficult. Another identification issue is that the identified shocks in these studies are likely not orthogonal to each other (multiple models problem), thereby distorting the quantitative findings, as emphasized above. Relatedly, under the proposed sign restrictions, these models may even be too large (even with seven variables) to resolve the multiple models problem using the Fry-Pagan MT method.

C. Baseline Empirical Specification

The structural empirical model incorporates a parsimonious set of macroeconomic variables needed to investigate emerging Asian credit dynamics. The baseline two-country SVAR contains the quarterly logarithmic growth rates of real GDP and CPI inflation and the level of short-term interest rates for both blocks, but only the quarterly logarithmic growth rate of real credit for emerging Asia as shown below:

$$Z_t = c + \sum_{i=1}^{p} A_i Z_{t-i} + B\varepsilon_t \tag{1}$$

where c is a (7×1) vector of constants, A_i is a (7×7) matrix of autoregressive coefficients, and ε_t is a (7×1) vector of structural disturbances which are uncorrelated and normalized to have unit variances.[3] The (7×7)matrix B is discussed momentarily below. The endogenous variables, Z_t, that we include in the VAR are:

$$Z_t = \begin{bmatrix} \Delta ln(Real\ GDP_t^{USEUR}) \\ \Delta ln(CPI_t^{USEUR}) \\ i_t^{USEUR} \\ \Delta ln(Real\ GDP_t^{EMAS}) \\ \Delta ln(CPI_t^{EMAS}) \\ i_t^{EMAS} \\ \Delta ln(Real\ Credit_t^{EMAS}) \end{bmatrix}$$

Lag length p is determined by standard likelihood ratio tests and the Akaike information criterion, as is typical in the sign restriction literature, and turns out to be one.

[3] Future work would include considering the addition of a combination of credit variables for the USEUR block and (real) exchange rates, possibly as gaps (deviations from trend).

D. Technical Details of the Block-Cholesky-Sign Restrictions Identification Strategy

Identification of the baseline model shown in equation (1) boils down to the identification of matrix *B*, which without further restrictions, is unidentified. As discussed above, in line with Uhlig (2005), initially, we identify only six structural shocks, namely, monetary policy, aggregate supply, and aggregate demand shocks for each of the two blocks (USEUR and EMAS).

Let Ω be the estimated variance-covariance matrix of the reduced-form residuals for equation (1), and F be the lower triangular in the Cholesky decomposition for Ω, i.e. $FF' = \Omega$. On the other hand, since ε_t is uncorrelated and has unit variances, we have $BB' = \Omega$. Using the observation that any two decompositions $\Omega = AA'$ and $\Omega = \tilde{A}\tilde{A}'$ have to satisfy that

$$\tilde{A} = AQ,$$

for some orthonormal matrix *Q*, that is, $QQ' = QQ = I$, we can conclude that $B = FQ_1$ for some orthonormal matrix Q_1 (see, for example, Uhlig, 2005).

On the other hand, suppose Q_2 is an arbitrary orthonormal matrix with the same dimension as the matrix *B*, then we can rewrite equation (1) as:

$$Z_t = c + \sum_{i=1}^{p} A_i Z_{t-i} + FQ_0' \tilde{\varepsilon}_t \,, \tag{2}$$

where $Q_0 = Q_2 Q_1'$ is also orthonormal, and the variance of the new shocks $\tilde{\varepsilon}_t = Q_2 \varepsilon_t$ is $Var(\tilde{\varepsilon}_t) = Var(Q_2 \varepsilon_t) = Q_2 \cdot I \cdot Q_2' = I$. In other words, we construct a new set of uncorrelated shocks with unit variances. In general, the orthonormal matrix Q affects both the contemporaneous effects of shocks on variables and the standard deviations of shocks. Thus the impulse responses generated by the new set of shocks $\tilde{\varepsilon}_t$ change.

The Block-Cholesky Recursive Structure

Here, in line with one of the main contributions of this paper, we propose the following block-Cholesky-sign restrictions method. Consider a general two-country Structural VAR(*p*) model:

$$\begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \varepsilon_t^X \\ \varepsilon_t^Y \end{bmatrix}, \quad t = 1,2,\cdots,T \tag{3}$$

where: $A_{ij}(L) = A_{ij}^{(0)} + A_{ij}^{(1)} L + A_{ij}^{(2)} L^2 + \cdots + A_{ij}^{(p)} L^p$ with $i, j \in \{1, 2\}$. $A_{ij}^{(k)}$'s are the structural coefficient matrices, and L is the lag operator. X_t is a $m \times 1$ vector and denotes the block for the variables of the more "exogenous" country (which will be called as country *X* from now on). Y_t is a $n \times 1$ vector and denotes the block for the variables of the other country (which will be called as country Y). ε_t^X and ε_t^Y are the structural shocks with dimensions $m \times 1$ and $n \times 1$ respectively. For example, in our two-country SVAR model in equation (1),

$$X_t = \begin{bmatrix} \Delta logY_t^{USEUR} \\ \Delta logCPI_t^{USEUR} \\ i_t^{USEUR} \end{bmatrix}, Y_t = \begin{bmatrix} \Delta logY_t^{EMASIA} \\ \Delta logCPI_t^{EMASIA} \\ i_t^{EMASIA} \\ \Delta log\left(\frac{credit}{CPI}\right)_t^{EMASIA} \end{bmatrix}, \varepsilon_t^X = \begin{bmatrix} \varepsilon_t^{AS,USEUR} \\ \varepsilon_t^{AD,USEUR} \\ \varepsilon_t^{MP,USEUR} \end{bmatrix}, \varepsilon_t^Y = \begin{bmatrix} \varepsilon_t^{AS,EMASIA} \\ \varepsilon_t^{AD,EMASIA} \\ \varepsilon_t^{MP,EMASIA} \\ \varepsilon_t^{?} \end{bmatrix},$$

where initially we keep agnostic to the last structural shock. Define

$$B_{ij}(L) = -\left[A_{ij}^{(1)} + A_{ij}^{(2)}L^1 + \cdots + A_{ij}^{(p)}L^{p-1}\right], \;\; i,j \in \{1,2\}$$

then $A_{ij}(L) = A_{ij}^{(0)} - B_{ij}(L) \cdot L$, and model (1) can be written as:

$$\begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix} \begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} B_{11}(L) & B_{12}(L) \\ B_{21}(L) & B_{22}(L) \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^X \\ \varepsilon_t^Y \end{bmatrix}, \;\; t = 1,2,\cdots,T \tag{4}$$

where for notational simplicity, we denote $H_{ij} = A_{ij}^{(0)}$ with $i,j \in \{1,2\}$.

Before proceeding, it would be useful to highlight three important assumptions:

1. The structural shocks $[\varepsilon_t^{X\prime} \quad \varepsilon_t^{Y\prime}]' \sim i.i.d.(0,\, I_{m+n})$. This first assumption is standard in the SVAR literature, and normalizes the uncorrelated structural shocks so that they all have unit variances.

2. The structural coefficient matrices H_{11} and H_{22} are invertible.

3. The structural coefficient matrix $H_{12} = 0$. The third assumption is exactly the assumption of the block-Cholesky decomposition. The first two assumptions imply that the entire structural coefficient matrix $\begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix}$ is invertible, and there is no contemporaneous effect of ε_t^Y on X_t. The latter along with sign restrictions in country X gives us the identification of the corresponding structural shocks across the two countries.[4]

[4] It may be useful to indicate that Canova (2005), for example, assumed that the entire polynomial $A_{12}(L) = 0$—implying a small-open economy setup—which would not be a reasonable assumption in our two-country SVAR setup containing the USEUR and EMAS blocks as discussed above.

Therefore, the reduced-form VAR can be written as:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} H_{11} & 0 \\ H_{21} & H_{22} \end{bmatrix}^{-1} \begin{bmatrix} B_{11}(L) & B_{12}(L) \\ B_{21}(L) & B_{22}(L) \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} H_{11} & 0 \\ H_{21} & H_{22} \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_t^X \\ \varepsilon_t^Y \end{bmatrix}, \quad t = 1,2,\cdots,T \qquad (5)$$

By the formula of the inverse of partitioned matrix, we have:

$$\begin{bmatrix} H_{11} & 0 \\ H_{21} & H_{22} \end{bmatrix}^{-1} = \begin{bmatrix} H_{11}^{-1} & 0 \\ -H_{22}^{-1} H_{21} H_{11}^{-1} & H_{22}^{-1} \end{bmatrix},$$

which is exactly the matrix B defined in equation (1) and the objective of our identification strategy. Now the reduced-form VAR becomes:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} H_{11}^{-1} & 0 \\ -H_{22}^{-1} H_{21} H_{11}^{-1} & H_{22}^{-1} \end{bmatrix} \begin{bmatrix} B_{11}(L) & B_{12}(L) \\ B_{21}(L) & B_{22}(L) \end{bmatrix} \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} e_t^X \\ e_t^Y \end{bmatrix}, \quad t = 1,2,\cdots,T \qquad (6)$$

where $[e_t^{X\prime} \quad e_t^{Y\prime}]'$ are the reduced-form residuals:

$$\begin{bmatrix} e_t^X \\ e_t^Y \end{bmatrix} = \begin{bmatrix} H_{11}^{-1} & 0 \\ -H_{22}^{-1} H_{21} H_{11}^{-1} & H_{22}^{-1} \end{bmatrix} \begin{bmatrix} \varepsilon_t^X \\ \varepsilon_t^Y \end{bmatrix}, \qquad t = 1,2,\cdots,T \qquad (7)$$

Since we can estimate the reduced-form VAR and obtain the estimated variance-covariance matrix for residuals, denoted by Σ and partitioned according to $[\varepsilon_t^{X\prime} \quad \varepsilon_t^{Y\prime}]'$ as

$$\begin{bmatrix} \Sigma_X & Cov \\ Cov' & \Sigma_Y \end{bmatrix},$$

then by the first assumption, we have:

$$\begin{bmatrix} H_{11}^{-1} & 0 \\ -H_{22}^{-1} H_{21} H_{11}^{-1} & H_{22}^{-1} \end{bmatrix} \begin{bmatrix} H_{11}^{-1} & 0 \\ -H_{22}^{-1} H_{21} H_{11}^{-1} & H_{22}^{-1} \end{bmatrix}' = \Sigma = \begin{bmatrix} \Sigma_X & Cov \\ Cov' & \Sigma_Y \end{bmatrix}.$$

This leads to the following three formulae:

$$\begin{cases} H_{11}^{-1} H_{11}^{-1\prime} = \Sigma_X & (8) \\ -H_{22}^{-1} H_{21} = Cov' \cdot \Sigma_X^{-1} & (9) \\ H_{22}^{-1} H_{22}^{-1\prime} = \Sigma_Y - Cov' \cdot \Sigma_X^{-1} \cdot Cov & (10) \end{cases}$$

Denote the impulse response function of vector z_t to a 1 standard deviation shock in the structural disturbance or residual vector v_t^j by a series of matrices, $IRF_z^{v,j}(i)$, where $i = 0,1,2,\cdots$ is the time horizon (in quarters), $z, j \in \{X, Y\}$, and $v \in \{\varepsilon, e\}$. For example, the

(k, l)-th element in the matrix $IRF_X^{\varepsilon,X}(i)$ is the impulse response of the k-th variable in X_t to a one standard deviation shock in the l-th structural disturbance in ε_t^X after i quarters. Note that the impulse response functions of z_t to residual shock e_t^j, namely, $IRF_X^{e,X}(i), IRF_Y^{e,X}(i)$, $IRF_X^{e,Y}(i)$ and $IRF_Y^{e,Y}(i)$, can be calculated by the Wold decomposition theorem using the estimated reduced-form VAR coefficient matrices.

