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Transmission of Shocks from Japan to Southeast Asia: Can Open-Economy New Keynesian Model Account for the Facts?

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ABSTRACT

This paper documents that for Southeast Asia (1) Japan's favorable output shock and monetary policy tightening prosper thy neighbors and is welfare-enhancing; (2) regional output and price rise while currency depreciates facing Japan's price shock; (3) yen depreciation against U.S. dollar is contractionary and deflationary to the region; and (4) regional currencies generally peg softly to U.S. dollar. We find that the open-economy New Keynesian model cannot explain these facts simultaneously. We suggest that production interconnectedness and trade in intermediate inputs are critical to comprehend macroeconomic dependence of Southeast Asia on Japan.

Keywords: Structural vector autoregression, New Keynesian model, Vertical specialization; Transmission of shock

JEL classification: E3, E5, F1, F41

INTRODUCTION

No one casts doubt on the relevance of Japan to the economic dynamics of Southeast Asia. As second-tier newly industrializing countries Southeast Asia depends non-negligibly on Japan as a source of market for trade and foreign investment. In particular, Japan has persistently been the most important destination besides United States for Southeast Asian exports and imports in past decades, overtaken by China only in recent years[1].

[1] Throughout the years of 1990-2007, according to Asian Development Bank country report of various issues, Japan has been the largest market for imports for Indonesia, Malaysia and Thailand. Japan also constitutes the largest export market for Indonesia, second largest for Philippines and Thailand, and third largest for Malaysia. Although China and Singapore have overtaken Japan's position since then, the fact is that Japan remains the top three most important destinations for trade.

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Hidden beneath the aggregate numbers is the unique vertical production connectedness and trade between Southeast Asia and Japan. Having this said means Southeast Asia imports intermediate inputs from Japan for re-manufacture and the processed output will then be re-exported to Japan and other regional trading partners for subsequent stage of production[2]. Based on Asian International Input-Output tables from years 1975 to 2000, Uchida (2008) documented that total vertical trades as a share of total exports in Southeast Asia were generally more than 40 percent in year 2000. The share is even more than 50 percent in Malaysia and Singapore. More interesting is that Southeast Asia alone has digested one-third of Japanese intermediate inputs for further processing. As Wakasugi *et al*. (2008) have surveyed, about half of the value-added of Japanese manufacturing firms is contributed by foreign subsidiaries, in which Southeast Asia has accounted for almost one quarter.

It is worthwhile to note that although China has surpassed Japan as the more important destination for Southeast Asian exports recently, it provides no prima facie for the declining role of Japan. What occurred is the re-formation of regional production network that witnesses mounting indirect influence of Japan on Southeast Asia. Haddad (2007), for instance, argued that the rise of China has restructured the production network in intra-East Asia in such a way that China (no longer Southeast Asia) emerges as the most important final assembly hub for final good markets in the United States and European nations, while Japan as the most important source for high-skilled materials and Southeast Asia as the source for other parts and components. Athukorala and Yamashita (2006) highlighted this indirect role of Japan on Southeast Asia by showing that the Greater China (mainland China + Hong Kong SAR + Taiwan) absorbs 24 percent of Southeast Asian parts and components exports for reprocessing which are re-exported either as final or half-processed manufacturing goods to Japan.

Of particular interest is the macroeconomic implication of this trade and production linkages. Will Japan's output expansion be beneficial to Southeast Asia? Does Japan's monetary expansion beggar-thy-neighbor? Can vertical production connectedness rationalize the general addiction of regional currencies to U.S. dollar? Wong and Eng (2010), for instance, conjectured that in the presence of vertical production sharing foreign inflation shock will cause home inflation to rise and output to fall. Arndt (2008) inferred that countries that export to U.S or Japan

[2] A number of terms with respect to the phenomenon in which the productions and trades of two or more countries are linked vertically and sequentially are used interchangeably in the literature: among many others, vertical trade, vertical specialization, vertical fragmentation, intra-product trade, international production network and production sharing (Feenstra, 1998; Hummels *et al*., 2001; Yi, 2003).

indirectly via China, like Southeast Asia, has stabilized own currencies against U.S. dollar in order to mitigate exchange rate risk on trade.

Hence, this paper has two goals in succession. First, we attempt to establish a set of stable empirical regularities about the macroeconomic dependence of Southeast Asia on Japan that is useful as a guide to the theoretical formalization of intra-regional economic interaction and policy coordination.

Several interesting facts come to light from a battery of analysis. For instance, we find that Japan's monetary tightening has an expansionary spillover effect to Southeast Asia. This is in contrast to Mackowiak (2006) that found beggar-thy-neighbor effect but is in line with McKinnon and Schnabl (2003) that emphasized the favorable expenditure-switching effect of yen appreciation on regional exports induced by monetary tightening. However, the influence of Japan's monetary policy shock is negligible to Southeast Asian macroeconomic fluctuations over the long run as on average it accounts for only 10.5% and 6%, respectively, of the variability of regional output and price.

To the contrary, Japan's output and price shocks are more important in that the former can explain on average 16.1% and 18.6% – while the latter 13.3% – of the variability of regional output and price. On top of that, shocks to Japan's output and price prosper thy neighbors, and rising Japan's price will be positively spilled over to regional price level, too. Equally interesting is the finding that yen depreciation against U.S. dollar is overwhelmingly contractionary and deflationary to Southeast Asia. Reaction of regional currencies toward the variability of yen-dollar exchange rates also confirms the hypothesis of fear-of-floating against U.S. dollar hypothesis (see, e.g. Calvo and Reinhart, 2002; McKinnon and Schnabl, 2004).

The second goal of this paper is to investigate whether standard open-economy New Keynesian model that typically ignores vertical and sequential trade in intermediates can coherently explain the transmission of shocks. We find the answer to be negative. We therefore suggest that explicit formalization of vertical and sequential trade in intermediates in international business cycle model is a promising yet challenging task for future research in order to understand the macroeconomic dependence of Southeast Asia on Japan, and intra-East Asia macroeconomic interactions in general.

The rest of the paper is organized as follows. A structural vector autoregression (VAR) model is laid out in next section with detailed explanation on the baseline identification scheme and estimated results. In section that follows we set up a canonical open-economy New Keynesian model that features habit persistence, Calvo-type price and wage stickiness with partial indexation and investment adjustment cost. We inspect the quantitative performance of this model in accounting for the facts established using structural VAR. Last section concludes.

SOME FOUR-VARIABLE SRUCTURAL VECTOR AUTOREGRESSIVE EVIDENCES

Suppose the economy can be illustrated by a structural VAR of *s* order

$$A_0 z_t = \sum_{s=1}^{n} A_{t-s} z_{t-s} + u_t \tag{1}$$

where u_t is a vector of structural shock satisfying $E\left[u_t \mid z_{t-s}, s > 0\right] = 0$ and $E[u_t u_t' \mid y_{t-s}, s > 0] = I$. $z_t = [e_t(j), y_t(h), p_t(h), s_t]'$ is a vector of four variables, consisting of Japan's real output ($y(j)$), consumer price level ($p(j)$), interest rate ($i(j)$) and nominal yen-dollar exchange rates (yen-dollar), one at a time, and real output ($y(h)$), consumer price index ($p(h)$) and nominal exchange rate defined as home currency per unit of Japanese yen (s) for respective Southeast Asian economies. The structural VAR of Eq. (1) has a reduced form as follows:

$$z_t = A_0^{-1} \sum_{s=1}^{n} A_{t-s} z_{t-s} + \varepsilon_t \tag{2}$$

where $\varepsilon = A_0^{-1} u_t$. The unrestricted VAR of Eq. (2) can be easily estimated with ordinary least squared method. To recover the economic meaning of Eq. (2), however, we need some identifying information on A_0^{-1}.

