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Re-examining Symmetry of Shocks for East Asia: Results Using a VAR with Sign Restrictions

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Re-examining Symmetry of Shocks for East Asia: Results Using a VAR with Sign Restrictions*

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Abstract

I revisit the hotly debated topic regarding the possibility of introducing a common currency for East Asia from the point of view of shock symmetry. I first point out a serious problem of the existing studies which use the VAR method with long-run restrictions developed by Blanchard and Quah (1989) in that the signs of the impulse response functions to the same structural shock are not necessarily consistent across the countries. This means that the high (low) correlations of structural shocks do not necessarily imply low (high) costs of a common currency area. To overcome this problem, I apply the VAR method with sign restrictions developed by Uhlig (2005). I used the AD-AS model to impose sign restrictions on the responses of GDP and CPI to demand and supply shocks. One main finding is that demand shocks are significantly positively correlated among almost all East Asian countries. But overall, East Asia as a whole is not suitable for a common currency because correlations of supply shocks are low.

Keywords: Structural VAR, Long run restriction, Sign restriction, Symmetry of Shocks, Common Currency, East Asia.

JEL Classification: E32, F33, F41.

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1. Introduction

As economic integration is prevailing rapidly in East Asia, the discussion about a common currency (hereafter CC) for the region is gaining more and more attention from both academicians as well as policy makers. An important criterion to judge if a group of countries form an optimum currency area or not is *symmetry of shocks*, which is first proposed by Mundell (1961), and is related to the cost aspect of forming a common currency area (hereafter CCA). The reasoning is as follows. When a group of countries introduce a CC, they have to relinquish their independent monetary authority and a central bank of the region (like the ECB now) will take the authority to adopt one common monetary policy for the whole region. If shocks are symmetric between the countries, then monetary policy can be used to deal with the shocks. Conversely, if shocks are asymmetric, then monetary policy can not be utilized, and it is needed to use other policies in an asymmetric manner. In this latter case it is much more costly. Analyzing the symmetry of shocks, therefore, is an important task when considering a CC.

One popular method in the literature is the method of structural VAR developed by Blanchard and Quah (1989). Studies using this method are, among many others, Bayoumi and Eichengreen (1993, 1994), Zhang et al. (2004), Kawai and Motonishi (2005), and Kim (2007). Using a VAR model and imposing the so-called long-run restrictions, these studies identify structural shocks (e.g. demand and supply shocks) from time series data of (real) GDP, CPI etc. They then calculate the correlation coefficients by type of shocks between each pair of countries. These correlation coefficients are regarded as a proxy for symmetry of shocks, i.e. the higher they are the more symmetric are shocks between the countries.

In this paper, I revisit this topic. I first point out a serious problem of the afore-mentioned Blanchard-Quah VAR method in analyzing the symmetry of shocks. The problem is that with this method, the responses to the same structural shock are *not* necessarily consistent across the countries. By consistent here I mean "the impulse response functions having the same sign", the sign is positive if an economic variable increases in response to a shock, and negative vice versa. The inconsistency in the responses across the countries means that the high (low) correlations of the identified structural shocks do not necessarily imply low (high) costs of forming a CCA. This serous problem may invalidate the analysis results of the existing studies. Specifically, as exercises using Blanchard-Quah VAR and several East Asian countries' data on GDP and CPI show, there is a case in which GDP increases in some country while decreases in some other country in response to a positive demand shock. In this case, not symmetric but *asymmetric* demand shocks are desirable. More often is the case in which the responses of economic variables (GDP and CPI) show mixed results, for instance, they may be consistent between the countries in the long run but not in the short run or vice versa. In such a case it is more difficult to draw a conclusion about the relationship between the symmetry of shocks and the costs of forming a CCA. I go further to examine the identification procedure of the VAR with long-run restrictions and show that the results noted above are by no means surprising because the method per se only aims to identify two types of structural shocks, namely *temporary* and *permanent* ones, but does not warrant the consistency of the responses between the countries.

To overcome this problem, I utilize the structural VAR method with sign restrictions developed by Uhlig (2005). This method, as its name suggests, identifies a structural shock by imposing restrictions on the signs of the responses of economic variables to that shock. In the literature, this method has so far been used mainly to check the response of some economic variable to some kind of structural shock. Here, however, I apply it for the purpose of identifying structural shocks and calculating their correlations as a proxy for symmetry of shocks. I use Zhang et al. (2004) data set of GDP and CPI for ten East Asian countries and the US, and impose sign restrictions based on the AD-AS model to identify AD and AS shocks for these countries. Thus the shocks I obtain will, by definition, have the corresponding responses consistent with the AD-AS model and thus consistent across all countries.

The remainder of the paper is organized as follows. Section 2 briefly explains the concept symmetry of shocks and the application of the VAR method with long-run restrictions to calculate the symmetry of shocks in the existing studies, especially the ones regarding East Asia. Section 3 explains the identification procedure of the VAR with long-run restrictions, discusses its problems in calculating symmetry of shocks, and then explains the identification procedure of the VAR with sign restrictions. Section 4 analyzes the results obtained using the two methods. Section 5 concludes.

2. Symmetry of shocks and the application of the VAR method with long-run restrictions in the existing studies

Since the seminal work of Mundell (1961) symmetry of shocks has become one of the central criteria for judging whether or not a group of countries form an optimum currency area.[1] With the proceeding of European monetary unification (EMU), many studies such as Cohen and Wyplosz (1989), Poloz (1990), Eichengreen (1990)[2] tackle the task of computing the symmetry of shocks. These studies, however, have a shortcoming that they do not (or could not) analyze the symmetry of shocks and the response to shocks in the same framework. It was not until the work of Bayoumi and Eichengreen (1993) that this shortcoming was overcome. These authors use the structural VAR method with long-run restrictions developed by Blanchard and Quah (1989) to identify demand and supply shocks from time series CPI and GDP data, and then calculate their correlation coefficients as a proxy for shock symmetry. They also use the impulse response to calculate the speed of adjustment to shocks. They study the case of European countries, including eleven EC members, and compare with the regions in the US.

Later, this method was applied to other regions. Bayoumi and Eichengreen (1994) use a 2-variable VAR framework to study the prospects for monetary unification in various parts of the world. For the case of East Asia, some main contributions are as follows. Bayoumi, Eichengreen and Mauro (2000) use the same 2-variable framework to analyze the possibility of forming a CCA for ten ASEAN countries, while Zhang et al. (2004) adopt a 3-variable VAR model to study for the case of ten East Asian countries. In fact, the VAR with long-run restrictions is now becoming quite a popular method to calculate the symmetry of shocks, even in the area of policy discussion. An example is Kawai and Motonishi (2005), a policy discussion paper of Asian Development Bank (ADB) on monetary integration in East Asia.

[1] It is needed to note here that of course symmetry of shocks is not the only criterion. In this paper, however, I focus exclusively on it and thus do not consider other criteria as well as the topic of endogenous optimum currency areas argued by Frankel and Rose (1998). For a comprehensive and detailed explanation of the criteria of an optimum currency area, see De Grauwe (2004).

