Rising China, anxious Asia? A Bayesian New Keynesian view

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Abstract

Should Asia feel anxious about China's expansion? We look for the answer through the estimation of a two-country New Keynesian model of production fragmentation covering ten Asian economies, including China. The estimates show that vis-à-vis China, the developed Asia has a more fragmented production structure with higher domestic value-added embodied in intermediates traded with China whereas the developing Asian production chains are less fragmented with more foreign value-added. We also find that China's expansion made possible by favorable demand and price shocks benefits all Asian neighbors. Expansion driven by total factor productivity improvement, however, lifts the aggregate value-added in the developed Asia but not in the developing Asia, unless the shocks symmetrically originate in both China and the developing Asia. Fixing the regional currencies irrevocably to the U.S dollar ensures that China's productivity improvements are beneficial to all, regardless of the symmetry of shocks, although it is nearly irrelevant for responses to other type of shocks. Therefore, our answer to the introductory question is a simple no for the developed Asia and a conditional no for the developing Asia.

Keywords: Production fragmentation; Value-added trade; China; New Keynesian model; Bayesian estimation

JEL classification: F41, F44

1. Introduction

The rise of China as a manufacturing powerhouse and export platform has been frequently noted in recent years. China deserves the attention from its Asian neighbors in which production and trade have been highly integrated into the rest of the world (Amador and Cabral, 2009). To Asian economies, China's rise means both an opportunity and a threat. On one spectrum, the rapid expansion of China's processing exports implies a greater demand for parts and components from its Asian neighbors. For example, by calibrating and simulating a computable general equilibrium model, Ianchovichina and Walmsley (2005) show that China's WTO accession has crowded in Japan and the East Asian newly industrialized economies that supply materials to China (see Greenaway et al., 2008). On another spectrum, as the main source of labor-intensive value-added for the United States and the Euro Area, Chinese expansion also triggers a displacement effect on the exports of developing Asian economies with an approximate endowment structure. Eichengreen et al. (2007) also find that, while China's growth is beneficial to advanced East Asian economies that export capital-intensive goods, pain is felt by the developing Southeast Asian countries that export labor-intensive goods (see also Wood and Mayer, 2011; Roland-Holst and Weiss, 2004; Haltmaier et al. 2007; Ahearne et al., 2003 show contradictory findings).

Figure 1 neatly visualizes this comrade-or-competitor conjecture. The rapid expansion of East and Southeast Asian trade with China, particularly following China's accession into the World Trade Organization (WTO) at the end of 2001, is obviously accompanied by declining levels of export and import with the United States. For example, in the first quarter of 1990, of the total Malaysian exports to the rest of the world, China only accounted for 2.3 percent whereas the U.S accounted for 18 percent. Just prior to China's WTO accession, the relative

importance of China steadily climbed to 8 percent although the U.S. share still stood firmly at 20 percent. However, within the subsequent eight years, China became the nation that digested 18 percent of Malaysian exports in conjunction with a rapid fall in the share of exports to the U.S. to a historically low level of 11 percent.

-- [INSERT FIGURE 1 HERE] --

Has China actually displaced other Asian countries' exports to the United States? Or can the great trade reshuffling be attributed to the reorganization of value chains in such a way that other Asian countries now export to China for final goods assembly and export to the rest of the world (Athukorala, 2007)? It should not be forgotten that the pattern of exports can be endogenous to other shocks. A shift in U.S consumers' attitudes toward Chinese goods, for instance, may drive this great reshuffling in the direction of trade. For instance, permanently favorable Chinese productivity shock, although it enhances its export competitiveness and may have displaced other Asian exports, actually improves the regional terms of trade and welfare. In either case, "friend or foe" is an irrelevant narrative.

Instead of examining the export competition, this paper is aimed at a larger purpose. We ask two questions: First, what is the bilateral production and trade linkage between China and the rest of Asia? Second, how has bilateral fragmentation in production and trade shaped the responses of Asian neighbors to the macroeconomic disturbances of China? To search for the answers, we set up a medium-scale, two-country, dynamic New Keynesian model of production fragmentation in Section 2 and take this model in Section 3 to data from ten Asian countries (including China) using a Bayesian approach.