Baseline Identification Scheme

The most fundamental consideration in the baseline identification scheme is to assume Southeast Asian economies as small open economy to Japan, meaning that the real output, price level and exchange rates (with respect to yen) of each nation are affected contemporaneously by shocks to Japan, as captured in Eq. (3) below. However, all variables can react to all shocks after one period (one quarter in the present paper).

$$\begin{bmatrix} \varepsilon_{e(j)} \\ \varepsilon_{y(h)} \\ \varepsilon_{p(h)} \\ \varepsilon_{s} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & a_{24} \\ a_{31} & a_{32} & 1 & a_{34} \\ a_{41} & 0 & 0 & 1 \end{bmatrix}^{-1} \begin{bmatrix} u_{e(j)} \\ u_{y(h)} \\ u_{p(h)} \\ u_{s} \end{bmatrix} \tag{3}$$

Besides contemporaneous effect of Japan's shocks on Southeast Asia, the remaining setting is fairly standard. In line with open-economy New Keynesian model, home price responds contemporaneously to disturbances on nominal exchange rates and home output. The latter is affected contemporaneously by shock to nominal exchange rates, too.

It is worthwhile to point out that as we construct the data on Japan's interest rate and nominal exchange rate from end-of-period values, the baseline identifying restrictions in turn imply that private agents have taken expected nominal exchange rates and foreign monetary policy stance into account in forecasting output and price throughout the period. This certainly fits into New Keynesian macroeconomics that emphasizes the role of forward-looking behavior in household's decision making.

Model Specification

In so far as the data set is concerned, five Southeast Asia countries (Indonesia, Malaysia, Philippines, Singapore and Thailand) are studied. The data is mainly sourced from International Financial Statistics (IFS) that runs from 1987 first quarter to 2008 first quarter. In particular, gross domestic output of Japan and Southeast Asian nations are deflated by respective consumer price index. Discount rate at end of each quarter is used as proxy for Japan's monetary policy. End-of-period nominal exchange rate is defined as home currency per yen. All data but discount rate are in logarithm, implying that the variables are specified in levels. This is consistent with most recent VAR studies that allows for any potential cointegrating relationship between the variables to be implicitly determined in the model in order to avoid the imposition of incorrect cointegrating restrictions that results in incoherent parameters (see, for instance, Bjornland, 2009).

To ensure that the VAR is invertible and is more comparable with existing literature of New Keynesian model that focuses on deviation from trend rather than the level itself, as Bjornland (2009) suggested, we estimate this four-variable VAR in level with constant and linear trend for all five Southeast Asia countries. The lag length is determined based on the Likelihood Ratio test statistics with issues of stability condition and degree of freedom taken into account[3].

Main Results

There are two concerns to be addressed in the interpretation of main results: how important is shock to Japan in explaining the macroeconomic fluctuations of Southeast Asia? How is the shock transmitted?

Table 1 shows the relative contribution of shocks (in percentage) to Japan's output, price, interest rate and yen-dollar exchange rates to the variability of output, price and local currency-yen exchange rates for each of the countries.

[3] Other criterions such as Akaike Information Criteria and Final Prediction Error are also examined in order to check for the appropriateness of lag length selected.

Interestingly, monetary policy shock is Japan's most irrelevant influence on regional macroeconomic fluctuations since it has very little explanatory power on contemporaneous, medium or long run effects on any variables of this region. At best, monetary policy shock accounts for 21% and 29% of the variability of Malaysia's output in the medium and long run, 12% and 19% of the variability of Philippines peso-yen exchange rates in the medium and long run, and 11% of the variability of Singapore's price in the long run.

To the contrary, disturbance on yen-dollar exchange rates has non-trivial implication on the fluctuations of regional output and price level over medium and long run. Its contributions to the variability of output and price range from 17% to 36% and 11% to 36%, respectively, in long run. Most interestingly, a glance at the role of yen-dollar exchange rates in the variations of local currency-yen exchange rates has lent support to the hypothesis of fear-of-floating against U.S. dollar.

For instance, as a country known of using exchange rates as policy instrument, the variability of yen-dollar exchange rates can account for 83% of variations of Singapore dollar-yen exchange rates in short run, 67% in medium run and 51% in long run. Malaysia is another country that also shows strong intervention in stabilizing Malaysian ringgit against U.S. dollar when considering the relative contributions of yen-dollar exchange rate fluctuations that range from 43% to 64% over different time horizons. To a lesser extent is the case of Philippines, as yen-dollar fluctuations account for only 19% of the variations of Philippines peso-yen exchange rates in long run. Two inflation targeters in this region – Indonesia and Thailand – witness the least influence of yen-dollar exchange rate fluctuations in the variability of respective home currency against yen.

Table 1 Relative Contributions of Japan's Shocks to Southeast Asia

Japan's shocks		**Indonesia**	**Malaysia**	**Philippines**	**Singapore**	**Thailand**
Output	Y					
	Impact	0.3	2.1	1.1	2.9	1.2
	3-year average	12.7	23.8	9.6	1.7	3.1
	Long run	20.2	29.5	20.0	3.0	7.9
	P					
	Impact	0.1	0.4	0.4	0.5	0.3
	3-year average	10.3	5.9	10.2	3.8	2.6
	Long run	13.5	25.2	33.4	14.4	6.3
	S					
	Impact	8.3	1.1	0.1	2.2	1.6
	3-year average	16.0	11.5	4.8	10.5	3.2
	Long run	16.7	15.5	7.2	15.2	5.1

Table 1 (Cont'd)

Price	Y					
	Impact	0.0	0.9	0.1	7.4	0.2
	3-year average	12.3	3.6	9.2	12.6	7.2
	Long run	20.5	7.3	12.5	17.6	8.5
	P					
	Impact	0.0	0.7	3.8	9.2	4.1
	3-year average	13.5	3.9	24.8	15.3	13.0
	Long run	17.7	3.1	13.4	17.0	14.8
	S					
	Impact	4.2	6.3	10.9	0.6	6.5
	3-year average	19.4	13.9	14.7	0.6	16.8
	Long run	21.6	13.1	14.3	0.5	24.2
Interest rate	Y					
	Impact	0.2	0.0	2.3	0.5	0.3
	3-year average	0.9	21.1	5.9	4.4	1.5
	Long run	1.3	29.2	8.9	6.7	6.2
	P					
	Impact	2.1	0.0	0.0	0.1	5.6
	3-year average	2.0	0.8	4.1	4.6	2.4
	Long run	4.9	3.3	7.5	10.8	5.7
	S					
	Impact	0.3	4.4	1.5	6.8	2.9
	3-year average	1.8	2.3	11.6	8.5	1.7
	Long run	7.6	2.1	18.7	9.5	1.7
Yen-dollar	Y					
	Impact	0.0	0.3	5.0	0.0	13.3
	3-year average	8.1	11.6	18.6	25.7	19.0
	Long run	18.1	27.6	22.4	35.6	17.4
	P					
	Impact	1.5	0.2	5.0	1.4	0.1
	3-year average	7.1	7.2	32.2	10.0	2.5
	Long run	11.9	11.1	35.6	18.4	19.4
	S					
	Impact	2.2	42.7	48.4	83.0	12.1
	3-year average	3.8	56.9	36.7	66.7	9.3
	Long run	4.1	63.5	18.8	51.3	16.1

Japan's output and price shocks, when compared to monetary shock, are apparently more important on average to account for the long-run macroeconomic fluctuations of Southeast Asia, though it matters little in short run, too. For instance, in long run output shock explains approximately 30%, 25% and 16% of the variability of Malaysia's output, price, and ringgit-yen exchange rates, while price shock accounts for 21%, 18% and 22% of the variability of Indonesia's output, price and rupiah-yen exchange rates.

To address the second concern, Figure 1 throughout Figure 5 depicts the identified impulse responses of output (LY), price (LP) and nominal exchange rates (LS) for respective countries towards disturbances on Japan's output (Yj), monetary policy (Ij), price (Pj) and yen-dollar exchange rates (YD).

Generally, favorable shock to Japan's output prospers Southeast Asia[4]. In addition, price falls and home currency appreciates against yen[5]. This is in line with the new open-economy macroeconomics (NOEM) literature (see, e.g., Corsetti and Pesenti, 2001). Rising Japan's output depreciates yen to initiate greater consumption – an efficient international risk sharing mechanism that can be derived in a standard two-country dynamic general equilibrium model – which will be spilled over to Southeast Asia through rising demand over exports. Home currency appreciation against yen lowers the price of imports, improves the terms of trade, and is thus welfare-enhancing.