[2] See Bayoumi and Eichengreen (1993) for a survey of this literature.

In the literature, the reason for decomposing the movements of output and the price level into supply and demand parts is as follows. We keep in mind the behavior of the central bank in each country in response to shocks. We assume that the central bank derives its optimal monetary policy to minimize a loss function (say, a quadratic one) of inflation gap and output gap in terms of their equilibrium levels. The central bank will act to smooth out the movements of both inflation and output. The optimal monetary policy will differ depending on the type of shocks. In the case of a demand shock, for example a sudden decrease in private consumption, the AD line shifts downward causing both output and inflation to decrease, and the central bank will react by a monetary loosening. In the case of a supply shock, for example sudden a rise in oil price, the AS line shift upward, output decreases while inflation goes up, the central bank faces a trade-off and will respond with a tightened monetary policy to cool down inflation at the expense of output to some extent.

3. The identification procedure of structural VARs

In this section we will explain the basic identification procedure of the two structural VAR methods: the VAR with long-run restrictions and VAR with sign restrictions. We will also discuss problems arising when applying the former in computing shock symmetry, and then see how the latter is utilized.

As usual in the VAR literature, the estimation of structural VARs starts from estimating a reduced-form VAR model. For an illustrative purpose here and for the estimation purpose in the next section, we consider the case of a bivariate reduced-form

VAR as follows

$$x_t = B_0 + B_1 x_{t-1} + B_2 x_{t-2} + \ldots + B_p x_{t-p} + u_t \qquad (1),$$

where $x_t = \left(\Delta \log gdp_t, \Delta \log cpi_t\right)'$ is a 2×1 vector of data of real GDP and CPI at period t, $B_s\,(s=1,\ldots,p)$ are 2×2 matrices of coefficients to be estimated from data, u_t is a 2×1 vector of residuals, p is the lag length. We include a 2×1 vector of constant terms B_0 in the model. Let Σ be the 2×2 residual variance-covariance matrix. GDP and CPI are in first order log-differences to ensure stationary. Also, for the case of the VAR with long-run restrictions GDP must be in first order log-differences, for which the reason will be clear later. We use the OLS method to estimate. With the VAR model in (1) and data, we can obtain the estimated values of B_s and u_t, and hence Σ.

One point here is that structural shocks are assumed to be contained in the residual vector, and our task is to identify them. For the bivariate VAR in (1), we assume that there are two types of structural shocks, namely ε_{1t} and ε_{2t}. Conventionally, for simplicity, the structural shocks are normalized to have means equal to zero and variances equal to unity, and are mutually independent (put differently, their variance-covariance matrix is the unity matrix of size 2×2). Also, they are serially uncorrelated at all leads and lags. In addition, it is assumed that there exists a linear relationship between the shock vector $\varepsilon_t = \left(\varepsilon_{1t}, \varepsilon_{2t}\right)'$ and the residual vector u_t, i.e.

$$u_t = A\varepsilon_t \qquad (2),$$

where A is a 2×2 matrix. From (2), if we can identify matrix A then we can identify the structural shocks. With the assumptions noted above, one can obtain the following relationship between the two matrices Σ and A as follows

$$\Sigma = \mathrm{E}\left(u_t u_t'\right) = A\mathrm{E}\left(\varepsilon_t \varepsilon_t'\right) A' = AA' \qquad (3).$$

Since Σ is a 2×2 symmetric matrix and A contains four unknown elements, we need to impose one more restriction to identify A in (3). Almost the structural VAR approaches share the same identification discussed above. They are only different in the way the restriction is imposed. There are several ways of imposing. They can be ad hoc or based on some economic theory. An example of the former is to assume that A is a triangular matrix, and thus is identical to the Cholesky decomposition of Σ which is uniquely determined. Two examples of the latter are the long run restriction and sign restrictions which we focus on in this paper. Below, we will explain the procedure of them one by one.

3.1 The VAR with long-run restrictions: Identification procedure and problems in computing symmetry of shocks

This approach was first developed by Blanchard and Quah (1989) in a study to specify the effects of fundamental disturbances on economic fluctuations[3]. Bayoumi and Eichengreen (1993) apply this method in their study on the symmetry of shocks for European countries. Below we will explain the framework used by Bayoumi and Eichengreen, and we will continue to work with the system noted above. Two types of structural shocks, namely temporary shock ($\varepsilon_{tem,t}$) and permanent shocks ($\varepsilon_{per,t}$), are considered based on their effects on GDP. Using the AD-AS model, Bayoumi and Eichengreen interpret these shocks, respectively, as demand and supply shocks for that

[3] In Blanchard and Quah (1989), the two variables are unemployment rate and the first-difference of log real GNP. They consider two types of disturbances, one which has only temporary (or short-run) effects, and one which may have permanent (or long-run) effects on GNP. The effects of the two on unemployment rate are temporary.

demand shocks have only temporary effects on real output (these effects will disappear in the long run), while supply shocks can have permanent effects on real output.[4] Below, based on the AD-AS model, we will see if this interpretation is justifiable or not.

Now let us see in more detail how this long-run restriction works to identify the structural shocks. The following explanation is based on Enders (2004).

Suppose that matrix A has four elements to be identified as follows

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}.$$

Equation (3) implies the following three equations

$$a_{11}^2 + a_{12}^2 = \sigma_{u,gdp}^2 \quad (3.1),$$

$$a_{21}^2 + a_{22}^2 = \sigma_{u,cpi}^2 \quad (3.2),$$

$$a_{11}a_{21} + a_{12}a_{22} = \sigma_{u,cpi-gdp} \quad (3.3),$$

where $\sigma_{u,gdp}^2$, $\sigma_{u,cpi}^2$, and $\sigma_{u,cpi-gdp}$ are the variances of the first and second residual terms in (1), and their covariance, respectively. If the VAR system in (1) is stable, it is invertible and has a MA representation as follows

$$\begin{pmatrix} \Delta gdp_t \\ \Delta cpi_t \end{pmatrix} \equiv x_t = B_0 + B_1 x_{t-1} + B_2 x_{t-2} + \ldots + B_p x_{t-p} + u_t = B_0 + B(L)x_t + A\varepsilon_t$$

$$= [I - B(L)]^{-1}(B_0 + A\varepsilon_t) = [I - B(L)]^{-1} B_0 + [I - B(L)]^{-1} A\varepsilon_t$$

$$= [I - B(L)]^{-1} B_0 + \frac{1}{\det[I - B(L)]} \begin{pmatrix} 1 - b_{22}(L) & b_{12}(L) \\ b_{21}(L) & 1 - b_{11}(L) \end{pmatrix} \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} \varepsilon_{tem,t} \\ \varepsilon_{per,t} \end{pmatrix} \quad (4).$$

Here, L denotes the lag operator, and $b_{ij}(L) = \sum_{s=1}^{p} b_{ij,s} L^s$ with $b_{ij,s}$ the (i, j) element of

[4] For the effects on the price level, because CPI enters the system in (1) in first order log-differences, both types of shocks can have permanent effects on CPI, as we will see later.