Our objective is to find expressions for $IRF_X^{\varepsilon,X}(i), IRF_X^{\varepsilon,Y}(i), IRF_Y^{\varepsilon,X}(i)$, and $IRF_Y^{\varepsilon,Y}(i)$ for each i based on the reduced-form VAR estimates. According to the Wold decomposition theorem, we have:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \sum_{i=0}^{\infty} \begin{bmatrix} IRF_X^{e,X}(i) & IRF_X^{e,Y}(i) \\ IRF_Y^{e,X}(i) & IRF_Y^{e,Y}(i) \end{bmatrix} \begin{bmatrix} e_{t-i}^X \\ e_{t-i}^Y \end{bmatrix}, \quad t = 1,2,\cdots,T \tag{11}$$

It is easy to see that the block-Cholesky decomposition $H_{12} = 0$ and the third assumption implies $IRF_X^{e,Y}(0) = 0$.

Using the relationships between structural shocks and residuals (7), we can rewrite (11) as:

$$\begin{aligned} \begin{bmatrix} X_t \\ Y_t \end{bmatrix} &= \sum_{i=0}^{\infty} \begin{bmatrix} IRF_X^{e,X}(i) & IRF_X^{e,Y}(i) \\ IRF_Y^{e,X}(i) & IRF_Y^{e,Y}(i) \end{bmatrix} \begin{bmatrix} H_{11}^{-1} & 0 \\ -H_{22}^{-1} H_{21} H_{11}^{-1} & H_{22}^{-1} \end{bmatrix} \begin{bmatrix} \varepsilon_{t-i}^X \\ \varepsilon_{t-i}^Y \end{bmatrix} \\ &= \sum_{i=0}^{\infty} \begin{bmatrix} IRF_X^{e,X}(i) \cdot H_{11}^{-1} - IRF_X^{e,Y}(i) \cdot H_{22}^{-1} H_{21} H_{11}^{-1} & IRF_X^{e,Y}(i) \cdot H_{22}^{-1} \\ IRF_Y^{e,X}(i) \cdot H_{11}^{-1} - IRF_Y^{e,Y}(i) \cdot H_{22}^{-1} H_{21} H_{11}^{-1} & IRF_Y^{e,Y}(i) \cdot H_{22}^{-1} \end{bmatrix} \begin{bmatrix} \varepsilon_{t-i}^X \\ \varepsilon_{t-i}^Y \end{bmatrix} \\ &= \sum_{i=0}^{\infty} \begin{bmatrix} \left(IRF_X^{e,X}(i) + IRF_X^{e,Y}(i) \cdot Cov' \cdot \Sigma_X^{-1}\right) H_{11}^{-1} & IRF_X^{e,Y}(i) \cdot H_{22}^{-1} \\ \left(IRF_Y^{e,X}(i) + IRF_Y^{e,Y}(i) \cdot Cov' \cdot \Sigma_X^{-1}\right) H_{11}^{-1} & IRF_Y^{e,Y}(i) \cdot H_{22}^{-1} \end{bmatrix} \begin{bmatrix} \varepsilon_{t-i}^X \\ \varepsilon_{t-i}^Y \end{bmatrix} \end{aligned}$$

where the last equality is due to (9).

The Cholesky decomposition for Σ_X and $(\Sigma_Y - Cov' \cdot \Sigma_X^{-1} \cdot Cov)$ can be written as

$$\begin{cases} \Sigma_X = F_X \cdot F_X' \\ \Sigma_Y - Cov' \cdot \Sigma_X^{-1} \cdot Cov = F_Y \cdot F_Y' \end{cases}$$

where F_X and F_Y are both lower triangular matrices. Then by (8) and (10), and using the observation that any two decompositions $\Sigma_X = AA'$ and $\Sigma_X = \tilde{A}\tilde{A}'$ must satisfy that $\tilde{A} = AQ$ for some orthonormal matrix Q, (see also Uhlig, 2005) we have:

$$\begin{cases} H_{11}^{-1} = F_X \cdot Q_X \\ H_{22}^{-1} = F_Y \cdot Q_Y \end{cases} \tag{12}$$

where Q_X and Q_X are some orthonormal matrices which can be generated by either the Givens matrices or the Householder transformations (see, for example, Fry and Pagan, 2007). Now we can obtain the expression for impulse response functions of all variables to structural shocks by:

$$\begin{cases} IRF_X^{\varepsilon,X}(i) = \left[IRF_X^{e,X}(i) + IRF_X^{e,Y}(i) \cdot Cov' \cdot \Sigma_X^{-1}\right] F_X Q_X \\ IRF_Y^{\varepsilon,X}(i) = \left[IRF_Y^{e,X}(i) + IRF_Y^{e,Y}(i) \cdot Cov' \cdot \Sigma_X^{-1}\right] F_X Q_X \\ IRF_X^{\varepsilon,Y}(i) = IRF_X^{e,Y}(i) \cdot F_Y Q_Y \\ IRF_Y^{\varepsilon,Y}(i) = IRF_Y^{e,Y}(i) \cdot F_Y Q_Y \end{cases} \tag{13}$$

with $i = 0,1,2,\cdots$.

Then we only keep the Q_X's and Q_Y's such that the associated $IRF_X^{\varepsilon,X}(i)$ and $IRF_Y^{\varepsilon,Y}(i)$ satisfy the sign restrictions that are imposed on the variables of both countries. Note that we only impose sign restrictions on the impulse responses of all the variables to domestic shocks, and leave the across-country impulse responses agnostic. For example, in our model we impose the following sign restrictions on the two blocks (USEUR and EMAS) as summarized in **Table 1**. In the matrix displayed in the table, the first "< 0", for example, represents the sign restriction for the contemporaneous impulse response of $\Delta logY_t^{USEUR}$ to AS^{USEUR} shock, that is, $IRF_{\Delta lnY,USEUR}^{AS,USEUR}(0) < 0$, and the "0" represents the block-Cholesky decomposition (recursive restrictions across the blocks). As in the literature, "?" denotes the lack of any restrictions.

Through the above procedure, we have identified, in the sense of sign restrictions,

$$\begin{bmatrix} H_{11}^{-1} & 0 \\ -H_{22}^{-1}H_{21}H_{11}^{-1} & H_{22}^{-1} \end{bmatrix},$$

which is exactly the matrix B in equation (1) under the first two assumptions, as well as the matrix version of the impulse vector for structural shocks as defined and identified in Uhlig (2005).

We use a Bayesian approach following Uhlig (2005), Farrant and Peersman (2006), and Peersman (2011) to estimate equation (1), the reduced-form VAR. The prior and posteriors belong to the Normal-Wishart family. Because there are an infinite number of admissible decompositions for each draw from the posterior when using sign restrictions, we use the following procedure. We first take a draw from the posterior for the usual unrestricted Normal-Wishart posterior for the VAR parameters, and for each draw we take another draw for the Householder transformations to generate the rotation matrices for H_{11}^{-1} and H_{22}^{-1} according to (12). We then construct impulse response functions according to (13). If the impulse response functions satisfy all imposed sign restrictions listed above, then the results for that draw are accepted. Otherwise, the draw is rejected. Then we find the median impulse responses for each shock and each variable, and apply the Fry-Pagan median target (MT) method by searching for a single rotation that generates a set of impulse response functions which are as close to the median impulse responses as possible.

IV. Results

This section presents the main findings of the paper starting with a discussion of variance decompositions pertaining to real credit growth in emerging Asia (EMAS). As argued below, and further reinforced through robustness checks, domestic factors seem to be more influential than external factors in driving rapid credit growth in emerging Asia. Then impulse response functions are discussed to further understand the dynamics of real credit growth. Lastly, two illustrative counterfactual scenarios are presented which serve to highlight that domestic monetary policy could play a pivotal role in terms of managing rapid credit growth in emerging Asia.

A. Forecast Error Variance Decompositions

One of the main questions this paper seeks to address is the following: In terms of emerging Asian credit growth, are domestic or external factors more important? To provide a quantitative answer to this question, the SVAR model described above is used to generate variance decomposition of emerging Asia (EMAS) real credit growth, which is presented in **Figure 3**. As is quite clear, it appears that in terms of explaining the variability of EMAS real credit growth, domestic factors are more dominant than the external factors. In fact, while domestic monetary, aggregate demand and supply shocks explain 53 percent of the variation in EMAS real credit growth, the external counterparts of these shocks only account for 16 percent of the variation. In particular, domestic aggregate demand shocks account for 37 percent of EMAS real credit variability.

What Role for Domestic Monetary Policy?

Domestic monetary policy shocks explain a greater share of EMAS real credit variability than the external monetary policy shocks do. This finding is also based on **Figure 3** which reports that the domestic and external monetary policy shocks capture 7 percent and 4 percent of the total variation in EMAS real credit growth, respectively. The finding that domestic monetary policy shocks explain a larger share of EMAS credit variation than their foreign counterpart is noteworthy because external monetary policy shocks could be considered proxies for changes in global liquidity conditions as they are likely to be tied to international interest rates.

It is important to underscore that domestic factors are more dominant than external factors in driving emerging Asia's credit growth, and *not* capital inflows. While Elekdag and Wu (2011) find that credit booms are preceded by episodes of large capital inflows, all of these external sources of financing need not be directed into domestic credit. In fact, there are other asset classes which are likely absorbing these inflows including real estate, equity (both public as monitored on exchanges, but also private equity), FDI (related to equity, but also "green-field" FDI which is associated with physical capital accumulation), fixed income securities (for example, corporate bond issuance), and credit, which linked to non-financial institutions or off-balance sheet vehicles (which are more difficult to monitor). In fact, as reported in Elekdag and Wu (2011), in the build-up phase, credit booms are characterized by a significant rise in investment, stock prices, and house prices, along with bank and nonbank source of credit.

While domestic monetary policy shocks account for 7 percent of EMAS real credit variation, as shown further below, monetary policy nonetheless plays an important role in terms of managing credit growth in EMAS. A reason is because monetary policy could affect credit growth through at least three main channels: the first channel operates as higher interest rates suppress consumption and investment, thereby the demand for credit. The second channel assumes some exchange rate flexibility. Higher interest rates could bring about an appreciation of the exchange rate, tightening monetary conditions, and like the first channel, help cool off the economy by restraining domestic demand—again putting downward pressure on the demand for credit (for example, as exporters' need for working capital declines on the back of lower international competitiveness). The third channel would work through balance sheets, and mainly affect the supply of credit by contrast to the first two channels. Higher interest rate would depress asset prices, having a dual impact: (i) it would decrease collateral values limiting the amount of borrowing by potential debtors, and (ii) higher interest rates would adversely affect the equity of financial intermediaries which—owing to a capital crunch, Bernanke and Lown (1991) — would then likely curtail their lending activities.