Fairly standard also is the impulse responses towards disturbances on yen-dollar exchange rates. Given the addiction to peg softly to U.S. dollar for emerging countries (Calvo and Reinhart, 2002), particularly for East Asia (McKinnon, 2000), the variability of regional currencies vis-à-vis yen must be non-trivially driven by the variability of yen-dollar exchange rates. Throughout the figures for all countries, it can be easily seen that home currency appreciates on impact vis-à-vis yen in the aftermath of shock to yen-dollar exchange rates that depreciates yen against U.S. dollar. This appreciation is deflationary for all the countries excluding Indonesia, and is contractionary for the region excluding Philippines.

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[4] There are certainly some differences in the impulse responses of each country with respect to duration and timing. For instance, Malaysia (Figure 2) and Indonesia (Figure 1) demonstrate a hump-shaped response in which the impact peaks at 4th and 6th quarter, respectively. For Philippines, however, the favorable effect is relatively short-lived: output starts falling after 6th quarter (Figure 3). Meanwhile, Singapore's output rises only after one year of shock to Japan's output.

[5] The difference of timing should be noted. While Indonesia shows the hump-shaped responses, the decline in price of other nations is relatively short-lived. Price starts to rise after 6th in Malaysia, 3rd in Philippines and 4th in Singapore. For the case of Thailand, price falls only after 6th quarter.