the coefficient matrix B_s. From (4), one can see that the *long run* effect of one unit of the temporary shock at period t ($\varepsilon_{tem,t}$) on GDP is, by definition, the effect of the shock on GDP at infinity (gdp_∞) in (4), which is equal to the *accumulated* effect of the shock on the whole sequence $\{\Delta gdp_k\}_{k=t}^{\infty}$ and thus equal to $a_{11}[1-b_{22}(1)]+a_{21}[b_{12}(1)]$. Note that for this to be true, GDP must enter (1) in first-difference form. The long run restriction, thus, means that

$$a_{11}[1-b_{22}(1)]+a_{21}[b_{12}(1)]=a_{11}\left[1-\sum_{s=1}^{p}b_{22,s}\right]+a_{21}\left[\sum_{s=1}^{p}b_{12,s}\right]=0 \qquad (5).$$

With four equations (3.1)~(3.3) and (5), it is possible to solve for the four elements a_{ij} of matrix A, and the system is just-identified. It is worth noting that, once A is identified, a matrix made by changing the sign of any column of A also satisfies the system in (3.1)~(3.3) and (5). In practice, in statistical software packages like Eviews the matrix A is normalized such that its diagonal elements (i.e. a_{11} and a_{22} in this case) are nonnegative. This kind of normalization explains why the first impacts of the first shock on the first variable, and the second shock on the second variable shown in Eviews are always non-negative. It also affects the form of the impulse response functions, which we will see in the next section.

We now turn to discussing some problems of the VAR with long-run restrictions explained above when applying it to calculate shock symmetry. The first one is the problem of interpreting the identified structural shocks. Motivated by a traditional Keynesian view of economic fluctuations, Blanchard and Quah (1989) interpret the disturbances as demand and supply ones, respectively, for the reason that demand shocks are considered to have only short-run effects, while supply shocks can have long-run effects on output. For the same reason, but based on the AD-AS model, Bayoumi and Eichengreen (1993) also interpret the two shocks as demand and supply ones. My argument here is that even though we interpret the identified shocks as demand and supply ones, they are in essence temporary and permanent ones, respectively, as the VAR method with long-run restrictions suggests. Whether our interpretation is justified or not is left to the data. We can check this by looking at the responses of variables to shocks. It turns out in the next section that, for the case of East Asia with quarterly GDP and CPI data, the responses of GDP and CPI to shocks are *not* necessarily consistent with the AD-AS model. The second and most serious problem is that, the consistency of the responses to structural shocks across different countries is not warranted by the method of VAR with long-run restrictions. That is, the responses to the same shock can be opposite between different countries, for example GDP may increase in one country while decrease in another in response to a positive demand (≡temporary) shock, or CPI can increase in one country while decrease in some other in response to a positive supply (≡permanent) shock. The estimated results in the next section show that this is true in many cases. If the responses to shocks are different then simply taking their correlations does not make much sense.

3.2 An application of the VAR method with sign restrictions

To overcome the problems discussed above I utilize the VAR method with sign restrictions developed by Uhlig (2005). In the literature, this method has so far been used mainly to check the response of some economic variable to some kind of structural shock. For example, it was used to check the effect of a monetary shock on GDP in the Uhlig (2005), to analyze the effect of a technology shock on total hours worked in Braun

Table 2.1: The responses of GDP and CPI to positive demand and supply shocks in the short run and long run according to the AD-AS model

		Effects on GDP		Effects on CPI	
A demand shock	SR	+	(↑)	+	(↑)
	LR	0	(unchanged)	+	(↑)
A supply shock	SR	+	(↑)	−	(↓)
	LR	+	(↑)	−	(↓)

Step 1: I use the AD-AS model[5] to see how CPI and GDP respond to demand and supply shocks. As shown in Table 2.1, a positive demand shock increases both GDP and CPI in the short run, and increases CPI but does not affect GDP in the long run. A positive supply shocks increases GDP both in the short run and long run, while reduces CPI in both the short run and long run. The short run and the long run are defined as follows. Suppose that period 1 is the period when a shock occurs. The short run is defined to be the time interval from period 1 through

[5] See, for example, Dornbusch et al. (2001) for an explanation of the model in more detail.

period n_{SR}, and the long run is the time interval after period n_{LR}. The sign restrictions are imposed such that the responses of GDP and CPI to demand and supply shocks satisfy what is noted in Table 2.1. In addition, the effect of a demand shock on GDP must be close to zero from period n_{LR} and on.[6]

Step 2: I randomly generate a large number of the residual variance-covariance matrix Σ, and the VAR coefficient matrix $B=[B_0,...,B_p]$ $(n_{\Sigma B})$ as follows. From the estimated reduced-form VAR in (1) I obtain the estimated matrices $\hat{\Sigma}$ and $\hat{B}$. Next, I randomly generate Σ from the inverse Wishart distribution $invW(\hat{\Sigma}^{-1}/T,T)$, where T is the sample size. And conditional on Σ, I randomly generate matrix B's column-wise vectorized form $vec(B)$ from the Normal distribution $N(vec(\hat{B}),\Sigma\otimes(X'X)^{-1})$, where X is the data matrix of the independent variables in (1), and $\otimes$ denotes the Kronecker product.

Step 3: For each draw (B,Σ) generated in step 2, I randomly generate a large number (n_A) of matrix A as follows. I use the following results: given that A_0 is a matrix satisfying (3), then any other matrix A that satisfies (3) must satisfy $A=A_0Q$ where Q is an orthonormal matrix.[7] Here, I choose A_0 to be the Cholesky decomposition of matrix Σ and generate Q randomly by Q-R decomposing[8] a matrix generated from the standard Normal distribution $N(0,1)$.

Step 4: For each draw (B,Σ,Q), I calculate the *accumulated* responses[9] of CPI and GDP

[6] To express this, I set the absolute value of the impulse response function of GDP to the demand shock to be smaller than 0.001 from period n_{LR} and on. This is referred to as "range restriction" in Braun and Shioji (2006).

[7] That is, the columns (rows) of Q are mutually orthogonal and all have norm equal to unity.

[8] A relatively new version of Matlab provides a command for this decomposition.

[9] Because endogenous variables of the VAR in (1) are in first-differences, and the sign restrictions are

to one unit demand and supply shocks, and check if these responses are consistent with the AD-AS in both the short run and long run or not. If they are, I use this (B,Σ,Q) to calculate the series of demand and supply shocks from data and store them. I call this a valid case (or valid draw). If the responses are not consistent with the AD-AS model, I discard the corresponding (B,Σ,Q).

After finishing generating all the random draws and the calculation in step 2 through step 4, I obtain a certain number of valid cases (n_{valid}) and a set of corresponding structural shocks for each country. To be more concrete, I store the shocks obtained in a matrix $\Omega_{shock}^{(i,k)}$ of size $T \times n_{valid}$, where i denotes a country, k is the type of shocks ($k = demand, supply$). The matrices $\Omega_{shock}^{(i,k)}$ of all countries are used to calculate the correlations of each pair of countries as follows.