Remaining Macroeconomic Indicators

The variance decompositions of the other SVAR variables are shown in **Figure 4**. For five of the six variables, domestic shocks account for most of the variation, as with EMAS real credit growth. The one exception is EMAS policy rates, where external factors seem to be more influential. This should not be too surprising because monetary policy in some of the regional economies tracts that of the United States closely, for example, Hong Kong SAR will maintain a peg to the U.S. dollar. As demonstrated by an index capturing *de facto* exchange rate regime classification by Levy-Yeyati and Sturzenegger (2005), some regional exchange rates are closely associated with U.S. dollar. In these cases, historically, domestic policy rates have generally moved in tandem with the rates of their anchor economies. At the same time, the role of monetary policy rates is almost negligible. Technically, this is because the SVAR is having difficulty disentangling aggregate demand shocks and monetary policy shocks in the context of EMAS policy rates. This is also not surprising. Consider, once again, Hong Kong SAR. With a peg to the U.S. dollar, Hong Kong SAR does not implement independent monetary policy when viewed from the perspective of the SVAR, and so it is not able to differentiate domestic and external monetary policy shocks. Therefore, virtually all demand-related fluctuations are by definition attributed to the aggregated demand shocks.

Robustness

In terms of EMAS credit growth, the important role of domestic factors (which include domestic monetary policy) was emphasized above, but is this robust to alternative identification strategies? To assess the sensitivity of these results, we consider two alternative shock identification approaches. The first is based on Peersman (2005), called "sign restrictions," and the second is the classic Cholesky decomposition, which imposes a recursive ordering for the entire SVAR.

First Alternative Approach

Following Peersman (2005), we identify the shocks in the system using sign restrictions as summarized in **Table 2**. Rather than the block-Cholesky recursive structure we use in the baseline to differentiate shocks across blocks, here the innovation introduced by Peersman (2005) is utilized. Consider the case of the monetary policy shocks. In this alternative identification scheme it is assumed that a domestic monetary policy shock would affect domestic interest rates more than a foreign monetary policy shock. In other words, we impose another condition along with the sign restrictions that differentiates the EMAS and USEUR monetary policy shocks indicated by the notation in the table "< (3,3)". Similarly, in the case of the aggregate supply and demand shocks, this same assumption is used for inflation and output growth, respectively.

The variance decomposition of EMAS real credit growth using this alternative approach is shown in **Figure 5**. As before, in terms of explaining the variability of EMAS real credit growth, domestic factors are more dominant than the external factors. However, achieving these results is computationally very expensive. Namely, the acceptance was about seven valid draws out of over 10 million candidate draws. In addition, as expected, applying the Fry and Pagan (2010) MT method to generate meaningful variance decompositions and impulse response functions is also very computationally expensive. Recall that this is quite a parsimonious seven-variable two-country SVAR. Therefore even slight extensions could make the curse of dimensionality more acute rendering computation of meaningful quantitative results virtually infeasible as discussed above. This practical reality seems to highlight the contribution of our block-Cholesky-sign restrictions identification strategy introduced in this paper.

Second Alternative Approach

To assess the robustness of our results further, we also consider the classical Cholesky approach whereby shocks are identified owing to the imposition of a recursive structure. The variables are ordered as shown in the vector Z_t, see equation (1). Using the Cholesky decomposition implies that a seventh shock is identified, which warrants economic interpretation. Because this shock is associated with EMAS real credit growth, it will be interpreted as a domestic credit shock.

The results based on the recursive Cholesky structure are shown in **Figure 6**, and once again indicate the importance of domestic shocks in terms of accounting for EMAS real credit variation. Domestic credit shocks explain a large proportion of real credit growth in emerging Asia, and may reflect, in part, how lower lending standards (or government policies, for example, in the case of China) trigger an expansion of credit. The large share of credit growth variability attributed to the credit shock should also not be too surprising given the persistence of the real credit series and the statistical nature of the Cholesky identification scheme. Nonetheless, as before, in terms of emerging Asian credit growth, domestic, rather than external factors are more important.

It should also be noted that our main findings do not change if we remove the sign restrictions on real credit growth, if we switch the ordering of variables in the case of the "pure" Cholesky decompositions, and if we increase the horizon of the sign restrictions (along with the contemporaneous restrictions with $k = 0$, we also tested restrictions up to $k = 0, \cdots, 3$, that is, the sign restrictions on the impulse response functions would be imposed for up to one year give the quarterly frequency of our dataset).

Any Differences Over Time?

Figure 6 also shows how the results evolved over time. In particular, the role of the domestic nonmonetary shocks (aggregate demand and supply shocks), has increased in the post-2000 subsample, and is likely to be associated with increased regional integration. More importantly, domestic monetary policy accounts for a larger share of EMAS credit variation than foreign monetary policy, a proxy for global liquidity conditions, which influences capital inflows to the region. While the role of domestic monetary policy seems to have decreased somewhat in the post-2000 sub-sample, probably on the back of increased financial openness, it still plays a more prominent role relative to its foreign counterpart in terms of real credit dynamics overall.

Any Differences Within the Region?

To gain deeper insight on credit dynamics within the region, the model estimated using the data for each country individually. To further assess the robustness of the main results, two approaches are used to identify shocks: the first is the identification strategy proposed in this paper, namely combining sign restrictions with a block-Cholesky recursive structure, and the second approach is to use only the classical Cholesky decomposition. These results are then compared with various structural characteristics to get a better idea of what country-specific factors are most relevant in driving credit dynamics across the region.

Heterogeneity across the region implies a few notable findings. As before, and highlighted in **Figure 7** (both panels), domestic shocks are generally more important relative to external ones in terms of explaining credit variability across each economy in the region. This seems to be the case using both shock identification approaches.

Any Role for Exchange Rate Flexibility?

As a first pass at trying to understand heterogeneity across the region better, the results from the country-specific variance decompositions discussed above are compared to various structural characteristics of the economies within the region (for example, exchange rate regime, trade openness, and financial openness). The most compelling results are shown in **Figure 8**, which indicate that countries with more flexible exchange rate regimes (for example, Indonesia, the Philippines, and Thailand, as indicated by the Levy-Yeyati and Sturzenegger, 2005, index) are characterized by a lower share of external factors driving credit growth (the correlation is –0.6). Greater exchange rate flexibility acts as a shock absorber by smoothing out cyclical fluctuations that affect credit dynamics, and also helps mitigate the build-up of financial imbalances.

Summary

In sum, analyzing the variance decompositions reveals three main policy implications: First, domestic factors are more dominant than external factors in driving rapid credit growth in Asia. Second, and related to the first, this is particularly true for domestic monetary policy, which accounts for a larger share of real credit variability in emerging Asia than its foreign counterpart. Third, greater exchange rate flexibility could also promote financial stability as it reduces the role of external factors affecting domestic credit dynamics. Furthermore, additional checks seem to argue that these results are quite robust. It should also be noted, ordering of variables when using recursive identification schemes do not change these main conclusions. Also, sign restrictions were implemented using longer time periods (in contrast to just contemporaneous restrictions), and these also do not alter our main conclusions.

B. Impulse Response Functions

Using the baseline specification with shocks identified using a combination of sign restrictions and a recursive structure across the two blocks, we now provide an overview of the impulse response analysis. The impulse response functions to the six shocks are shown in **Figure 9** through **Figure 14**, and include the 5^{th}, 50^{th} (the median), and 95^{th} percentiles. The impulse response functions show the percentage point deviation from the mean owing to a 1 standard deviation shock. Furthermore, the medians using the Fry and Pagan (2010) MT method for our baseline identification scheme, and to assess sensitivity, the ones using the alternative identification approach are included. Recall that, as emphasized by Fry and Pagan (2010), the percentiles—including the median—convey the distribution across models and, therefore, has nothing to do with sampling uncertainty. In what follows, we focus on three shocks: domestic aggregate demand (given its importance highlighted in the variance decompositions above) and the two monetary policy shocks, given their relevance in terms of policy. The goal here is to give a bit of insight on the dynamics of the SVAR before moving onto another set of main quantitative results discussed in detail in the next section.

The dynamic reactions of the system variables to a domestic aggregate demand shock are shown in **Figure 10**. First note the impact of the aggregate demand (AD) shock on EMAS real GDP growth. While the shock affects domestic growth on impact by construction owing to the imposed sign restrictions, the identification scheme does not affect the strength of the impact. By contrast, the domestic AD shock has a protracted effect on domestic short-term interest rates, and implies a hump-shaped inflation reaction. As for domestic credit, note the sharp contraction lasts about two quarters.

Monetary Policy Shocks

Jumping ahead to **Figure 14** indicates that the foreign monetary policy shock does not have a sizable bearing on credit, but seems to affect EMAS real GDP growth on impact. Higher international rates (which to an extent indicate tighter global liquidity conditions) may have an adverse impact on EMAS growth owing to a "sudden stop" of capital flows as discussed in Calvo, Iquierdo, and Mejia (2004). However, while external sources of funding may dry up, this need not necessarily imply a credit drought. Recall that, as discussed above, capital inflows may fund other asset classes besides credit including, for example, real estate, equity, and corporate bonds. Moreover, as shown in **Figure 1**, credit growth actually increased in China during the global financial crisis, which intensified after the Lehman Brothers bankruptcy (owing to Chinese countercyclical policies).

Turning back to **Figure 11** shows, by contrast, that domestic monetary policy seems to affect credit on impact. While the impulse response in the initial quarter could be affected by the identification strategy, credit seems to decline rather sharply in response to a contractionary monetary policy shock over at least two quarters as indicated by the Fry-Pagan MT median. This suggests that EMAS monetary policy could be a key role in terms of managing credit growth in emerging Asia.

C. Counterfactual Scenarios

In this section, two illustrative scenarios serve to underscore the pivotal role of monetary policy in terms of influencing credit growth in emerging Asia. In what follows, the SVAR model is used to construct two scenarios: the first offers a historical perspective, while the second is forward looking and suggests that the monetary response to the immediate macroeconomic stability risks should be balanced by the possibility of lingering financial imbalances over the medium term.

Historical Scenario

The first illustrative scenario offers a historical perspective and seeks to address the following question: what if emerging Asia's monetary policy was not expansionary once the recovery after the global financial crisis gained traction? This scenario is presented in

Figure 15, which warrants clarification. For the recent period, it shows the actual evolution of emerging Asia real credit growth (bold black line), along with average real credit growth over the entire sample shown with a dotted line (8.9 percent). The counterfactual path of real credit is shown with the dashed line. The shaded area, spanning the year starting in 2008:Q4, corresponds to the most severe phase of the global financial crisis and also overlaps with growth rates lower than 4.6 percent, indicating a *growth* recession. Starting in end-2009, the recovery gains traction, and emerging Asia expands by 7.5 percent on average.

What Role for Monetary Policy?

As shown in **Figure 15**, monetary policy in emerging Asia can be effectively used to manage periods of rapid credit growth. Over this period, it turns out that the monetary policy shocks were all expansionary. In fact, during the 2008:Q4–2010:Q4 period, these shocks corresponded to a decrease in short-term rates of about one percentage point. The counterfactual scenario is constructed by setting the (expansionary) monetary policy shocks to zero. As shown, the counterfactual scenario indicates that without the monetary stimulus during the expansion, average credit would have been closer to its historical average. Overall, this illustrative scenario suggests that monetary policy in emerging Asia has a significant impact on real credit growth.