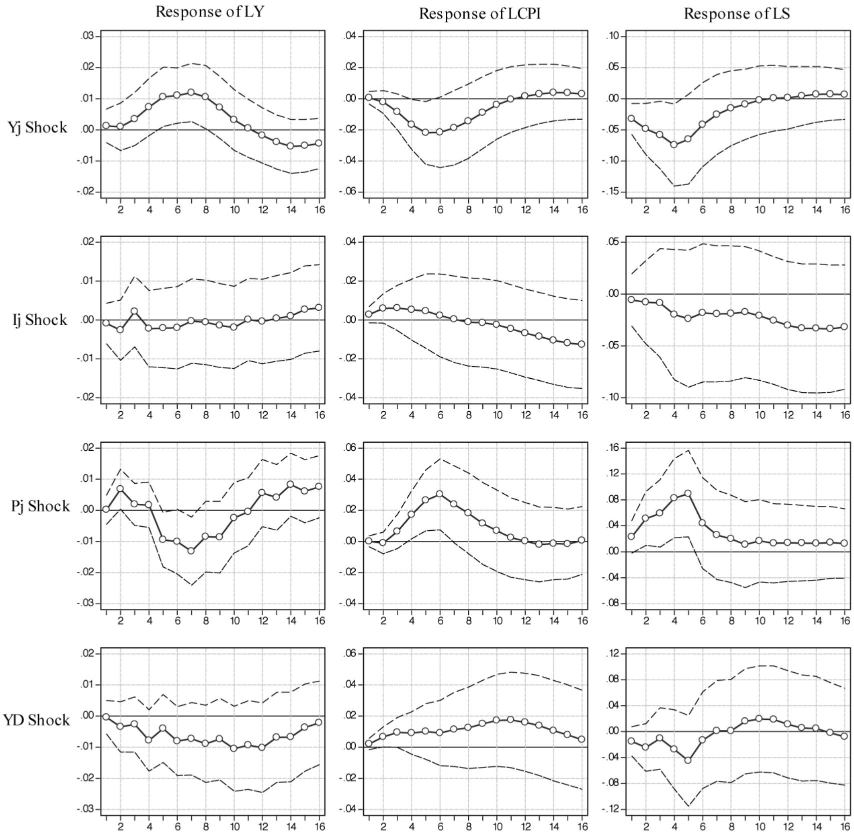

Figure 1 A 4-Variable structural VAR: Indonesia's impulse responses

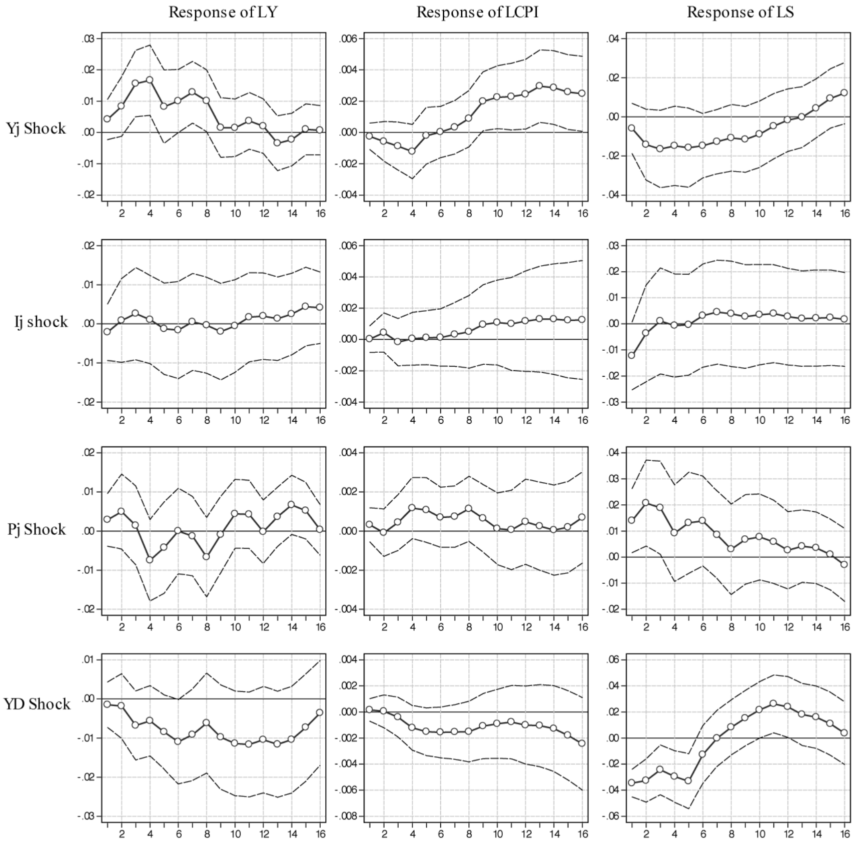

Figure 2 A 4-Variable structural VAR: Malaysia's impulse reponses

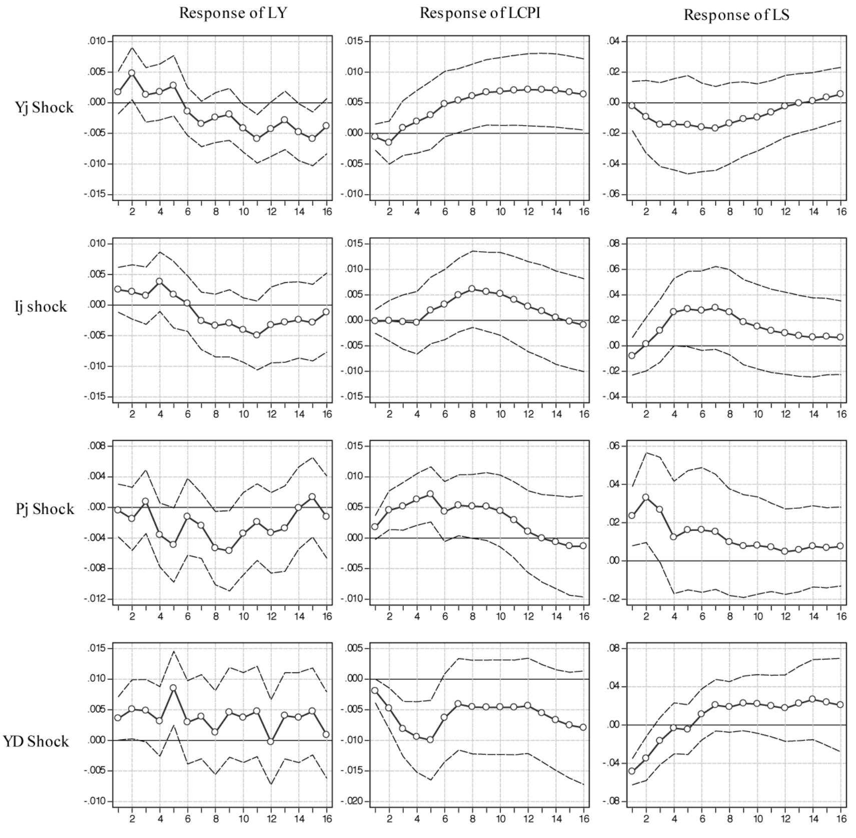

Figure 3 A 4-Variable Structural VAR: Philippines's Impulse Responses

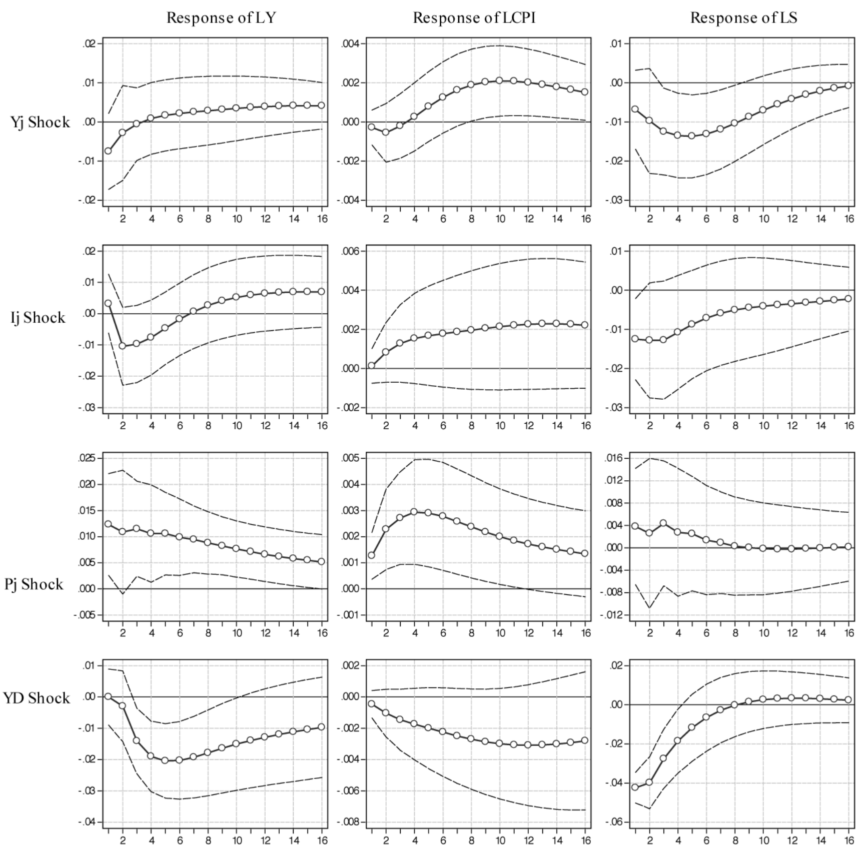

Figure 4 A 4-Variable Structural VAR: Singapore's impulse responses

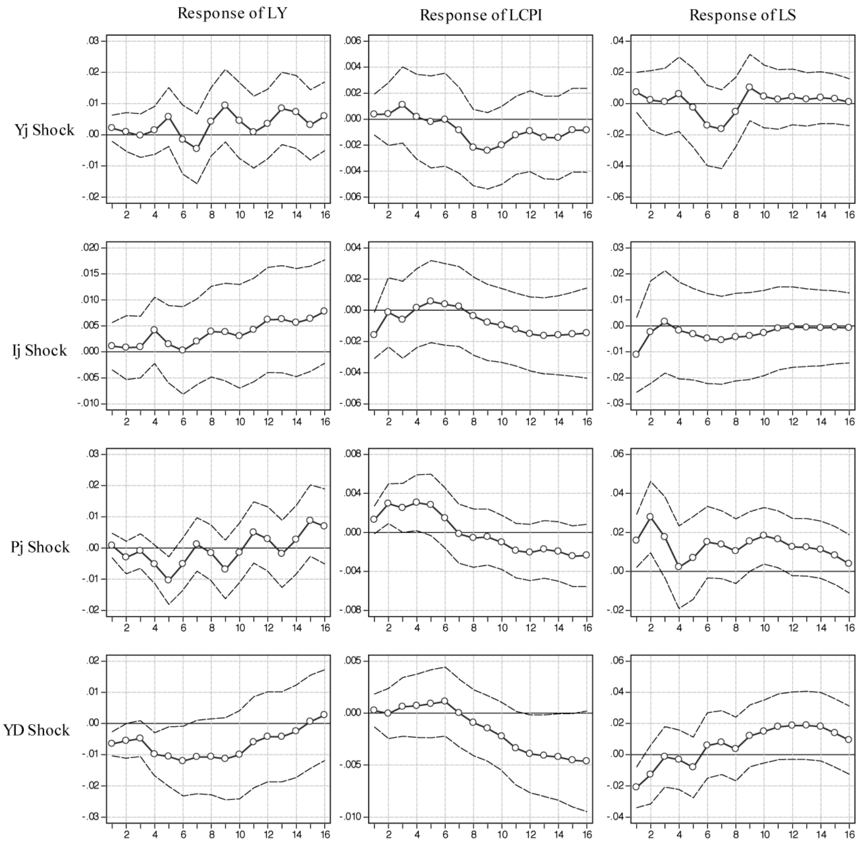

Figure 5 A 4-Variable structural VAR: Thailand's impulse responses

More perplexing is the mixed findings on the impulse responses toward monetary shock. For instance, outputs of Indonesia and Malaysia hardly respond to restrictionary monetary shock whereas outputs of Philippines, Singapore and Thailand react positively, though with different timings and magnitudes[6]. At the same time, an increase in Japan's interest rate has caused regional price levels, except for the cases of Singapore and Philippines, to fall and regional local currencies excluding Philippines to appreciate against yen.

This evidence is bewildering since what has been discussed above – rising output, falling price and appreciated home currency – is typically illustrated as the responses toward foreign monetary expansion not tightening. To check for robustness, we have also estimated the identified VAR model using M2 and base money alternatively as monetary policy instrument[7]. Except for Philippines, outputs of all these countries witness a fall following a rise in Japan's money supply, however defined. By shedding light on these robust finding, it can be inferred that Japan's monetary tightening has transmitted welfare-enhancing effects, whereas monetary expansion welfare-deteriorating, if any (recall that monetary shock is least important), to this region. Speaking differently, it disputes against beggar-prosper-neighbor effect of Japan's monetary expansion (see, for instance, Mackowiak, 2006)[8], and leans support to the view of Japan's monetary policy expansion as beggar-thy-neighbor policy (McKinnon and Schnabl, 2003).

Last but not least, we find that a positive shock to Japan's price will be channeled into Southeast Asia by raising price level of all countries. Rising Japan's price deteriorates terms of trade of this region, depreciates the local currencies against yen and fuels the home price in a hump-shaped dynamics. The effect of positive shock to Japan's price on regional output, however, is mixed. It beggars thy Indonesia, Philippines and Thailand but burgeoning Singapore, yet has no significant effect on Malaysia's output.

By considering the role of Japan's output, price and interest rate one at a time in a four-variable VAR model, the potential amplification or counterbalance implications originated in the interdependence between macroeconomic variables on shock transmission can be swept under carpet. Hence, we also check for the

[6] As in Figure 3, Philippines's output first rises then falls after six quarters. Figure 4 illustrates a pattern of Singapore's output in contrast to Philippines. Lastly in Figure 5, one can see that Thailand's output generally expands over the time horizons as a consequence of Japan's restrictionary monetary policy shock.

[7] The results are available upon request.