Step 5: For each pair of countries i and j, and the shock of type k, I calculate the correlation coefficient between the two matrices $\Omega_{shock}^{(i,k)}$ and $\Omega_{shock}^{(j,k)}$ column-wise. The result is a set $\Omega_{corr}^{(i,j;k)}$ of $n_{valid}^{i} \times n_{valid}^{j}$ values of the correlation coefficient. If n_{valid}^{i} and n_{valid}^{j} are reasonably large, $\Omega_{corr}^{(i,j;k)}$ is very large and can be considered to contain almost *all possible values* of the correlation coefficient. I then calculate and report the mean, maximum and minimum values of $\Omega_{corr}^{(i,j;k)}$ after cutting off its largest and smallest 2.5%. The correlation is said to be significantly positive (at the 5% level) if the minimum value (i.e. the critical value) is larger than zero.[10]

imposed on levels.

[10] I thank Etsuro Shioji for suggesting this way of testing if the correlation coefficient is positive. This is different from Zhang et al. (2004) who have to conduct a test based on the Fisher's variance-stabilizing transformation because their results are point estimates.

In general, with the sign restrictions imposed, the elements of Σ, B and A of the valid cases would lie in certain ranges. These ranges and the set of structural shocks Ω_{shock} obtained will depend on the strictness of the restrictions (i.e. n_{SR} and n_{LR}) and the numbers of random draws in steps 2 and 3 ($n_{\Sigma B}$ and n_A). The larger is n_{SR} and the smaller is n_{LR} (i.e. the stricter are the restrictions), the narrower are the ranges and the smaller is Ω_{shock}. In estimation, parameters are set as follows. Since our purpose is to calculate the correlations of structural shocks between the countries, it is desirable to have the set $\Omega_{corr}^{(i,j;k)}$ to be of the same size for all pairs of countries, which means that the number of valid cases (n_{valid}) should be the same for all countries. Therefore I set $n_{valid} = 300$. In addition, $n_A = 200$. Given these two parameters, $n_{\Sigma B}$ becomes "endogenous", i.e. the matrices (B, Σ) are drawn until we obtain enough number of valid cases. Thus, $n_{\Sigma B}$ can vary across the countries. The parameters for the time lengths of the short run and long run are set such that $n_{SR} = 30$ (equal to 7.5 years) and $n_{LR} = 100$ (equal to 25 years). Regarding these last two parameters, admittedly there is a little arbitrariness in setting them here because there is no explicit time length for the short run and the long run specified in the AD-AS model. Since the purpose of this paper is to identify shocks and calculate their correlations, I intend to, to some extent, narrow the ranges of elements of the matrices and thus the ranges of the correlation coefficients ($\Omega_{corr}^{(i,j;k)}$). It turns out from the results I have tried that, setting, for example, $n_{SR} = 10$ would widen these ranges, but setting $n_{SR} = 20$ or 40 does not change the results so much because the responses here are accumulated ones and are quite stable. Also note that recently there are some studies such as Peersman and Straub (2004), Dedola and Neri (2006), and Braun and Shioji (2007) which impose the sign restrictions in a more rigorous model-based sense. They adopt a theoretical model (in which the related variables in the VAR are included), simulate it and obtain the results for the responses of the corresponding variables which then are used as the sign restrictions in the VAR. It is interesting to extend this paper in this direction, and I leave it for a future study.

4. Data and estimation results

4.1 Data

Quarterly real GDP and CPI data of the US and ten East Asian countries, including Japan, Korea, Taiwan, Hong Kong, Singapore, Malaysia, Indonesia, Thailand, Philippines, and China were used for the analysis. The data set was provided by Kiyotaka Sato, a part of which was used in Zhang et al. (2004) and Sato and Zhang (2006). The sample period is 1975Q1-2003Q4, except for Korea (1975Q1-2003Q3) and China (1986Q1-2003Q4). Details about the data source are in Sato (2007).

All data were in logs and seasonally adjusted following the Census X-12 procedure. In addition, they were tested for unit roots using the Dickey-Fuller test. The test showed that the null hypothesis of having a unit root could not be rejected for each CPI and GDP series in levels, but their first-differences turned out to be stationary.

4.2 Results using the VAR method with long-run restrictions

In estimation of the reduced-form VAR in (1), as conventionally done in the literature when using quarterly data, I chose the lag length $p = 4$ (one year) for all countries.

Table 2.2: The signs of the responses estimated using the VAR with long-run restrictions

	Response of GDP to supply shock		Response of GDP to demand shock		Response of CPI to supply shock		Response of CPI to demand shock	
	SR	LR	SR	LR	SR	LR	SR	LR
AD-AS model	+	+	+	0	−	−	+	+
US	+	+	+	0	−	−	+	+
Japan	+	+	−	0	+	+	+	+
Korea	+	+	+	0	−	−	+	+
Taiwan	+	+	−	0	+	+	+	+
Hong Kong	+	+	−, +	0	+	+	+	+
Singapore	+	+	−	0	+	+	+	+
Malaysia	+	+	−	0	+	+	+	+
Indonesia	+	+	+, −	0	−	−	+	+
Thailand	+	+	+, −	0	+, −	+	+	+
Philippines	+	+	+, −	0	− +	−	+	+
China	+	+	+, −	0	−, +	+	+	+

Note: Results shown here are those for the point estimates. The time lengths for the short run (SR) and long run (LR) are defined such that $n_{SR} = 30$ and $n_{LR} = 100$ (see Sub-section 3.2).[11]

Now we see the results estimated using the VAR method with long-run restrictions. We focus on the responses of CPI and GDP to structural shocks. We will see whether or not these responses are consistent between the countries and with the AD-AS model. The results of the responses are shown in detail in Figure A2.1 in the Appendix, and are summarized in Table 2.2. Below in this sub-section we will use the labeling of shocks of Bayoumi and Eichengreen (1993), i.e. temporary shock and permanent shocks are demand and supply shocks, respectively. But it will turn out soon that this labeling is not justified.

[11] But the graphs in the Appendix are shown with the time horizon equal to 50. This is because 50 quarters is enough for CPI and GDP to reach their long-run levels in all cases.

The following results can be observed. First, overall, the responses of GDP to supply shocks and CPI to demand shocks are consistent with the AD-AS model. This is true not only for the case of point estimates but also for the confidence bands. Second, this result, however, is overturned when we look at the responses of GDP to demand shocks and CPI to supply shocks: only the two cases of the US and Korea are consistent with the AD-AS model in all four graphs, while all other cases are either mixed or inconsistent. Third, and most importantly, the responses are very different across the countries. For example, in response to a positive demand shock, GDP can either increase as in the graphs for the US and Korea, or decrease as in the cases of Japan, Taiwan, Malaysia and Singapore, or show up-and-down fluctuations when going from the short run to the long run as in the cases of Philippines, Thailand, Indonesia and China. The inconsistency across the countries can also be observed in the responses of CPI to a supply shock. For example, in response to a positive supply shock, CPI decreases for the cases of the US, Korea, Indonesia and Philippines, while increases for the cases of Japan, Taiwan, Hong Kong, Singapore and Malaysia, or decreases and then increases for the cases of Thailand and China.