Forward-Looking Scenario

In an effort to highlight possible risks, this second illustrative scenario, which is forward-looking in nature, asks the following: how might credit growth evolve if the current emerging Asia monetary policy stance remains on hold and what are the risks associated with such a scenario? The illustrative scenario is depicted in **Figure 16**, showing a two-year forecast horizon up to end-2012 in light blue, a gray shaded area corresponding to a growth recession (growth was below the sample average of 4.6 percent), the actual real credit growth rate (bold black line), and its historical average (dotted line). The horizontal dashed line corresponds to a level of real credit growth which, based on Elekdag and Wu (2011) may serve as an illustrative warning threshold above which real credit growth may be excessive (in that *real* credit growth over this level is more likely to be associated with a credit bust). The model-based forecast is the baseline, and is shown with the dashed black line and gradually converges to the historical average (albeit at a much slower rate after 2011).

Focusing on the forecast horizon, the first illustrative scenario is shown with the blue line along with 90 percent non-symmetric confidence bands in dashed blue (**Figure 16**). This credit growth scenario is based on the monetary stance that prevailed during the recovery (2008:Q4–2010:Q4), and is maintained over the two-year forecast horizon ending in 2012. This scenario implies that short-term interest rates are about 1 percentage point lower than the historical average. In addition, a second illustrative scenario is depicted with the orange line which overlays looser foreign monetary policy (corresponding to the monetary policy stance in the foreign block during the immediate aftermath of the Lehman Brothers bankruptcy).[5]

Three points worth underscoring are as follows:

- First, barring major global economic disruptions, if the current stance of monetary policy continues going forward, then credit growth in emerging Asia is likely to be higher than the baseline and follows an upward trajectory as indicated by the blue line.

- Second, credit is more likely to grow faster, rather than slower, under this scenario, as indicated by the non-symmetric 90 percent Bayesian confidence bands (in dashed blue). By end-2012, there is a one in three chance that real credit growth in emerging Asia will exceed the warning threshold discussed above.

- Third, while an increase in global liquidity in line with the 2009 experience could surely exacerbate credit growth throughout the region (indicated by the orange line), the impact seems to be more modest.

Overall, these scenarios underscore that domestic monetary policy plays a pivotal role in terms of guiding credit growth. Moreover, they serve to illustrate that the monetary response to the immediate macroeconomic downside risks should be balanced by measures to manage the risks associated with lingering financial imbalances over the medium term. Country-specific circumstances need to be recognized, but these illustrative scenarios highlight that if the current loose monetary policy stance within the region continues over the near term it could exacerbate financial imbalances, which have a tendency to end abruptly.

V. Conclusions

Episodes of rapid credit growth (credit booms) have been associated with crises. In fact, Asian credit booms have been characterized by a higher incidence of crises relative to all other emerging economies, including banking, currency, and debt crises. Against this backdrop, this paper seeks to uncover the main drivers of credit growth in emerging Asia using a structural empirical model.

This paper contributes to the literature by proposing a novel identification strategy in the context of multi-country structural vector autoregressive (SVAR) models. In particular, we present a two-country SVAR whereby shocks *within* the blocks are identified using sign

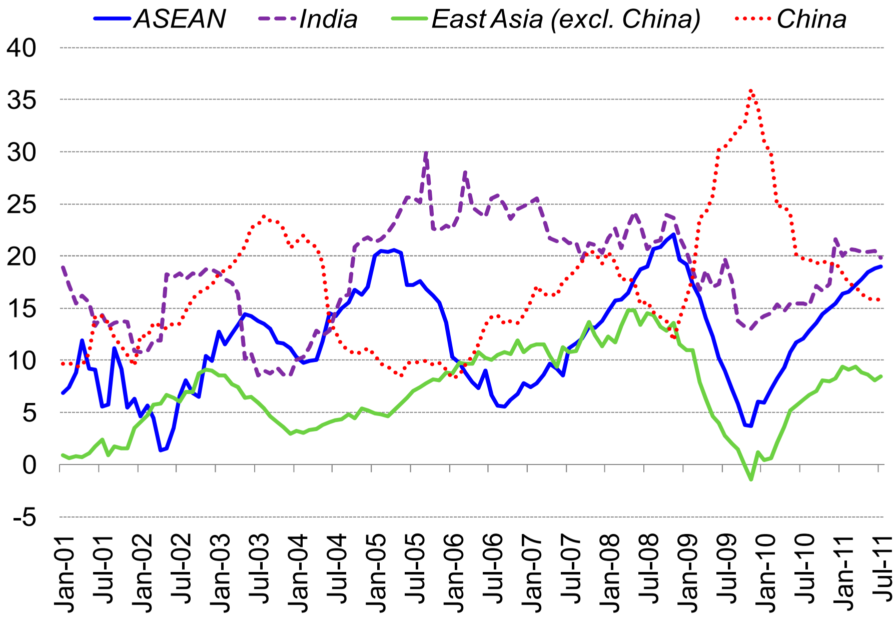
[5] Given the low level of nominal policy rates in the United States and the euro area, while the same cut in interest rates is not possible, nonconventional policies ("quantitative easing") is still an option. This scenario assesses the impact on EMAS real credit growth owing to a significant loosening of foreign monetary policy.

restrictions, whereas shocks *across* the blocks are identified using a recursive (block-Cholesky) structure. Specifically, underpinned by a three-equation New Keynesian framework a monetary policy, aggregate demand, and aggregate supply shock are identified *within* each block using sign restrictions. However, the classical recursive (block-Cholesky) structure is imposed to identify shocks *across* the two blocks consisting of (i) emerging Asia and (ii) the United States and euro area. Therefore, while one block can affect the other contemporaneously, feedback in the opposite direction occurs with a one-period lag. Such feedback is important because it does not seem realistic to posit emerging Asia (which includes economies such as China, India, Indonesia, Korea, Singapore, and Hong Kong SAR) as a small open economy.

A subtle contribution of our proposed identification scheme is that despite jointly imposing a combination of sign restrictions with a block-Cholesky recursive structure, it is computationally less expensive than alternative identification schemes using sign restrictions in many other two-country SVARs. This is important because it facilitates the utilization of the Fry-Pagan MT method needed to resolve the multiple models problem thereby generating meaningful forecast error variance decompositions, impulse response functions, and other quantitative results.

The main conclusions of this paper are as follows: first, domestic factors are more dominant than external factors in driving rapid credit growth in Asia. This is particularly true for domestic monetary policy, which plays a pivotal role in terms of guiding credit growth. Second, greater exchange rate flexibility could also promote financial stability as it reduces the role of external factors affecting domestic credit dynamics. Third, in terms of policy implications, a pause in monetary tightening may be appropriate for some economies in view of the current exceptionally uncertain global growth prospects relevant at the time of writing, but policymakers need to keep in mind the possibility of lingering financial imbalances over the medium term.

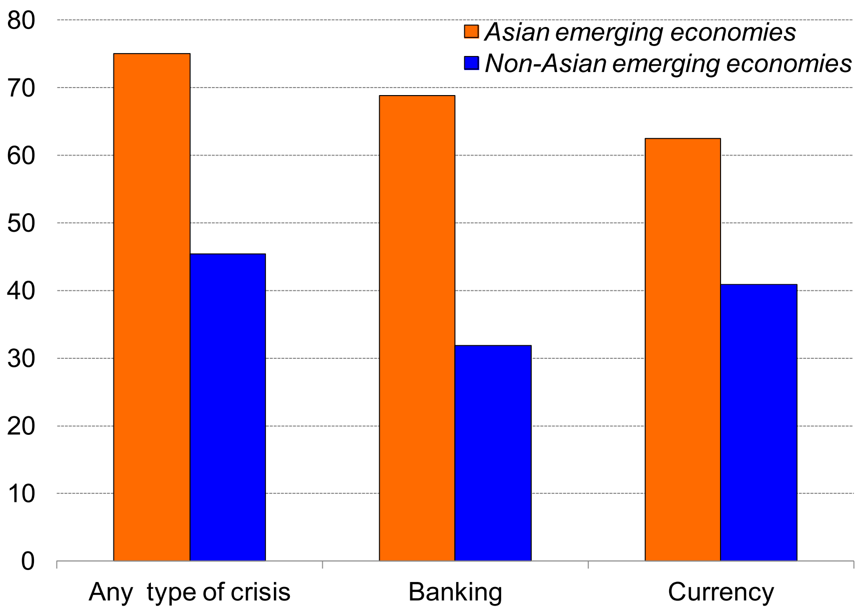
Figure 1. Emerging Asia: Nominal Credit to the Private Sector



Source: CEIC Data Company Ltd.; Haver Analytics; and Authors' calculations.

Note: Year-over-year percent changes, ASEAN includes Indonesia, Malaysia, the Philippines, and Thailand.

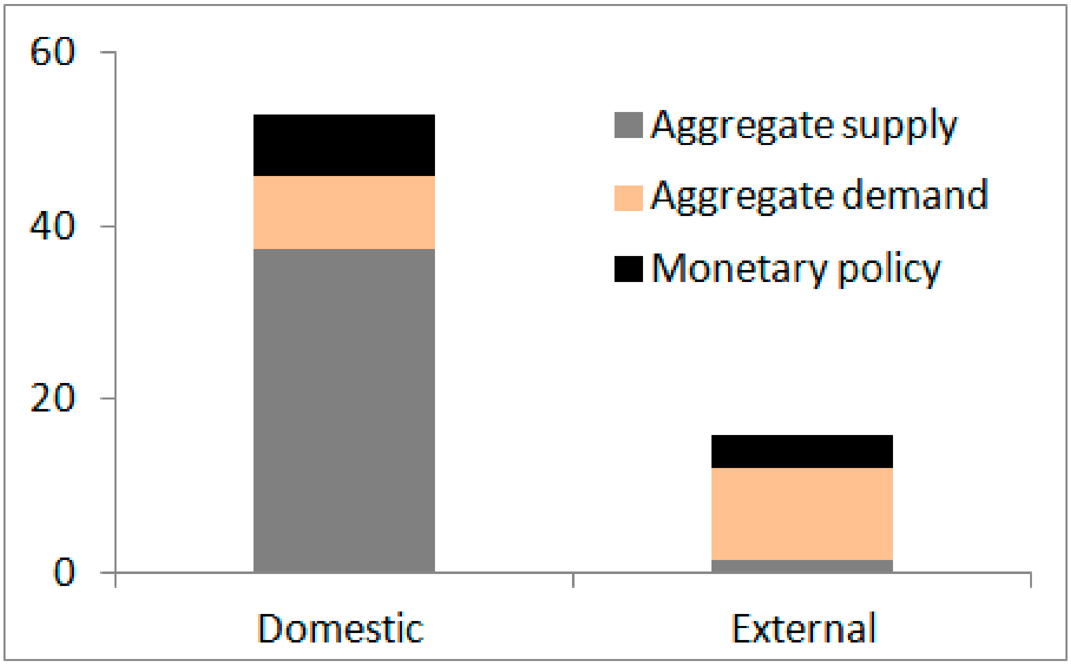
Figure 2. Crises Associated with Emerging Market Credit Booms



Source: Authors' calculations.

Notes: In percent of respective booms, taken from Elekdag and Wu (2011).

Figure 3. Are Domestic or External Shocks More Important in Driving Emerging Asia Real Credit Growth?



Source: Authors' calculations.