[8] Mackowiak (2006), by using sign restriction, also found that Japan's monetary policy shock contributes modestly (about 5%) to the macroeconomic fluctuations of her East Asian neighbors. However, he argued that Japanese monetary policy shocks do not have beggar-thy-neighbor effect as net exports of Japan's East Asian neighbors increase in the short run.

robustness of previous results by expanding the model to incorporate Japan's variables all at a time. Due to the space constraint, discussion on the baseline and alternative identification scheme for this seven-variable structural VAR model, the identification on Japanese shocks, and the results are omitted here but are available upon request.

On balance, as compared to the evidences of four-variable VAR model, the findings of seven-variable VAR model can be summarized as follows:

1. Japan's monetary tightening is overwhelmingly expansionary to Southeast Asia. Even for the cases of Indonesia and Malaysia that barely respond to Japan's policy shock in four-variable VAR model have reacted positively in expanded VAR model.
2. Except for the case of Malaysia and Singapore, the welfare-enhancing effect of Japan's output shock on this region has largely disappeared.
3. Positive shock to Japan's price sturdily causes regional price levels to rise and currencies to depreciate against yen. Except for Thailand, it has at little extent expansionary effect on regional output.
4. All regional currencies appreciate against yen in the aftermath of shock to yen-dollar nominal exchange rates, indicating that soft peg to U.S. dollar is really a widespread phenomenon in this region. However, output and price implications are somewhat heterogeneous. Yen depreciation against dollar is contractionary to Malaysia and Thailand but expansionary to Indonesia and Philippines prior to 6^{th} and 8^{th} quarter, respectively. It has been inflationary to Indonesia, deflationary to Philippines and Thailand, and inflationary prior to 6^{th} quarter to Malaysia and Singapore, which turns deflationary thereafter.

HOW WELL CAN OPEN-ECONOMY NEW KEYNESSION MODEL ACCOUNT FOR THE FACTS?

In this section we present a New Keynesian model a-la Gali and Monacelli (2005) for a small open economy with real and nominal frictions. In addition to Calvo's price stickiness and monopolistic competition in good market as featured in Gali and Monacelli (2005), our model also consider Calvo-type nominal wage rigidities, partial indexation in price and wage setting, investment adjustment cost and habit persistence in consumption. Our goal is to inspect whether the standard analytical model is sufficiently equipped with the mechanism that is capable to explain the macroeconomic dependence of Southeast Asia on Japan.

Intermediate Goods Production

Suppose there is a unit mass continuum of identical, perfectly competitive intermediate good producers producing homogenous goods Y_{1t} at date t with the following production technology

$$Y_{1t} = A_{1t}[K_{1t}]^{\alpha}[L_{1t}]^{1-\alpha} \tag{4}$$

where A_{1t} is the state of aggregate productivity, K_{1t} is the capital stock and is $L_{1t} = \left[\int_0^1 \{L_{1t}(j)\}^{(\varepsilon_L - 1)/\varepsilon_L} dj\right]^{\varepsilon_L/(\varepsilon_L - 1)}$ the variety of labors employed in the production. $\varepsilon_L > 1$ is the elasticity of substitution between varieties of labors. The demand curve for $L_{it}(j)$.

$$L_{1t}(j) = \left[W_{1t}(j)/W_{1t}\right]^{-\varepsilon_L} L_{1t} \tag{5}$$

where $W_{1t} = \left[\int_0^1 \{W_{1t}(j)\}^{1-\varepsilon_L} dj\right]^{1/(1-\varepsilon_L)}$.

Accessing to production technology in Eq. (4) requires firm to bear the rental cost of capital, wage paid to labors and adjustment cost of investment. The cost structure is thus given by

$$(r_{Kt} + \delta)K_{1t-1} + W_{1t}L_{1t} + S(I_t/I_{t-1})I_t \tag{6}$$

where r_{Kt} refers to real return to capital stock, δ depreciation rate, I_t investment and W_{1t} real wage. The investment adjustment cost function, following Christiano *et al*. (2005) and Smets and Wouters (2003), satisfies the properties of $S(1) = S'(1) = 0$. Let λ_{1t} be the shadow price of the factors, the first order conditions of firm *j* can be summarized as what follows:

$$r_{Kt} + \delta = \lambda_{1t}\alpha A_{1t}[K_{1t-1}]^{\alpha-1}[L_{1t}]^{1-\alpha} \tag{7}$$

$$W_{1t} = \lambda(1-\alpha)A_{1t}[K_{1t}]^{\alpha}[L_{1t}]^{-\alpha} \tag{8}$$

$$\lambda_{1t}S'(I_t/I_{t-1})[I_t/I_{t-1}] + \lambda_{1t}S(I_t/I_{t-1}) = \lambda_{1t+1}S'(I_t/I_{t-1})[I_{t+1}/I_t]^2 \tag{9}$$

From Eqs. (7) and (8), one can easily derive the relative demand for factors, optimal demand for labors, capital stock accumulation, and real marginal cost function, respectively captured in Eqs. (10)-(13).

$$(r_{Kt}+\delta)/W_{1t}=\left[\alpha/(1-\alpha)\right]\left[K_{1t}/L_{1t}(j)\right]^{-1} \tag{10}$$

$$L_{1t} = A_{1t}\left[\alpha/(1-\alpha)\right]^{-\alpha}\left[W_{1t}/(r_{Kt}+\delta)\right]^{-\alpha} Y_{1t} \tag{11}$$

$$K_t = (1-\delta)K_{t-1} + \left[1 - S(I_t/I_{t-1})\right]I_t \tag{12}$$

$$\lambda_{1t} = \frac{[r_{Kt}+\delta]^{\alpha}[W_{1t}]^{1-\alpha}}{A_{1t}(\alpha_K)^{\alpha}(1-\alpha_K)^{1-\alpha}} \tag{13}$$

The processed materials are then demanded by home consumer-good producers in that

$$Y_{1t} = Y_{1Ht} \tag{14}$$

Consumer Good Production

A large continuum of identical, monopolistically competitive consumer goods producers, represented and indexed by $j \in [0, 1]$, combine a bundle of home and foreign intermediate goods following CES technology in order to produce consumer goods:

$$Y_{2t}^{j} = \left[(1-\kappa)^{1/\vartheta}\left(Y_{1Ht}^{j}\right)^{(\vartheta-1)/\vartheta} + \kappa^{1/\vartheta}\left(Y_{1Ft}^{j}\right)^{(\vartheta-1)/\vartheta}\right]^{\vartheta/(\vartheta-1)} \tag{15}$$

where

$$Y_{1Ht}^{j} = \left[\int_0^1 Y_{1Ht}^{j}(j)^{(\varepsilon-1)/\varepsilon}\, dj\right]^{\varepsilon/\varepsilon-1}$$

and $Y_{1Ft}^{j} = \left[\int_0^1 Y_{1Ft}^{j}(j)^{(\varepsilon-1)/\varepsilon}\, dj\right]^{\varepsilon/(\varepsilon-1)}$.

Each variety of processed intermediate goods in respective bundle is substitutable for other varieties with constant elasticity of substitution $\varepsilon > 1$. $\vartheta > 0$ is the constant elasticity of substitution between home-produced and imported intermediated inputs.

Let $P^j_{1Ht} = \left[\int_0^1 P^j_{1Ht}(j)^{1-\varepsilon} dj \right]^{1/(1-\varepsilon)}$ and $P^j_{1Ft} = \left[\int_0^1 P^j_{1Ft}(j)^{1-\varepsilon} dj \right]^{1/1-\varepsilon}$

be the domestic price of home and imported intermediate goods, respectively. The relative demand for home and imported intermediate goods is given by

$$\frac{P^j_{1Ft}}{P^j_{1Ht}} = \left[\frac{Y^j_{1Ht} \big/ (1-\kappa)}{Y^j_{1Ft} \big/ \kappa} \right]^{1/\vartheta} \tag{16}$$

The cost minimization of firm *j* results in the following optimal demand for intermediate inputs.

$$Y^j_{1Ht}(j) = \left[P^j_{1Ht}(j) \big/ P^j_{1Ht} \right]^{-\varepsilon} Y^j_{1Ht} \tag{17}$$

$$Y^j_{1Ft}(j) = \left[P^j_{1Ft}(j) \big/ P^j_{1Ft} \right]^{-\varepsilon} Y^j_{1Ft} \tag{18}$$

$$Y^j_{1Ht} = (1-\kappa) \left[P^j_{1H,t} \big/ P_{1t} \right]^{-\vartheta} Y^j_{2t} \tag{19}$$

$$Y^j_{1Ft} = \kappa \left[P^j_{1Ft} \big/ P_{1t} \right]^{-\vartheta} Y^j_{2t} \tag{20}$$

where

$$P_{1t} = \left[(1-\kappa) \left(P^j_{1Ht} \right)^{1-\vartheta} + \kappa \left(P^j_{1Ft} \right)^{1-\vartheta} \right]^{1/(1-\vartheta)} \tag{21}$$

P_{1t} is utility-based producer price index.