The above results confirm what we discussed in the previous section. That is, the VAR method with long-run restrictions does not warrant the consistency of the responses to structural shocks across the countries. This causes a serious problem when using this method to compute the symmetry of shocks because as far as the responses to shocks are not consistent across the countries, the correlations of the shocks series cannot be used as a proxy for symmetry of shocks.

4.3 Results using the VAR method with sign restrictions

Figure A2.1 in the Appendix shows the responses of GDP and CPI to AS and AS shocks for 95% of the valid cases obtained from Step 4 in Section 3. It is easy to confirm that in all cases the responses are consistent with the AD-AS model. This is just what we intended to impose through the sign restrictions. Table A2.1 in the Appendix shows the number of draws of matrices (Σ, B) $(n_{\Sigma B})$ required to obtain 300 valid draws $(n_{valid} = 300)$ for each country. We can see that $n_{\Sigma B}$ varies largely between countries, and as a result the ratio $valid\_draw / total\_draw$ also changes across the countries. The highest values for this ratio are 2.41% for the US, and 1.09% for Korea in which cases there was at least one valid draw for each draw of the pair (Σ, B), while the smallest values are 0.02% for Singapore, and 0.04% for Japan in which cases there was no valid draw for many draws of the pair (Σ, B). Interestingly, the US and Korea are also the only countries where the point-estimate responses obtained using the VAR with long-run restrictions are consistent with the AD-AS model.

Now we look at the correlations of AD and AS shocks between the countries, which are regarded as a proxy for the symmetry of shocks as noted above. Tables 2.3 and 2.4 display the mean values of the correlation coefficients. We will analyze based on these tables.[12]

According to Table 2.3, regarding AD shocks, all East Asian countries are positively correlated with the US, and furthermore all of the correlations, except the case of Singapore, are significant. Japan also shows high correlations with East Asian countries except Indonesia. These results are quite intuitive given the linkage of the US and Japan with other East Asian countries through trade and FDI. Overall, the results are impressive in that almost all East Asian countries (except only two countries

[12] I also calculate the maximum and minimum values of these correlation coefficients. Although not shown here, they are available upon request.

Table 2.3: Correlation coefficients of AD shocks (1976Q1-2003Q4) - Mean

	US	JP	KR	TW	HK	SI	ML	ID	TH	PH	CN
US	1.00										
Japan	**0.18**	1.00									
Korea	0.05	0.11	1.00								
Taiwan	**0.37**	**0.23**	0.07	1.00							
Hong Kong	0.09	0.08	**0.24**	**0.18**	1.00						
Singapore	0.07	**0.30**	**0.16**	0.10	**0.29**	1.00					
Malaysia	**0.21**	**0.16**	0.11	**0.22**	0.12	**0.35**	1.00				
Indonesia	0.05	-0.10	-0.01	**0.32**	0.11	0.14	0.05	1.00			
Thailand	**0.15**	**0.23**	0.03	**0.15**	0.14	**0.34**	0.13	0.12	1.00		
Philippines	**0.19**	**0.25**	**0.16**	**0.21**	0.12	**0.16**	**0.30**	0.06	0.08	1.00	
China	0.11	0.11	0.12	**0.16**	**0.22**	**0.23**	**0.31**	-0.17	0.01	-0.12	1.00

Note: Dashed numbers are ones that are significantly positive at the 5% level. See Step 5 in Section 3 for the test procedure. Bold numbers are those larger than or equal to 0.15.

Indonesia and China) are significantly positively correlated in AD shocks. This is the newest finding of this paper, which is different from those of the existing studies using the Blanchard-Quah VAR method such as Bayoumi and Eichengreen (1994), and Zhang et al. (2004) where only a part of East Asian countries are positively correlated in AD shocks.[13] In addition, we can find some sub-groups such as the group of some NIEs countries (including Korea, Hong Kong and Singapore), and the group of Singapore, Malaysia and Philippines where demand shocks are highly correlated. It is also interesting to observe that correlations among Greater China (including the mainland China, Taiwan and Hong Kong), which has been mentioned in some studies recently,[14] are high.

Next, we move on to the correlations of AS shocks. The results are shown in Table 2.4.

[13] In Zhang et al. (2004), for example, one finding is that the correlations of demand shocks of Japan and many other East Asian countries are negative or close to zero. See Table 5, pp. 1037 of their paper.
[14] For example, Zhang and Sato (2008).

Table 2.4: Correlation coefficients of AS shocks (1976Q1-2003Q4) - Mean

	US	JP	KR	TW	HK	SI	ML	ID	TH	PH	CN
US	1.00										
Japan	0.05	1.00									
Korea	**0.26**	**0.15**	1.00								
Taiwan	-0.16	-0.01	**0.21**	1.00							
Hong Kong	0.06	0.06	**0.26**	**0.20**	1.00						
Singapore	-0.04	0.00	0.05	**0.19**	**0.22**	1.00					
Malaysia	-0.13	0.10	**0.27**	0.07	0.07	**0.22**	1.00				
Indonesia	0.02	-0.06	**0.28**	0.09	0.04	0.10	**0.47**	1.00			
Thailand	0.14	-0.10	**0.22**	0.09	**0.21**	0.12	0.09	**0.27**	1.00		
Philippines	-0.10	0.01	0.01	-0.03	0.07	0.05	0.12	0.01	-0.02	1.00	
China	-0.04	-0.07	0.03	0.09	0.12	0.02	0.09	**0.16**	-0.11	-0.19	1.00

Note: Dashed numbers are ones that are significantly positive at the 5% level. See Step 5 in Section 3 for the test procedure. Bold numbers are those larger than or equal to 0.15.

The overall picture here is quite different from that in Table 2.3. The number of significantly positive correlations reduces considerably. Regarding the correlations with the US and Japan, many East Asian countries exhibit either negative or close-to-zero values. The correlations with Korea, on the other hand, are high for many countries. The results here on supply shocks are quite consistent with those reported in Zhang et al. (2004), except that the correlation between Korea and the US is positive here but negative in their study. We can see that supply shocks are high in some sub-groups of the NIEs countries, such as Korea, Taiwan and Hong Kong, or Taiwan, Hong Kong and Singapore. Also note that the correlations are significantly positive among Greater China, and relatively high among the four neighboring Southeast Asian countries Singapore, Malaysia, Indonesia and Thailand.

One may ask how the results obtained using the VAR with long-run restrictions and those obtained using the VAR method with sign restrictions are different. Tables A2.2

and A2.3 in the Appendix give an answer to this. In these two tables, I simply calculated the difference between the correlation coefficients computed using the VAR method with long-run restrictions and those computed using the VAR method with sign restrictions. Overall, we can see that, the VAR method with long-run restrictions underestimates the results for the correlations of both AD and AS shocks. It is interesting to observe that both methods yield almost the same results for the US and Korea, the only countries where the point-estimate responses in the VAR with long-run restrictions are consistent with the AD-AS model. It is also worth emphasizing here that, the main difference between the results of the two methods are in the disturbances identified, and not necessarily in the correlations. Two totally different pairs of time series can have the same correlation coefficient.