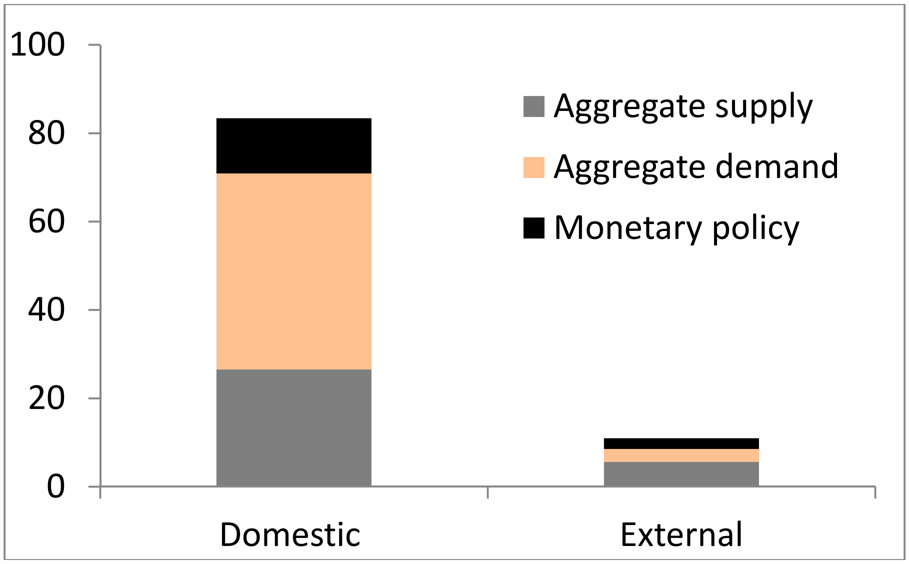
Notes: In percent. Figure displays a variance decomposition reporting the percent of emerging Asia real credit growth variation explained by the domestic (emerging Asia) and external (U.S. and Europe) aggregate supply, aggregate demand, and monetary policy shocks.

Figure 4. Remaining Macroeconomic Variables: Variance Decompositions

Source: Authors' calculations.

Notes: In percent. Variance decomposition report the percent variation in a variable explained by the aggregate supply, aggregate demand, and monetary policy shocks. For emerging Asia, external denotes the U.S. and Europe, and vice versa.

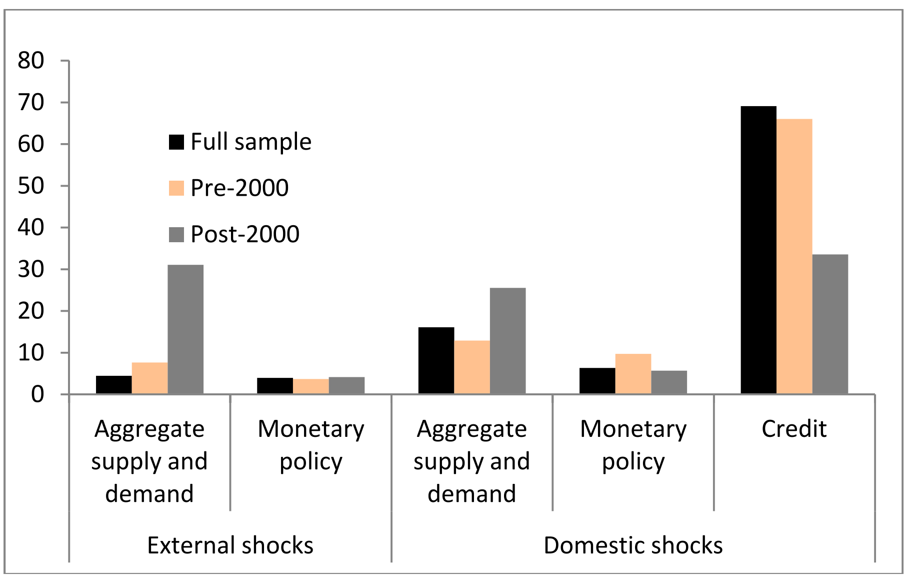
Figure 5. Robustness Analysis: Variance Decomposition of Emerging Asia Real Credit Growth



Source: Authors' calculations.

Notes: In percent. Variance decomposition report the percent of emerging Asia real credit growth variation explained by the domestic (emerging Asia) and external (U.S. and Europe) aggregate supply, aggregate demand, and monetary policy shocks.

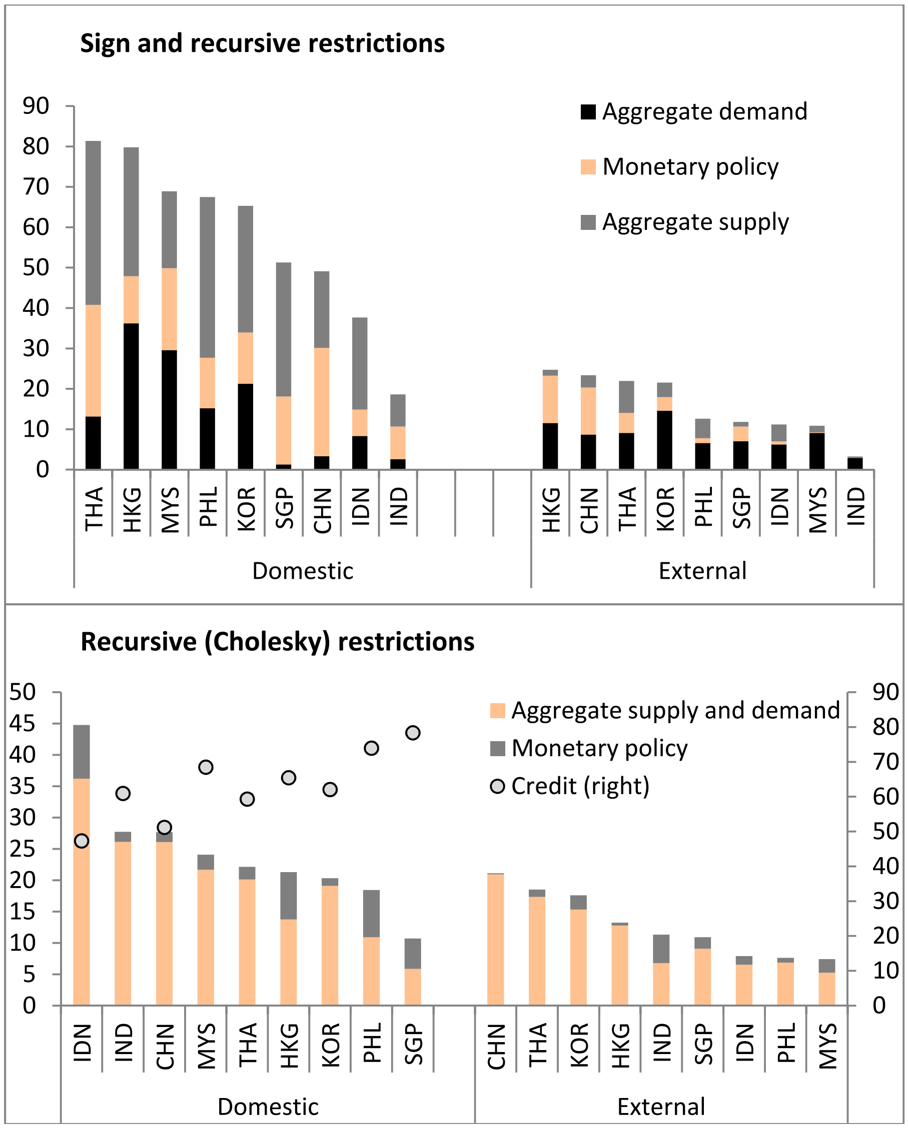
Figure 6. Evolution Over Time: Variance Decompositions of Emerging Asia Real Credit Growth



Source: Authors' calculations.

Notes: In percent. Variance decomposition report the percent of emerging Asia real credit growth variation explained by the domestic (emerging Asia) and external (U.S. and Europe) aggregate supply, aggregate demand, and monetary policy shocks.

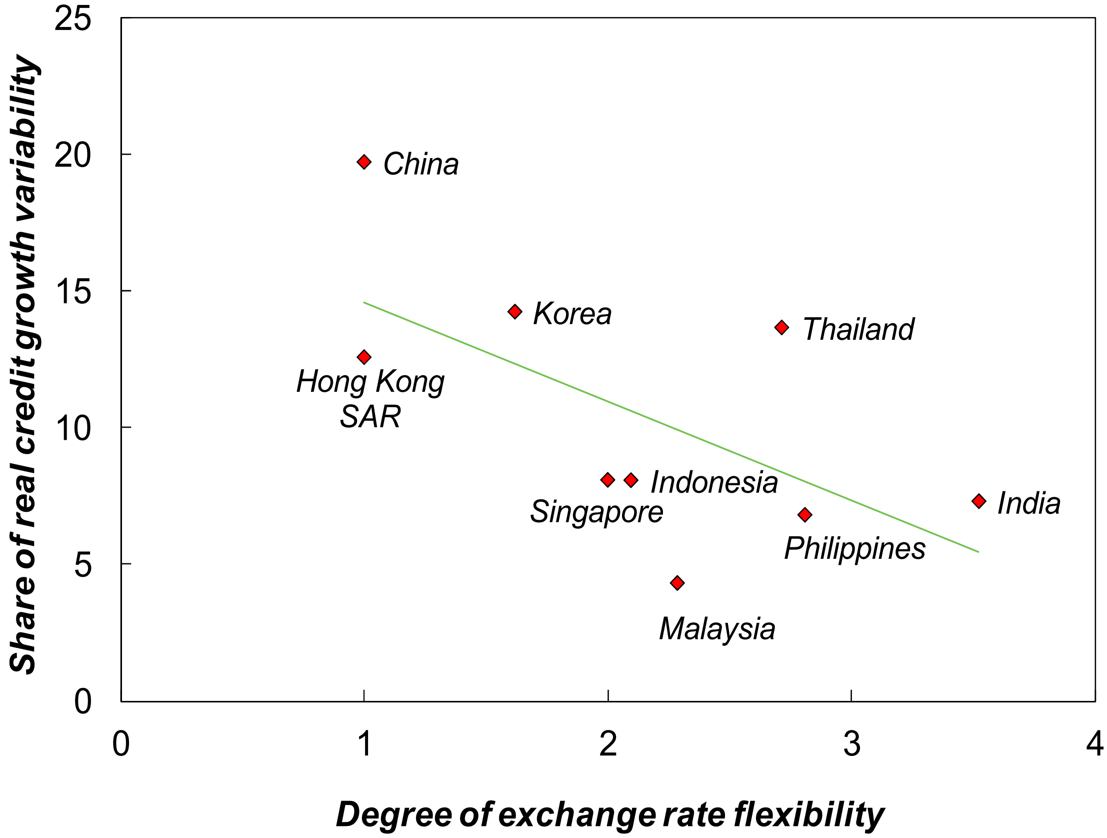
**Figure 7. Differences within Emerging Asia:
Variance Decompositions of Real Credit Growth**



Source: Authors' calculations.

Notes: In percent. Variance decompositions report the percent of real credit growth variation for individual emerging Asian economies explained by the domestic (emerging Asia) and external (U.S. and Europe) aggregate supply, aggregate demand, and monetary policy shocks.