As final goods will be either consumed domestically or exported, the market-clearing condition takes the form

$$Y^j_{2t} = C_{Ht} + C^*_{Ht} \tag{22}$$

Consumption

Suppose there is a continuum of infinitely-lived households, represented and indexed by $i \in [0, 1]$, that maximizes the utility function of

$$U_t = E_t \left\{ \sum_{t=0}^{\infty} \beta^t \left[(C_t - H_t)^{1-\sigma} \big/ (1-\sigma) - \left(N_t(i) \right)^{1+\chi} \big/ (1+\chi) \right] \right\} \tag{23}$$

where $H_t = bC_{t-1}$ indicates external habit formation in which b is the parameter that governs the extent of habit persistence, $0 < \beta < 1$ refers to subjective discount factor, σ measures the degree of constant relative risk aversion and the reciprocal of χ indicates the wage elasticity of labor supply.

Consumption bundle consists of home C_{Ht} and imported consumer goods C_{Ft}:

$$C_t = \left[(1-\gamma)^{1/\varphi} (C_{Ht})^{(\varphi-1)/\varphi} + \gamma^{1/\varphi} (C_{Ft})^{(\varphi-1)/\varphi} \right]^{\varphi/(\varphi-1)} \tag{24}$$

where $0 < \gamma < 1$ refers to the share of imported goods in consumption basket and $\varphi > 0$ is the elasticity of substitution between home and imported consumer goods. $C_{Ht} = \left[\int_0^1 C_{Ht}(i)^{(\varepsilon-1)/\varepsilon} di \right]^{\varepsilon/(\varepsilon-1)}$ and $C_{Ft} = \left[\int_0^1 C_{Ft}(i)^{(\varepsilon-1)/\varepsilon} di \right]^{\varepsilon/(\varepsilon-1)}$, respectively, denotes the composite indexes of home and imported consumer goods of a variety i. $\varepsilon > 1$ is the elasticity of substitution between varieties i of home and foreign consumer goods baskets and is identical to the elasticity of substitution between varieties of intermediate inputs for consumer goods producers. The utility-based consumer price index (CPI) is given by

$$P_t = \left[(1-\gamma)(P_{Ht})^{1-\varphi} + \gamma(P_{Ft})^{1-\varphi} \right]^{1/(1-\varphi)} \tag{25}$$

where $P_{Ht} = \left[\int_0^1 P_{Ht}(i)^{1-\varepsilon} di \right]^{1/(1-\varepsilon)}$ and $P_{Ft} = \left[\int_0^1 P_{Ft}(i)^{1-\varepsilon} di \right]^{1/(1-\varepsilon)}$. The household's budget constraint takes the form

$$\begin{aligned} &\int_0^1 P_{Ht} C_{Ht}(i) di + \int_0^1 P_{Ft} C_{Ft}(i) di + S_t B_t^* / P_t R_t^* RP_t + B_t / P_t R_t + K_t \\ &= \int_0^1 W_t N_t(i) di + \prod_t + B_{t-1}^* / S_t P_t + B_{t-1} / P_t + (1 + r_{Kt}) K_{t-1} \end{aligned} \tag{26}$$

where S_t is nominal exchange rate defined as home value of foreign currency, B_t one-period state-contingent bond (with asterisk refers to foreign bond), R_t gross return, RP_t exchange rate risk premium of holding foreign bond and Π_t distributed profit from firms. The household's optimal allocations can be derived as

$$C_{Ht}(i) = \left[P_{Ht}(i) / P_{Ht} \right]^{-\varepsilon} C_{Ht} \tag{27}$$

$$C_{Ft}(i) = \left[P_{Ft}(i) / P_{Ft} \right]^{-\varepsilon} C_{Ft} \tag{28}$$

$$C_{Ht} = (1-\gamma)\left[P_{Ht}/P_t\right]^{-\varphi} C_t \tag{29}$$

$$C_{Ft} = \gamma\left[P_{Ft}/P_t\right]^{-\varphi} C_t \tag{30}$$

$$\left[(C_t - bC_{t-1})/(C_{t+1} - bC_t)\right]^{-\sigma} = \left[P_t/P_{t+1}\right] R_t \tag{31}$$

$$N_t\,(i)^{\chi}\left[C_t - bC_{t-1}\right]^{\sigma} = W_t\,(i) \tag{32}$$

$$R_t = R_t^*\left[E_t S_{t+1}/S_t\right] RP_t \tag{33}$$

Aggregate demand in home nation can be written as

$$AD_t = C_{Ht} + C_{Ht}^* - C_{Ft} - Y_{1Ft} + \{1 - S(I_t/I_{t-1})\}I_t \tag{34}$$

Price and Wage Settings

In general, final-good firm *j* of good *i* faces the pricing decision in that the firm has to choose $\tilde{P}_{Ht}$ in order to maximize the expected discounted profits $E_t\Pi_t$ in the form[9]

$$E_t \prod\nolimits_t = E_t \sum_{i=0}^{\infty} (\theta\beta)^i \Lambda_{t+i}\left[\left(\tilde{P}^j_{Ht+i}(i) - \ddot{e}^N_{2t}\right)/P_{t+i}\right] \left[\tilde{P}^j_{Ht+i}(i)/P_{Ht}\right]^{-\varepsilon}\left[C_{Ht} + C^*_{Ht}\right] \tag{35}$$

where θ is the probability that firm *j* is not able to adjust price. Λ_{t+i} satisfies $(C_{t+1+i}/C_{t+i})^{-\sigma}$, $\beta^i C^{-\sigma}_{t+1+i}$ denotes the discounted factor in the interest of households and λ^N_{2t} is the nominal marginal cost that corresponds to Eq. (21). Solving for optimal reset price gives us the optimal reset price

$$\tilde{P}_{Ht+i} = \frac{\varepsilon}{\varepsilon - 1}\;\frac{E_t \sum_{i=0}^{\infty} (\theta\beta)^i \Lambda_{t+i}\lambda^N_{2t} Y_{2t+i} P^{-1}_{t+i}}{E_t \sum_{i=0}^{\infty} (\theta\beta)^i \Lambda_{t+i} Y_{2t+i} P^{-1}_{t+i}} \tag{36}$$

[9] We assume producer-currency pricing for export of home consumer goods as in the tradition of New Keynesian model.

Table 2 Calibrated parameters, steady states and shocks

Parameters	
α Capital share in production	0.360
δ Depreciation rate	0.023 (0.024)
κ Share of imported intermediate goods in good production	0.300
γ Share of imported consumer goods	0.800
φ Elasticity of substitution between home and imported consumer goods	0.290
ϑ Elasticity of substitution between home and imported intermediate goods	0.290
b Habit persistence	0.250 (0.102)
σ Constant relative risk aversion	0.170 (1.249)
χ Reciprocal of wage elasticity of labor supply	4.79
β Subjective discount rate	0.992 (0.995)
θ Calvo price stickiness	0.83
θ_W Calve wage stickiness	0.83
v_π Policy responsiveness toward inflation fluctuation	1.27
v_y Policy responsiveness toward output gap fluctuation	0.94
ω_i Interest rate smoothing	0.85
Steady states	
C_H^{SS}/y_2^{SS} Consumption-GDP ratio	0.491
I^{SS}/y_2^{SS} Investment-GDP ratio	0.412 (0.283)
tb^{SS}/y_2^{SS} Trade balance-GDP ratio	0.097
Japan's shock persistence	
ρ_a Productivity	0.949
ρ_i Monetary policy	0.35
ρ_π Inflation	0.974
ρ_{rp} Exchange rate risk premium	0.786
ρ_{yd} Yen-dollar nominal exchange rates	0.731
ρ_c Preference	0.892
Volatilities	
u_a Productivity	0.843
u_i Monetary policy	1.413
u_π Inflation	0.151
u_{rp} Exchange rate risk premium	0.044
u_{yd} Yen-dollar nominal exchange rates	0.056
u_c Preference	0.102

Notes: Numbers in bracket denote the corresponding value for Japan.