In the literature some authors regard only the correlations of supply shocks are important because they consider that most of the demand shocks are monetary ones, and that once the monetary union is formed these shocks will be automatically synchronized. To a certain extent I agree with this view, but I think that demand shocks other than monetary ones such as shocks to private consumption or investment are also important, and they may not necessarily be synchronized even when the monetary union is formed. Hence, it can be argued that correlations of both demand and supply shocks are important when considering forming a CCA.

From the above findings, we come to a judgment that East Asia as a whole does not form an optimal currency area. This is because the correlations of supply shocks between countries in the region are low. The results, however, suggest that some sub-groups such as the NIEs countries, Greater China, and the group of Singapore, Malaysia, Indonesia and Thailand are good candidates to introduce a CC.

5. Concluding remarks

In this paper, I have revisited the topic regarding the possibility of introducing a common currency for East Asia from the point of view of shock symmetry. I first pointed out a serious problem regarding the methodology of the existing studies which use the VAR method with long-run restrictions developed by Blanchard and Quah (1989) to identify structural shocks and compute their correlations as a proxy for symmetry of shocks. That is, with this method the signs of the response function to the same structural shock are not necessarily consistent across the countries. This means that the high (low) correlations of the identified structural shocks do not necessarily imply low (high) costs of forming a common currency area. To overcome this problem, I then applied the VAR method with sign restrictions developed by Uhlig (2005). I used the AD-AS model to impose sign restrictions on the responses of GDP and CPI to structural shocks, and hence was able to identify the "true" AD and AS shocks for each countries.

The newest finding of this paper is that demand shocks are significantly positively correlated among almost all East Asian countries, except Indonesia and China. The results also show that correlations of AS shocks are low for many pairs of countries. East Asia as a whole, therefore, is not suitable to form a CCA. However, some sub-groups such as the NIEs countries, Greater China, and the group of Singapore, Malaysia, Indonesia and Thailand are good candidates to introduce a CC.

In the future, I plan to extend the study further in the following directions. The first direction is to include more variables in the VAR. The second is to adopt a more rigorous "model based" sign restrictions in the VAR as in Dedola and Neri (2006), and Braun and Shioji (2007).

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Appendix

Table A2.1: Parameters set and results obtained in the VAR with sign restrictions

	The number of valid draws obtained (n_{valid})	The number of random draws of matrix A generated (n_A)	The number of random draws of matrices(Σ, B) generated ($n_{\Sigma B}$)	The ratio (*) $\frac{valid\_draw}{total\_draw}$
US	300	200	63	2.41%
Japan	300	200	3965	0.04%
Korea	300	200	138	1.09%
Taiwan	300	200	703	0.21%
Hong Kong	300	200	583	0.26%
Singapore	300	200	7677	0.02%
Malaysia	300	200	1067	0.14%
Indonesia	300	200	1959	0.08%
Thailand	300	200	882	0.17%
Philippines	300	200	1191	0.13%
China	300	200	4108	0.04%

Note: (*) $total\_draw = n_A \times n_{\Sigma B}$.

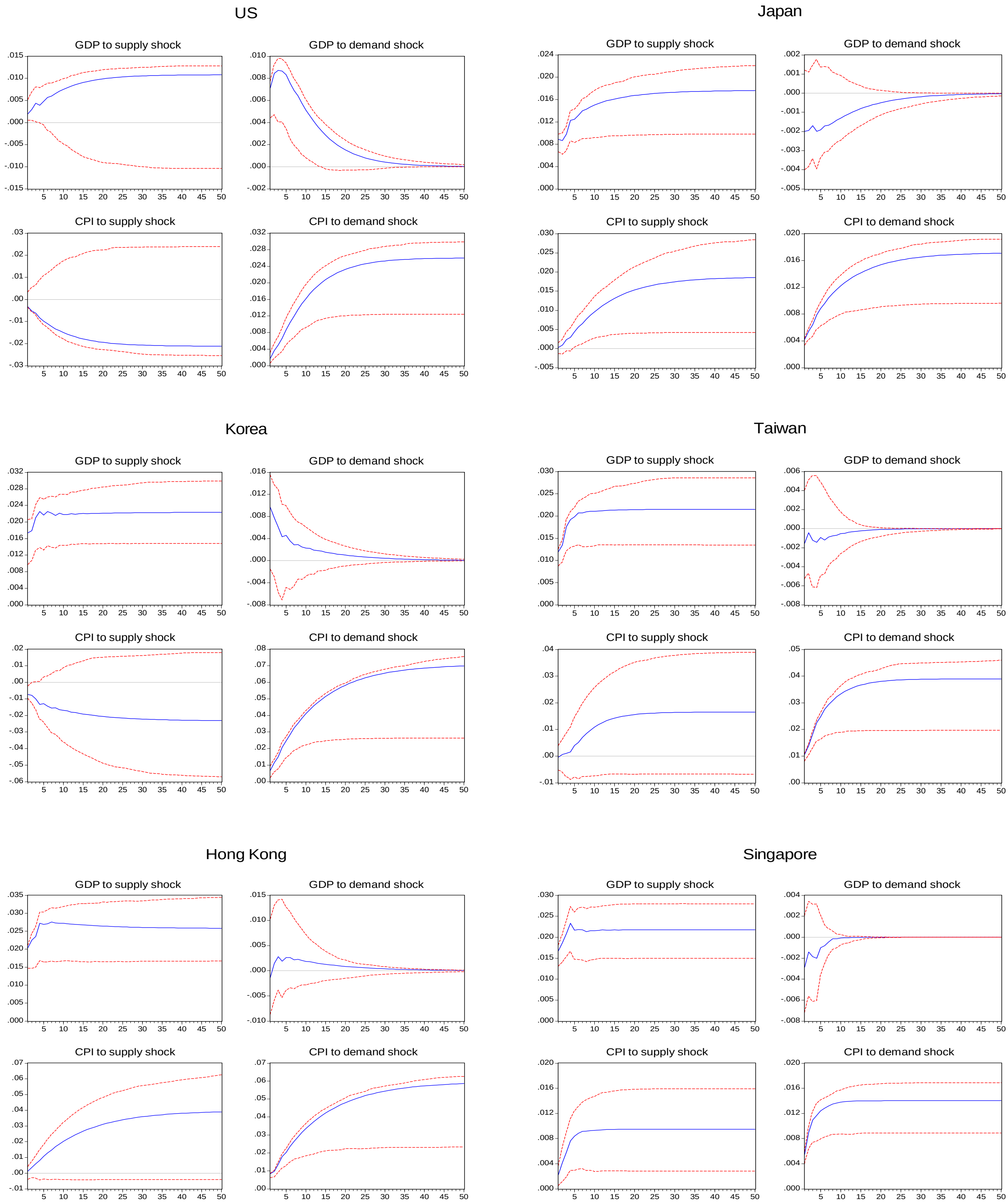
Table A2.2: The difference between results of the VAR with long-run restrictions and VAR with sign restrictions - AD shock correlations