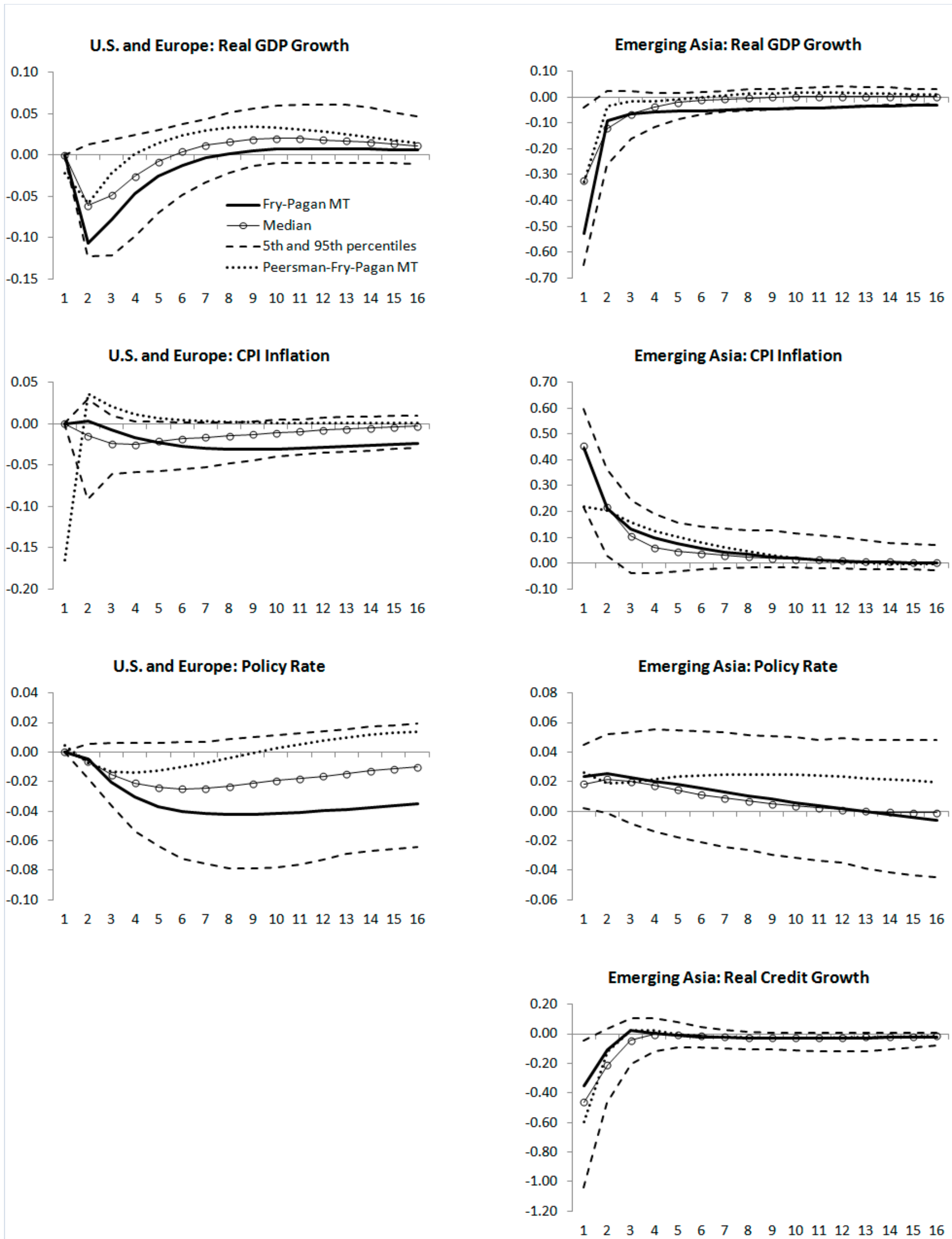
Figure 8. What Role for Exchange Rate Flexibility?



Source: Authors' calculations.

Notes: x-axis displays the degree of exchange rate flexibility as reported by the Levy-Yeyati-Sturzenegger (2005) index whereby higher numbers indicate a more flexible de facto exchange rate regime; y-axis reports the percent of real credit growth variation explained by the external shocks.

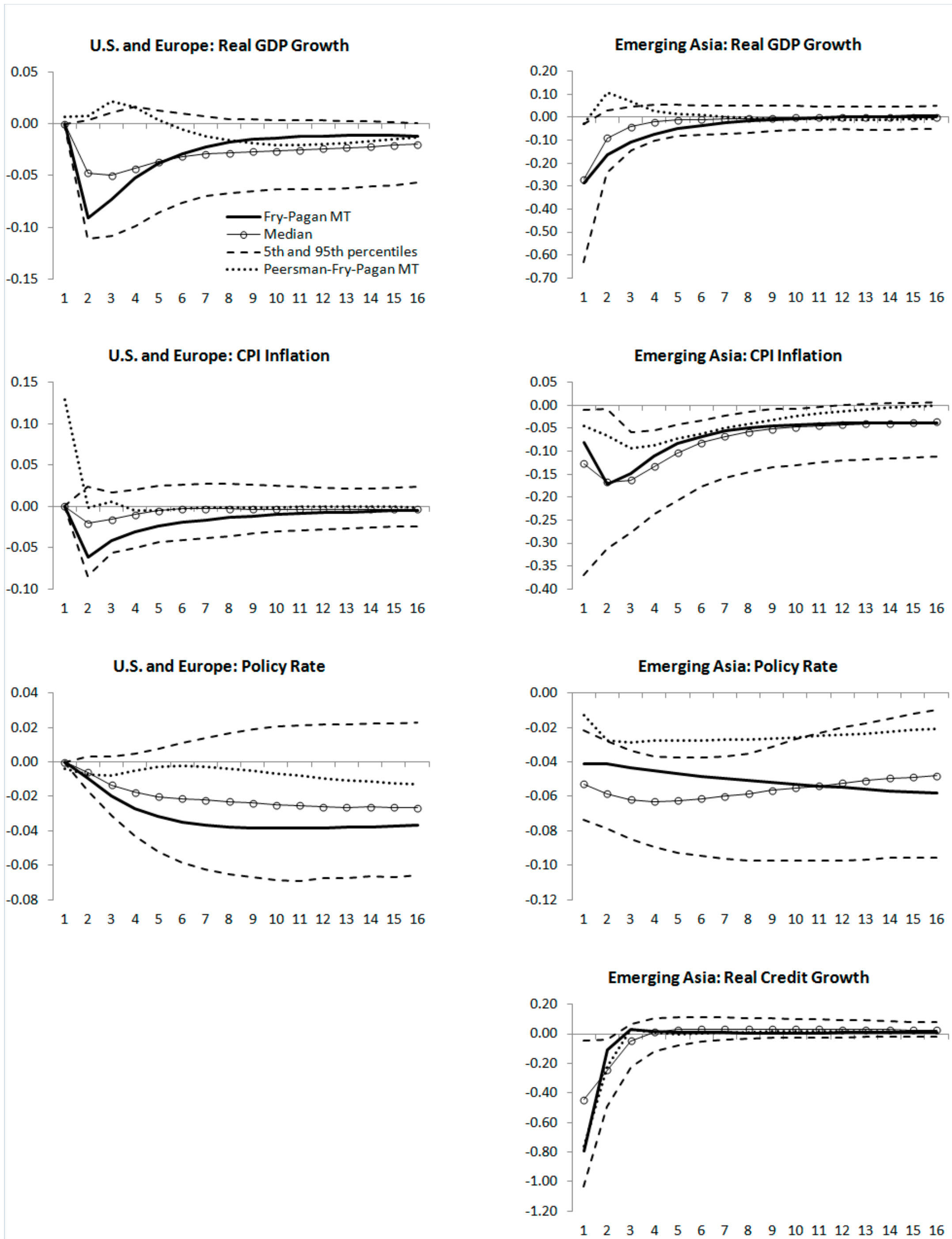
**Figure 9. Impulse Response Functions:
Aggregate Supply Shock: U.S. and Europe**



Source: Authors' calculations.

Note: One standard deviation shock, percentage point deviation from mean.

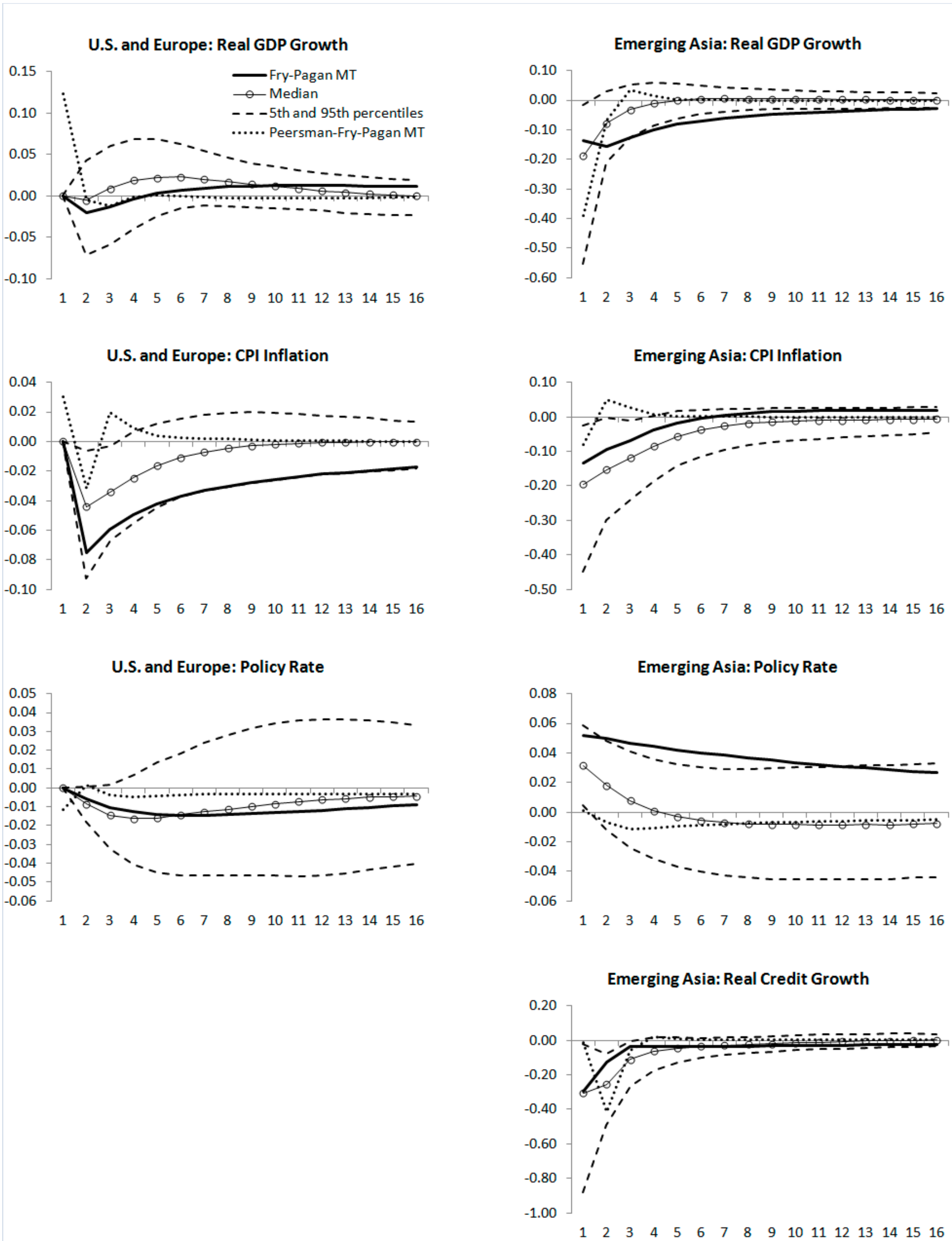
**Figure 10. Impulse Response Function:
Aggregate Demand Shock: U.S. and Europe**



Source: Authors' calculations.