In Calvo price setting, a fraction of firm $1-\theta$ will reset price that approximates optimal reset price. The remaining fraction of firms θ that cannot reset price optimally will index to last-period price adjusted by inflation. Since aggregate log price level at each date is a probability-weighted average of partially indexed aggregate log price level and newly reset price, the New Keynesian Phillips curve for domestic inflation and CPI inflation, respectively, is[10]

$$\begin{aligned}\pi_{Ht} = &\left\{1/(1+\theta\beta)\right\}\pi_{Ht-1} + \left\{\beta/(1+\theta\beta)\right\}E_t\pi_{Ht+1} \\ &+ \left\{(1-\theta)(1-\theta\beta)/\theta(1+\theta\beta)\right\}\hat{p}_{1Ht} \\ &+ \left\{(1-\theta)(1-\theta\beta)/\theta(1+\theta\beta)\right\}\kappa\hat{T}_t\end{aligned} \tag{37}$$

$$\begin{aligned}\pi_t = &\left\{1/(1+\theta\beta)\right\}\pi_{t-1} + \left\{\beta/(1+\theta\beta)\right\}E_t\pi_{t+1} \\ &+ \left\{(1-\theta)(1-\theta\beta)/\theta(1+\theta\beta)\right\}\hat{p}_{1Ht} \\ &+ \left\{[(1-\theta)(1-\theta\beta)/\theta(1+\theta\beta)]\kappa + \gamma\right\}\hat{T}_t\end{aligned} \tag{38}$$

where $tot_t = \hat{p}_{1Ft} - \hat{p}_{1Ht}$ denotes terms of trade fluctuation, and $\hat{p}_{1Ht} = \hat{\ddot{e}}_{1t}$. Note that a hat over the small letter variable indicates the log-deviation of the variable from steady state.

As we assume Calvo-type staggered wage setting for intermediate-good firm, a fraction of firms $1-\theta_W$ thus resets wage optimally according to the wage level satisfying marginal rate of substitution between labor supply and consumption. Another fraction of firms that cannot optimally adjust wage will index the current wage to inflation-adjusted last-period wage level. Nominal wage inflation equation can then be derived as

$$\begin{aligned}\pi_t^W = &\left\{1/(1+\theta_W\beta)\right\}\pi_{t-1}^W + \left\{\beta/(1+\theta_W\beta)\right\}E_t\pi_{t+1}^W \\ &+ \left\{(1-\theta_W)(1-\theta_W\beta)/\theta_W(1+\theta_W\beta)\right\}markup_t\end{aligned} \tag{39}$$

where $markup_t = \hat{w}_t^{MRS} - \hat{w}_t^{MPL} \bullet \hat{w}_t^{MRS}$ is log-deviation of wage that corresponds to

[10] See Gali (2008) for details of derivation.

marginal rate of substitution between labor supply and consumption in Eq. (32) and $\hat{w}_t^{MPL}$ is log-deviation of wage that equals marginal product of labor.

Monetary Policy

We consider a general form of monetary policy reaction as below:

$$R_t = \left\{R_{t-1}\right\}^{w_i} \left\{\left(1+\pi_t\right)^{v_\pi} \left(AD_t/Y_{2t}\right)^{v_y}\right\}^{-\omega_i} \tag{40}$$

where ω_i measures the interest rate persistence, v_π and v_y, respectively, indicates central bank's responsiveness toward deviations of CPI inflation and of aggregate demand over potential output.

Parameterization

To conduct numerical analysis we first linearize the model equations described previously around the non-stochastic steady state. The full linearized system is depicted in appendix. There are seven foreign disturbances that follow AR(1) process: productivity $\hat{a}_{1t}^*$, preference $\hat{c}_t^*$, monetary policy $\hat{i}_t^*$, inflation π_t^*, risk premium $r\hat{p}$, wage $\hat{w}_{1t}^*$ and yen-dollar nominal exchange rates $\hat{s}_t^{Yen/US\$}$, and two foreign endogenous variables: real return on capital $\hat{r}_{Kt}^*$ and real marginal cost of intermediate-good producers $\hat{\lambda}_{1t}^*$. Upon these foreign forces there are 26 endogenous variables with respect to production, consumption, trade balance, investment, inflation, exchange rate, terms of trade and monetary policy to be determined.

We calibrate the model to Japan and Singapore (as a representation for Southeast Asia) with parameter values and steady states reported in Table 2. The "big ratios", consumption, investment and trade balance as a share of GDP, are based on Penn World Table 6.1. Depreciation rates are computed according to Expended Penn World Table 2.1. The benchmark parameter values were largely based on Ramayandi (2008) that has estimated a small-open-economy dynamic stochastic general equilibrium model (DSGE) for ASEAN-5 using maximum likelihood approach. On the other hand, we calibrate Japan's block, particularly the persistence and volatilities of shocks, to the findings of Sugo and Ueda (2008) that estimated a DSGE model a-la Christiano *et al*. (2005) using Bayesian method.

Quantitative Performance of New Keynesian Model

The model is solved by perturbation approach in order to obtain an explicit solution for the forward-looking dynamic stochastic general equilibrium model. The solution is conducted with Dynare algorithm. Figures 6 to 9 illustrate the model-simulated impulse response of Singapore's economy toward disturbances on Japan's interest rate, productivity and preference, and yen-dollar nominal exchange rates, respectively[11].

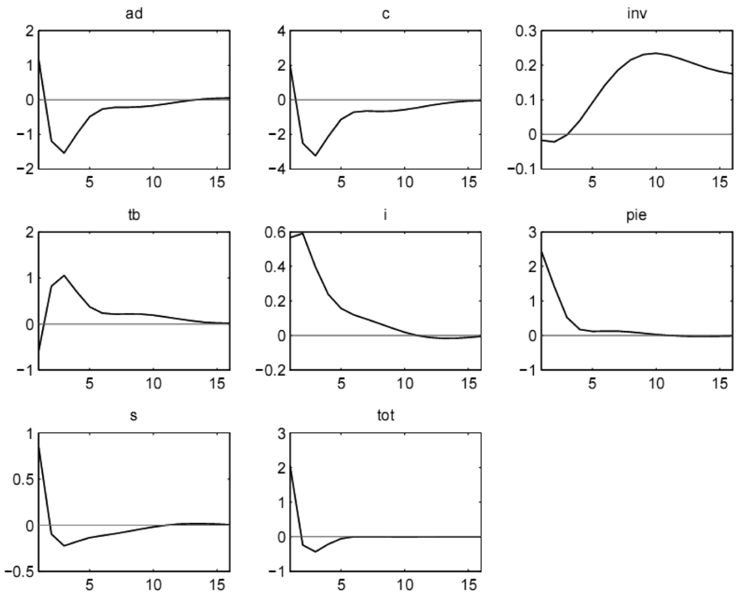

Figure 6 Simulated impulse response toward Japan's interest rate shock

[11] Vertical axis indicates the percentage of responses and horizontal axis indicates quarter.