	US	JP	KR	TW	HK	SI	ML	ID	TH	PH	CN
US	0.00										
Japan	-0.15	0.00									
Korea	-0.01	0.09	0.00								
Taiwan	-0.08	-0.08	0.08	0.00							
Hong Kong	0.09	0.04	-0.09	-0.06	0.00						
Singapore	-0.05	-0.05	0.04	-0.04	0.00	0.00					
Malaysia	-0.12	0.03	-0.02	-0.13	0.12	0.04	0.00				
Indonesia	-0.11	0.00	0.00	-0.04	-0.03	-0.04	0.03	0.00			
Thailand	0.01	-0.01	0.01	0.04	0.07	0.04	-0.01	-0.01	0.00		
Philippines	-0.04	-0.04	0.02	-0.03	-0.03	0.00	0.03	-0.04	0.01	0.00	
China	-0.02	0.08	0.13	-0.06	-0.12	-0.30	0.17	0.10	0.14	0.02	0.00

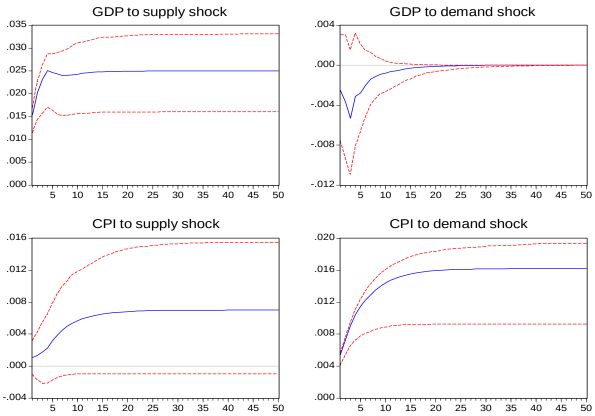
Table A2.3: The difference between results of the VAR with long-run restrictions and VAR with sign restrictions - AS shock correlations

	US	JP	KR	TW	HK	SI	ML	ID	TH	PH	CN
US	0.00										
Japan	-0.20	0.00									
Korea	0.00	-0.23	0.00								
Taiwan	-0.15	0.06	-0.17	0.00							
Hong Kong	-0.13	-0.03	0.02	0.08	0.00						
Singapore	-0.20	0.04	-0.13	0.06	0.03	0.00					
Malaysia	0.01	-0.01	0.03	0.18	-0.07	-0.06	0.00				
Indonesia	-0.06	-0.01	-0.03	0.09	0.05	0.02	-0.05	0.00			
Thailand	-0.03	-0.04	-0.04	-0.07	-0.12	-0.08	0.03	0.03	0.00		
Philippines	-0.01	0.05	-0.01	0.13	0.04	-0.06	-0.08	0.06	0.02	0.00	
China	-0.06	-0.04	-0.11	0.08	0.09	0.15	-0.23	-0.10	-0.13	0.06	0.00

Figure A2.1: Estimated results using the VAR with long-run restrictions - Accumulated responses to structural one s.d. innovations and the bootstrap 66% confidence bands



Malaysia



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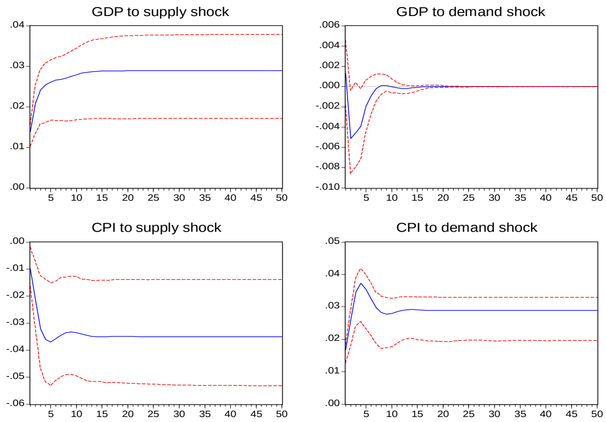

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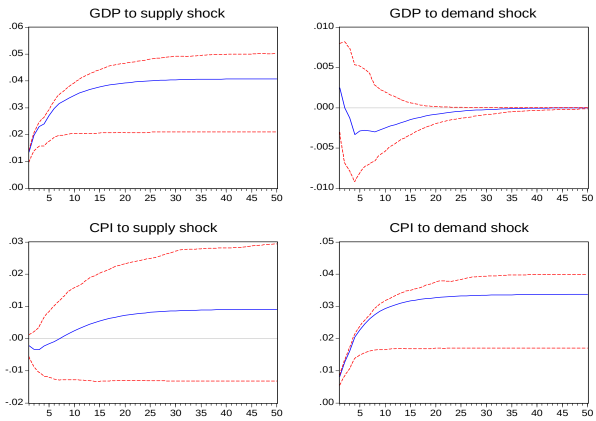
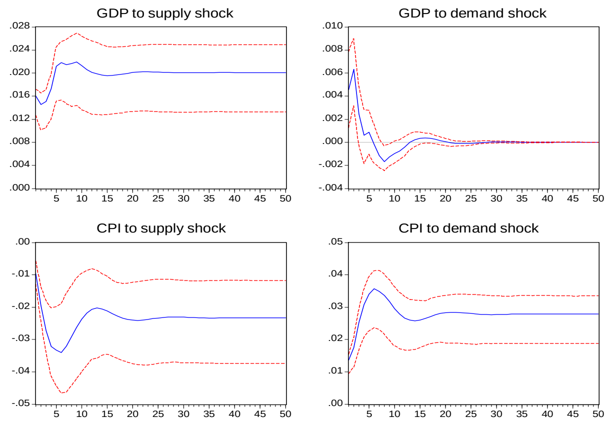