Note: One standard deviation shock, percentage point deviation from mean.

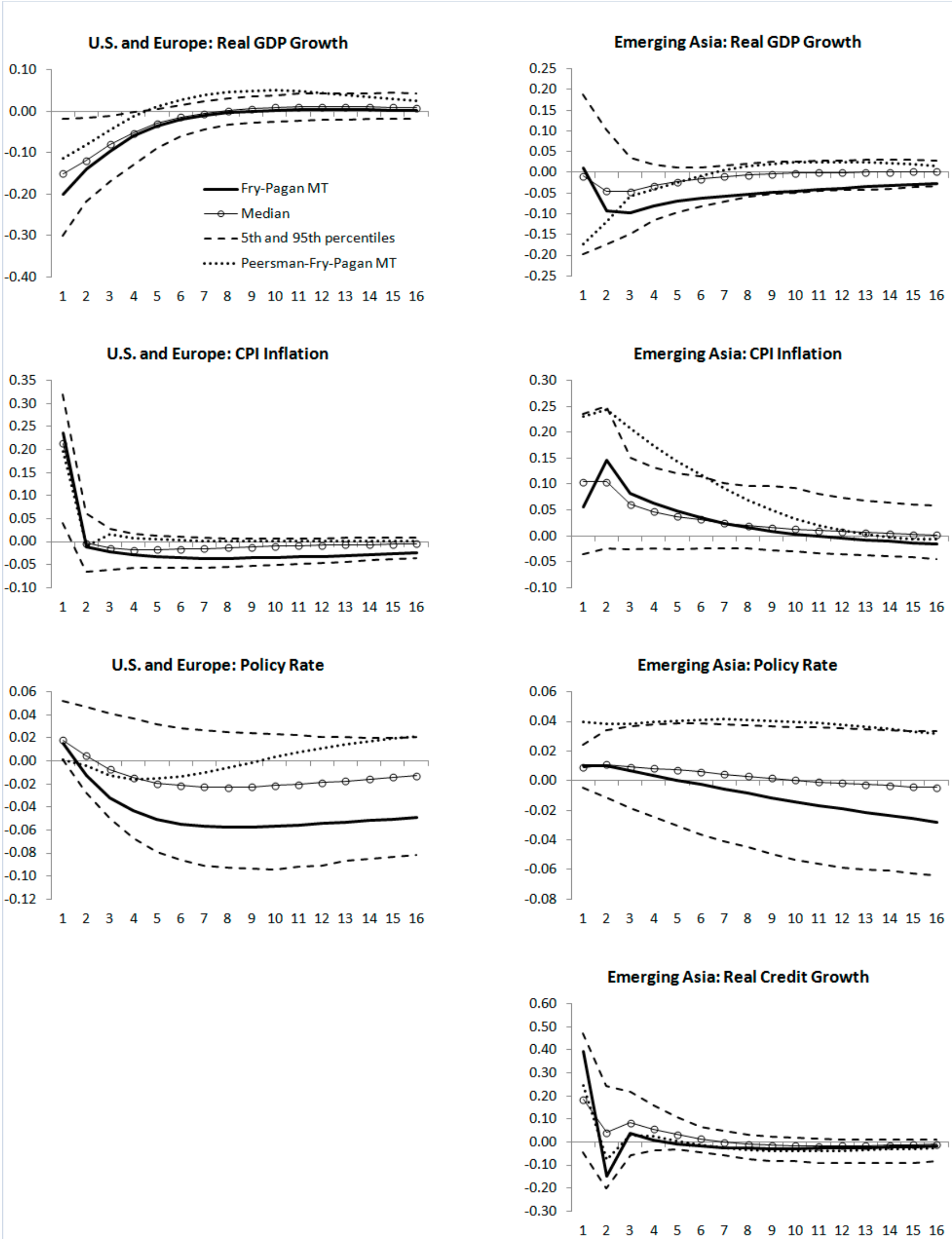
Figure 11. Impulse Response Functions:
Monetary Policy Shock: U.S. and Europe



Source: Authors' calculations.

Note: One standard deviation shock, percentage point deviation from mean.

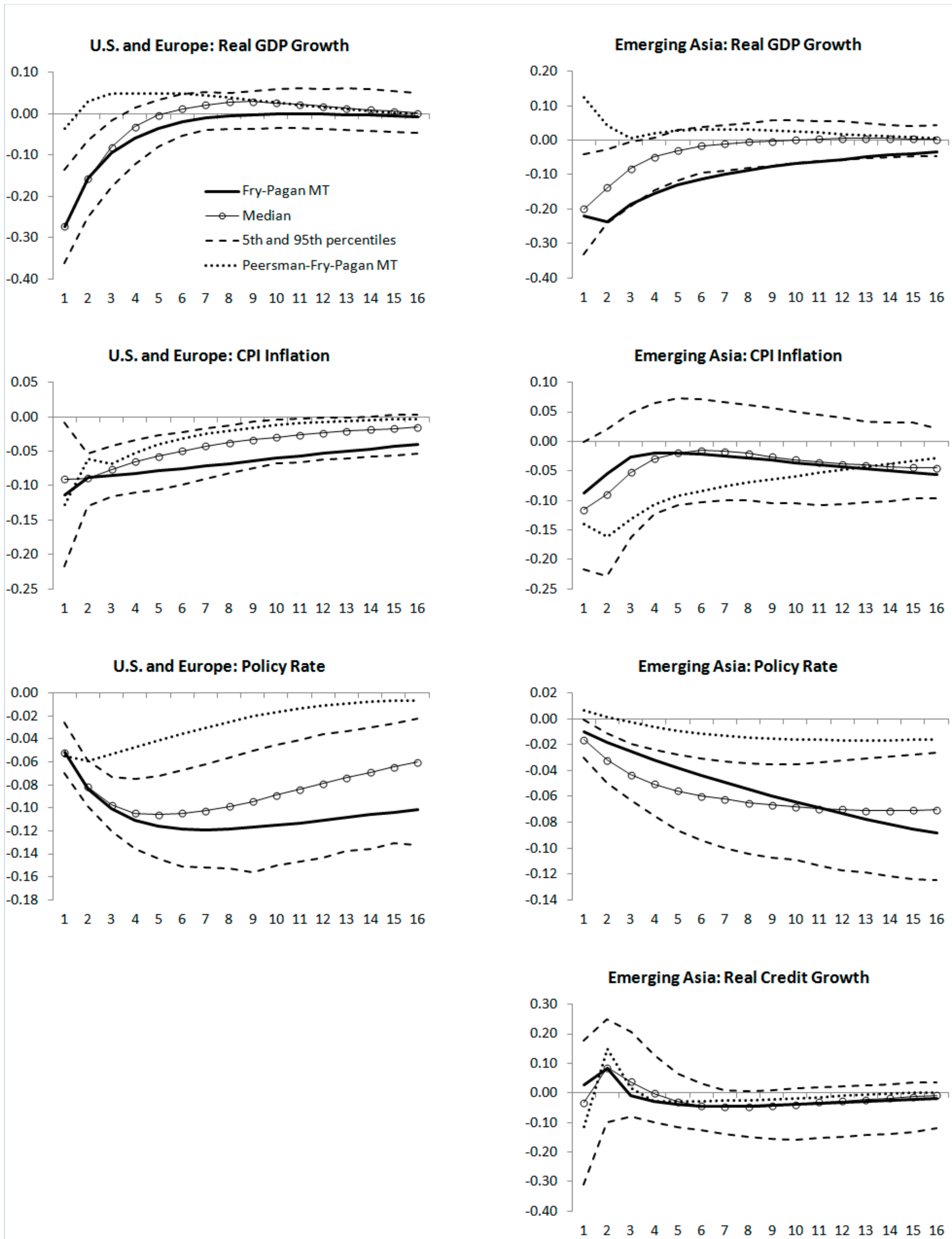
Figure 12. Impulse Response Functions: Aggregate Supply Shock: Emerging Asia



Source: Authors' calculations.

Note: One standard deviation shock, percentage point deviation from mean.

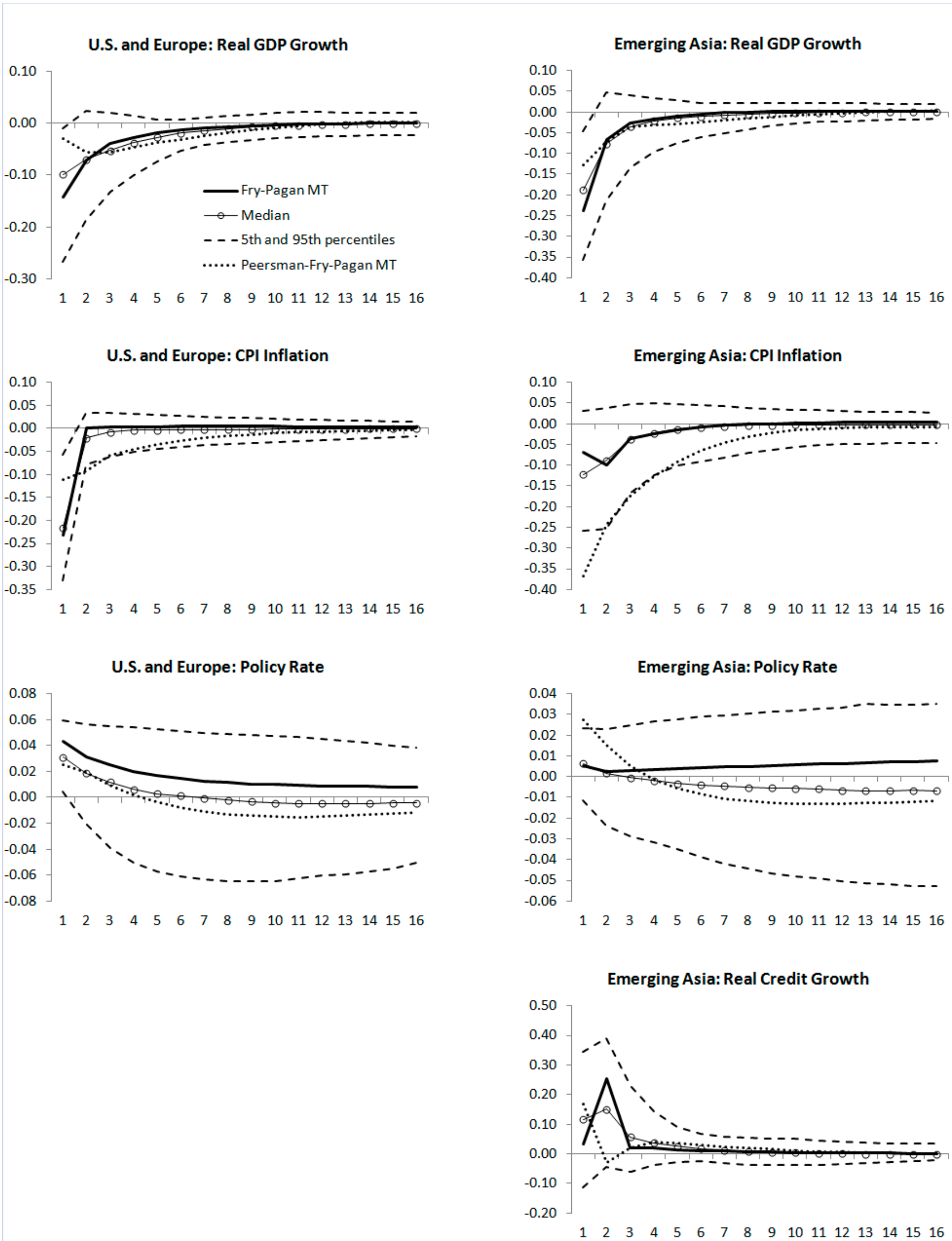
**Figure 13. Impulse Response Functions:
Aggregate Demand Shock: Emerging Asia**



Source: Authors' calculations.