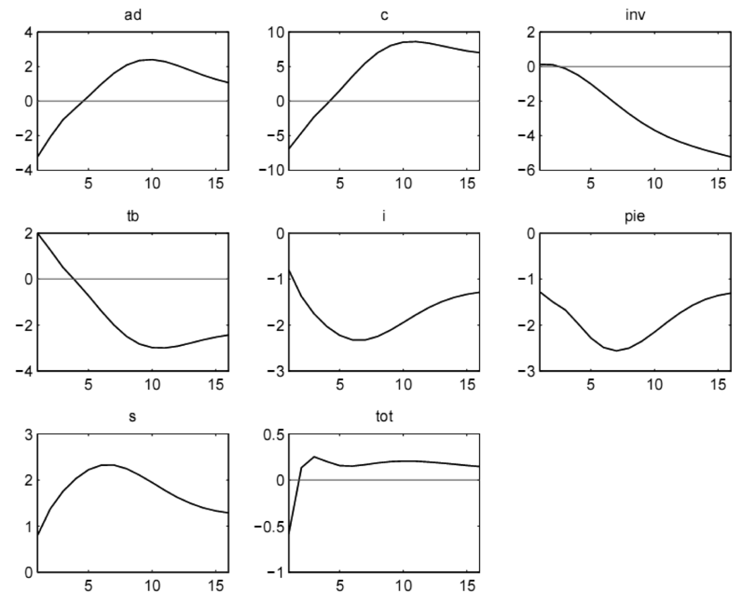

Figure 7 Simulated impulse response toward Japan's productivity shock

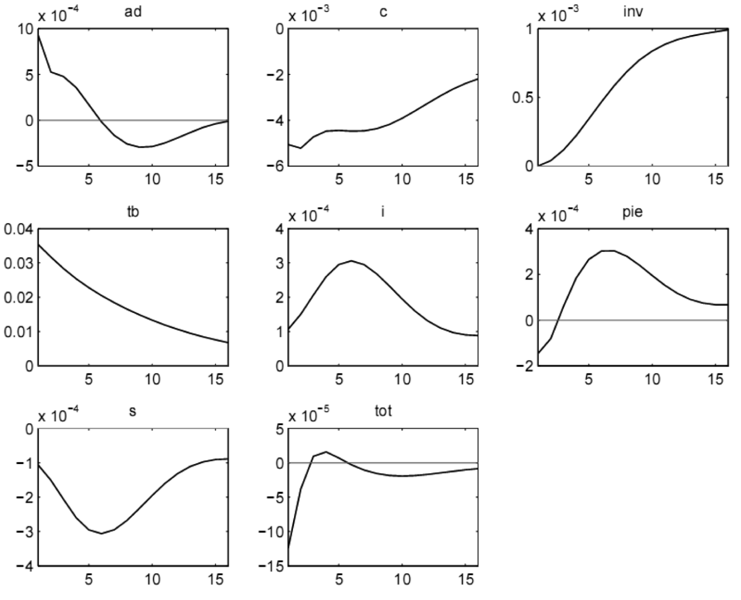

Figure 8 Simulated impulse response toward Japan's preference shock

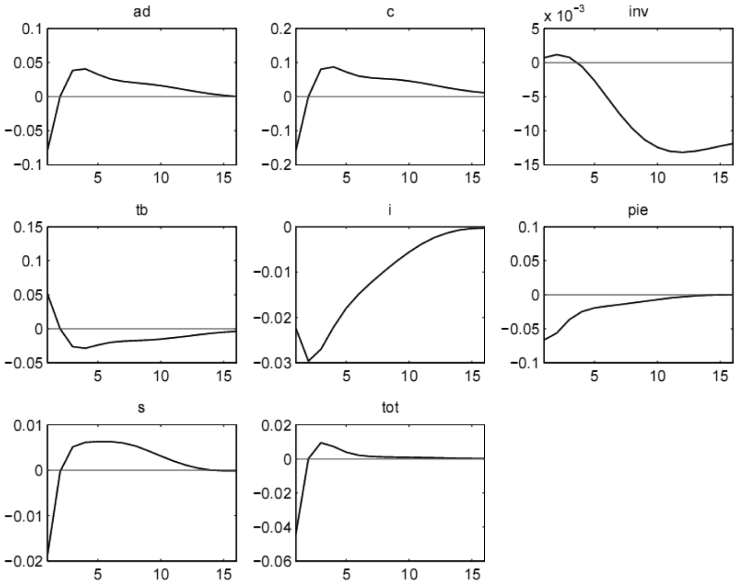

Figure 9 Simulated impulse response toward disturbance on Yen-Dollar exchange rates

When facing interest rate shock, output (ad) expands contemporaneously but contracts thereafter. This contraction is apparently driven by consumption dynamics (c) seeing that Japan's policy shock has been expansionary to investment (inv). Nominal exchange rate depreciates (s) deteriorating terms of trade (tot) and improving trade balance (tb). Terms of trade deterioration is inflationary. These results are starkly contrasted to empirical evidence discussed in previous section. A look at Figure 4 depicts that output contracts rather than expands contemporaneously and burgeon instead of contracting subsequently. Besides, Japan's interest rate shock appreciates, not depreciates, Singapore dollar against yen.

The incompatibility of the model in accounting for the stylized facts can be found in other types of shocks too. For instance, model inflation and exchange rate facing Japan's productivity shock, as shown in Figure 7, falls and depreciates, respectively. This is in contrast to the evidence of rising inflation and appreciated Singapore dollar against yen in the face of Japan's output shock. However, if we consider preference shock, which corresponds more closely than productivity shock to output shock in Figure 4, Figure 8 gives a better picture for the performance of the model. In particular, Japan's demand shock is generally expansionary, inflationary and welfare enhancing as terms of trade appreciate.

The model performs the best in capturing the effects of the variability of yen-dollar exchange rates. In line with the empirical findings, Figure 9 shows that shock to yen-dollar exchange rates is contractionary to output (though short-lived) and investment in particular, and is deflationary. Also, Singapore dollar appreciates on impact against yen, indicating the soft-peg to U.S. dollar.

The most unsatisfactory performance of the model is its failure to capture the effect of Japan's inflation shock in that the model economy does not respond at all to the disturbance on inflation. The intuition is indeed of a family resemblance to the Mundell-Fleming insights: expenditure-switching from Japan's own to imported consumer goods induced by Japan's inflation shock depreciates yen against Singapore dollar. With producer currency pricing, Singapore dollar appreciation would nullify the impact of rising Japan's price, stabilizing Singapore dollar price of imported goods and thus terms of trade. In other words, Japan's inflation shock would not be transmitted into Singapore's macroeconomy through imports.

On balance, we show that the open-economy New Keynesian model cannot explain satisfactorily the empirical findings on home dynamics driven by foreign monetary and inflation shocks[12], although it provides characterizations more consistent with the data in the face of shocks to foreign demand and yen-dollar exchange rates.

CONCLUSION

In this paper, we first investigate empirically the transmission of shocks from Japan to Southeast Asia. We show that in general for Southeast Asia (1) Japan's monetary policy tightening is expansionary to output and deflationary to price while appreciating home currencies against yen; (2) Japan's output shock prospers thy neighbors and is welfare-enhancing; (3) Japan's price shock bolsters output, inflates price and depreciates home currency against yen; (4) yen depreciation against U.S. dollar is contractionary and deflationary to the region; and (5) regional currencies generally peg softly to U.S. dollar.

We then inspect whether the popular open-economy New Keynesian model enriched by a variety of real and nominal frictions can explain these transmission of shocks simultaneously. We find the answer to be discouraging. Although it is able to characterize the transmission of preference shocks and yen-dollar exchange

[12] Wang and Wen (2007) found that neither the New Keynesian sticky-price model nor the sticky-information model can account for the facts that the average cross-country inflation is highly correlated, and that the correlation is significantly and systematically stronger than the cross-country output correlation.

rates shocks, it fails completely to account for the dynamics driven by foreign monetary shocks and inflation shocks.

In consequence, we conclude that macroeconomic dependence of Southeast Asia on Japan cannot be comprehended within a framework that ignores the production interconnectedness between Southeast Asia and Japan, and the derived trade in intermediate inputs. Whether explicitly formalizing vertical and sequential production connectedness and intermediate-input trade in a two-country (or multi-country) model can be responsible for the empirical regularities simultaneously would be a challenging yet promising task for future research.

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