Philippines



China

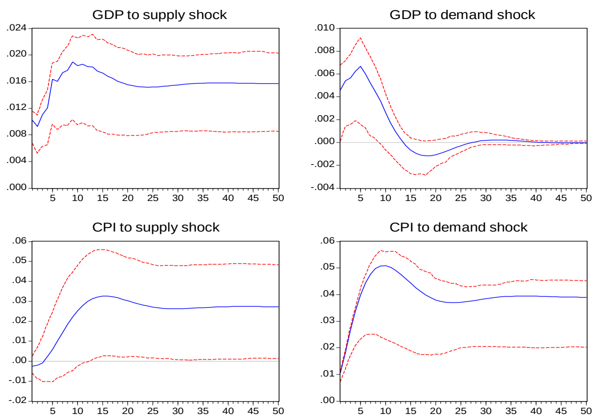
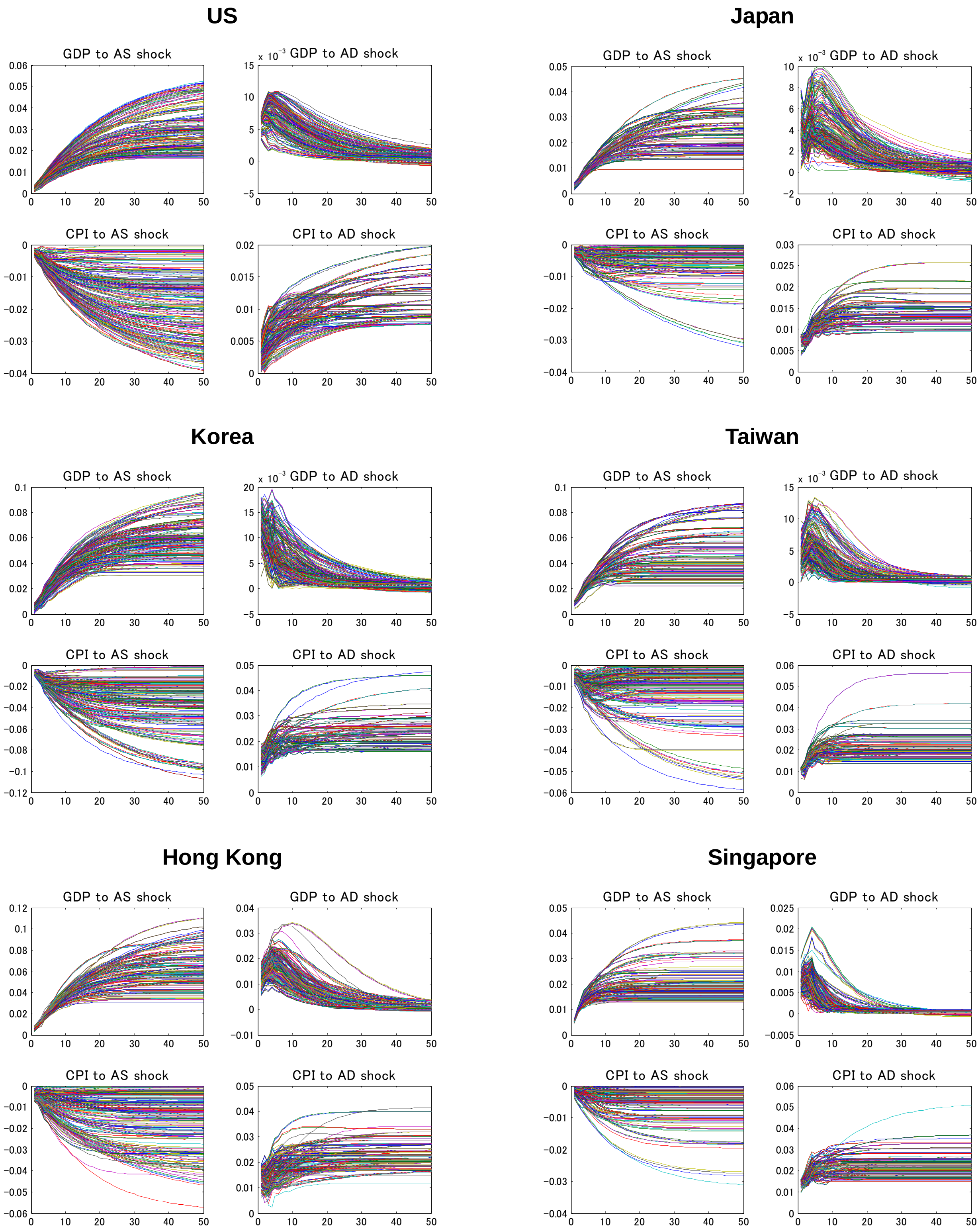
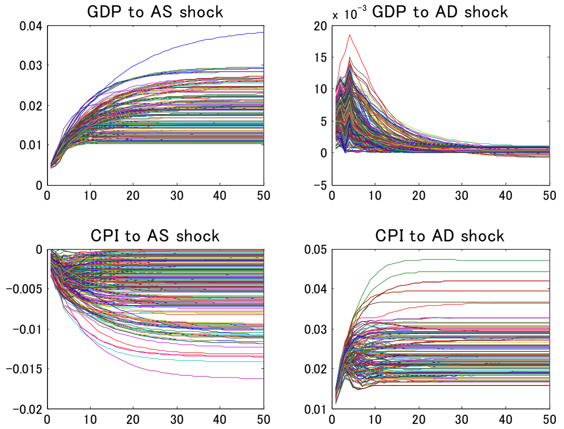


Figure A2.1: Estimated results using the VAR with sign restrictions - Accumulated responses to structural one s.d. innovations



Malaysia



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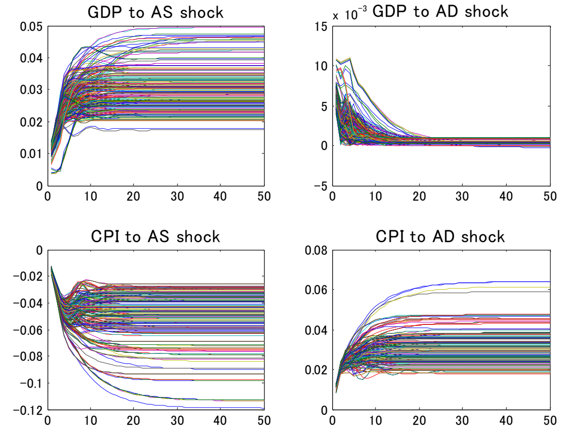

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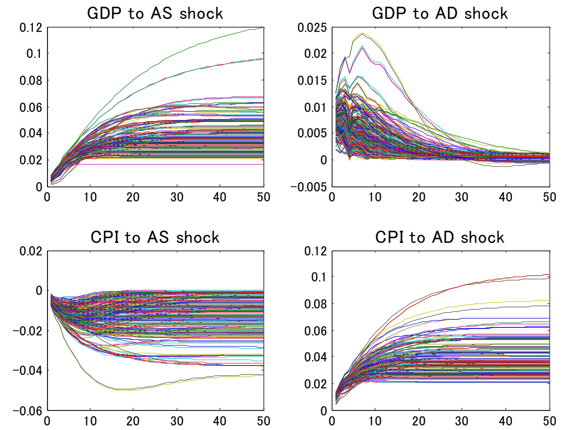

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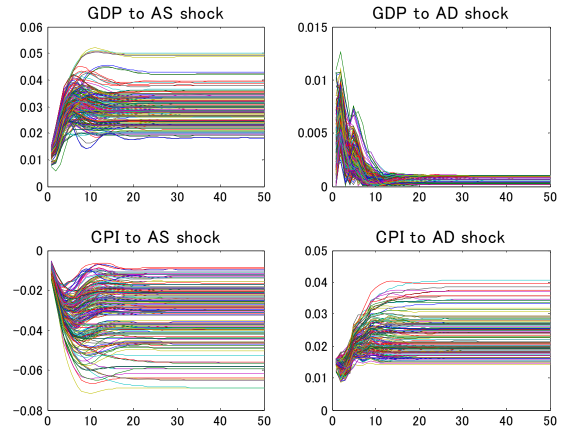

China