Note: One standard deviation shock, percentage point deviation from mean.

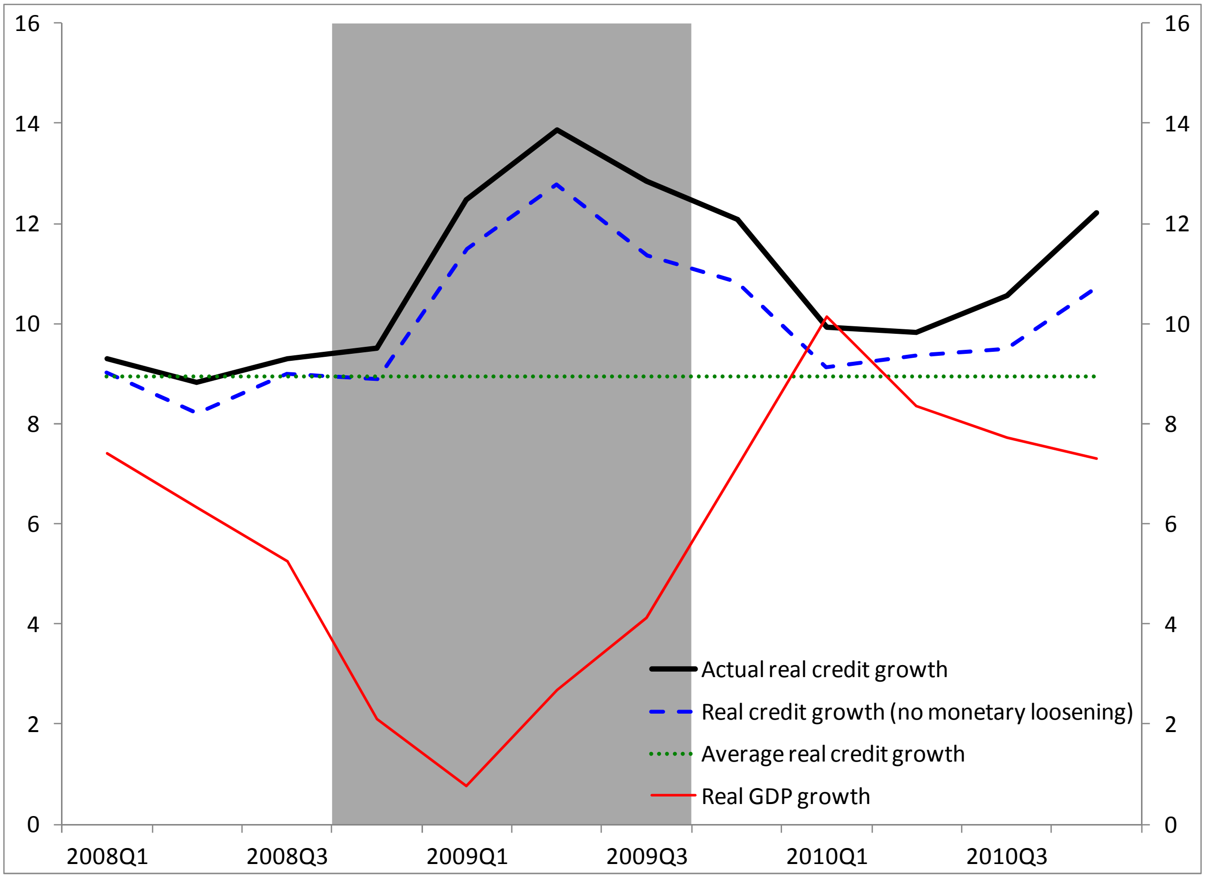
Figure 14. Impulse Response Functions: Monetary Policy Shock: Emerging Asia



Source: Authors' calculations.

Note: One standard deviation shock, percentage point deviation from mean.

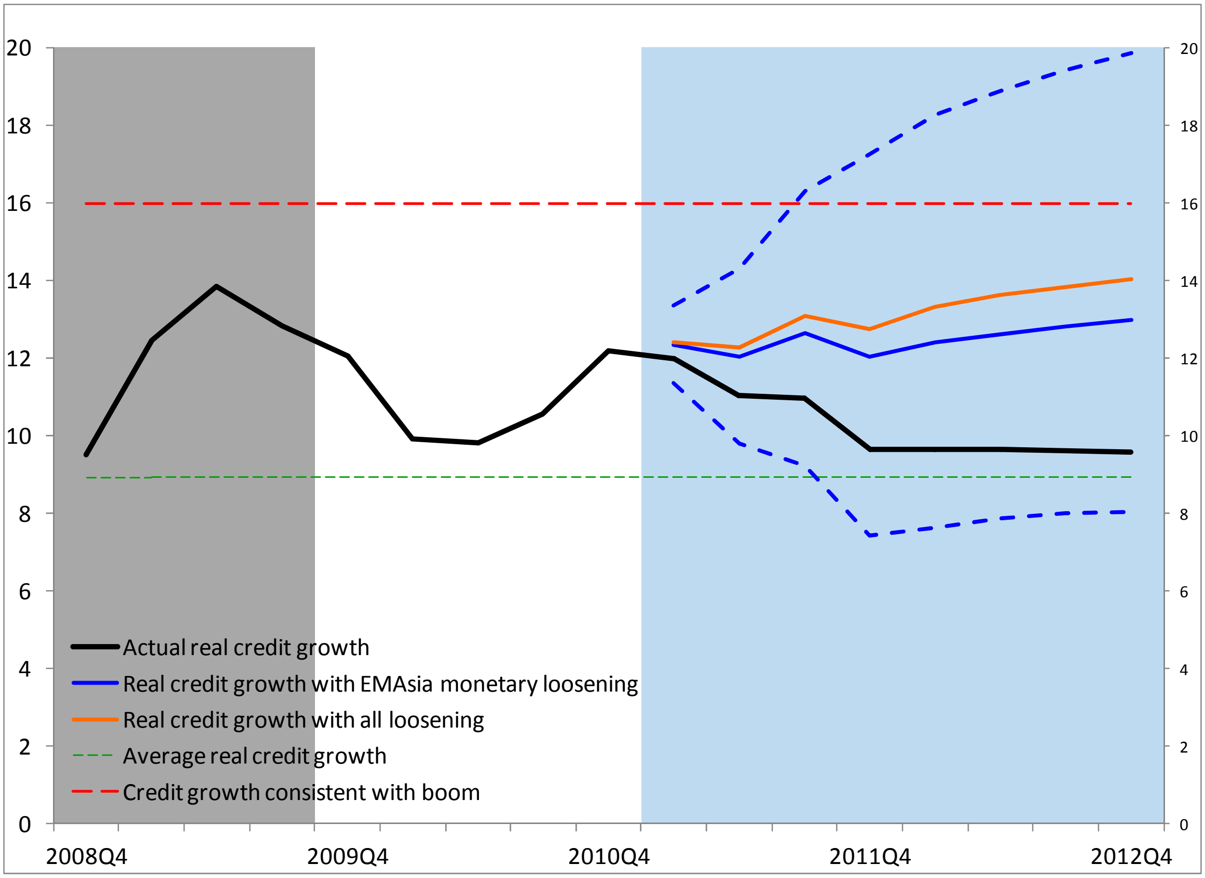
Figure 15. The Role of Domestic Monetary Policy on Real Credit Growth in Emerging Asia: Historical Counterfactual Scenario



Source: Authors' calculations.

Note: In percent, see table legend and text for further details.

Figure 16. The Role of Domestic Monetary Policy on Real Credit Growth in Emerging Asia: Forward-Looking Counterfactual Scenario



Source: Authors' calculations.

Note: In percent, see table legend and text for further details.

Table 1. Identification Strategy: Sign and Recursive (Block-) Cholesky Restrictions

	AS^{USEUR}	AD^{USEUR}	MP^{USEUR}	AS^{EMAS}	AD^{EMAS}	MP^{EMAS}
ΔlnY^{USEUR}	< 0	< 0	< 0			
$\Delta lnCPI^{USEUR}$	> 0	< 0	< 0		0	
i^{USEUR}	> 0	< 0	> 0			
ΔlnY^{EMAS}	?	?	?	< 0	< 0	< 0
$\Delta lnCPI^{EMAS}$	?	?	?	> 0	< 0	< 0
i^{EMAS}	?	?	?	> 0	< 0	> 0
$\Delta ln(Credit/CPI)^{EMAS}$	?	?	?	< 0	< 0	< 0

Source: Authors' calculations.

Note: Variables are the quarterly logarithmic growth rates of real GDP and CPI inflation and the level of short-term interest rates for both blocks (USEUR and EMAS), but only the quarterly logarithmic growth rate of EMAS real credit (credit scaled by CPI). Baseline model comprises three shocks: aggregate supply, aggregate demand, and monetary policy, denoted with AS, AD, and MP, respectively, with the superscripts corresponding to the two blocks. Table 1 presents a matrix where, for example, the first "< 0" represents the sign restriction for the contemporaneous impulse response of $\Delta \log Y_t^{USEUR}$ to AS^{USEUR} shock, that is, $IRF^{AS,USEUR}_{\Delta logY,USEUR}(0) < 0$, and the "0" represents the block-Cholesky decomposition (recursive restrictions across the blocks). As in the literature, "?" denotes the lack of any restrictions.

Table 2. Alternative Identification Strategy: Sign Restrictions Only

	AS^{USEUR}	AD^{USEUR}	MP^{USEUR}	AS^{EMAS}	AD^{EMAS}	MP^{EMAS}
ΔlnY^{USEUR}	< 0	< 0	< 0	?	< (1,2)	?
$\Delta lnCPI^{USEUR}$	> 0	< 0	< 0	< (2,1)	?	?
i^{USEUR}	> 0	< 0	> 0	?	?	< (3,3)
ΔlnY^{EMAS}	?	?	?	< 0	< 0	< 0
$\Delta lnCPI^{EMAS}$	?	?	?	> 0	< 0	< 0
i^{EMAS}	?	?	?	> 0	< 0	> 0
$\Delta ln(Credit/CPI)^{EMAS}$	?	?	?	< 0	< 0	< 0

Source: Authors' calculations.

Note: See Table 1 notes and Peersman (2005). Also note that in this alternative identification scheme it is assumed that a domestic monetary policy shock would affect domestic interest rate more than a foreign monetary policy shock (hence the entry "< (3,3)"). In other words, we impose another condition along with the sign restrictions that differentiates the EMAS and USEUR monetary policy shocks (see text for further details).

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