Previewing the results in Sections 4 and 5, we show that the value chains of production in advanced Asian economies have been sliced up to a greater extent than those in China. Perhaps

this observation is unsurprising compared with another finding, that China has a more vertically fragmented production structure vis-à-vis the developing Southeast Asian countries. As a result, China trades intermediates with advanced Asia but not with developing Southeast Asia. Although this varied bilateral relationship in production and trade has few implications on the impulse responses to China's demand and price shocks, it matters for the international transmission of total factor productivity (TFP) shock: China's favorable TFP shock lifts the aggregate value-added in advanced Asia but not in developing Southeast Asia.

More interestingly, the role of production fragmentation in the pattern and magnitude of responses to shock is influenced by the choice of exchange rate regime and the nature of the shock. An irrevocable peg of the Chinese reminbi to the dollar makes China's expansion beneficial to all countries in the region irrespective of the nature of shocks. Symmetric shock ties together the responses of all countries within the value chains. However, the most fragmented advanced Asia responds to China's shocks to a greater extent than developing Southeast Asia.

2.   Setting up a New Keynesian model of production fragmentation and trade

In this section, grounded in the two-country, three-production value chain model first developed by Wong and Eng (2013), we formalize the interaction between China and the rest of Asia. In this model, final goods produced at the downstream stage use the domestic and imported intermediates manufactured in the midstream stage, which in turn use the domestic and imported intermediates produced in the most upstream stage of production as an input of production. As such, a simple global input-output structure is established with outputs of all stages that are tradable. Shocks to any of the value chains will be transmitted across stages and across borders. In addition, by reinvesting a portion of the final goods as capital stock for upstream production, a

simple "intermediate loop" is also established. This parsimonious model is sufficient to account for the most comprehensive breakdown of value-added in gross exports, as advanced by Koopman et al. (2010) and Johnson and Noguera (2012).

The model also incorporates external habit persistence, investment adjustment cost, partial price and nominal wage indexation as well as time-dependent price and nominal wage setting mechanisms. The model is thus sufficiently rich, e.g., compared with the dynamic Ricardian model of Yi (2003), for investigation of the dynamic macroeconomic interactions between China and other countries. Because decisions made by China and the rest of the Asian countries are analogous in a two-country model, the discussion is thus mainly devoted to China as the home economy.

Before describing the model, it is noteworthy to note a well-known caveat of the two-country model: it can easily overlook the influence of a third country, particularly the role of the U.S. and Euro Area absorption for both China and the rest of the Asian exporters. We use three measures to overcome this limitation. First, we allow the U.S. monetary policy shock to spill over to both regions through an uncovered interest rate parity condition. Second, we use the observable series on aggregate exports and imports rather than the bilateral trade series in our estimations to accommodate for the potential third-country influence on the respective economies through trade. Third, in principle, third-country shock may affect China and the rest of Asia either through a door gate exclusively located in China, which is only rippled upward to other countries via input-output linkage, or concurrently through various stages of production. Hence, we supplement the baseline analysis in a model of vertical production linkage that

encounters asymmetric shocks originated in China with symmetric shocks that resemble the latter channel[1].

2.1. Household

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

$$U = E_t\left\{\sum_{t=0}^{\infty}\beta^t u_t^C\left[\frac{(C_t^i - bC_{t-1}^i)^{1-\sigma}}{1-\sigma} - u_t^N\frac{(N_t^i)^{1+\chi}}{1+\chi}\right]\right\} \tag{1}$$

where

$$C_t^i = \left[(\gamma)^{1/\varphi}(C_{C,t}^i)^{(\varphi-1)/\varphi} + (1-\gamma)^{1/\varphi}(C_{AC,t}^i)^{(\varphi-1)/\varphi}\right]^{\varphi/(\varphi-1)} \tag{2}$$

u_t^C and u_t^N refer to the i.i.d preference and labor supply shock, respectively.

$C_{C,t}^i\left\{= \left(\int_{i\in I}C_{C,t}^i(i)^\rho di\right)^{\frac{1}{\rho}}\right\}$ and $C_{AC,t}^i\left\{= \left(\int_{i\in I}C_{AC,t}^i(i)^\rho di\right)^{\frac{1}{\rho}}\right\}$ denote the composite varieties of

home and imported consumer goods, respectively, from the rest of Asia[2]. The parameter $\frac{1}{1-\rho}$

denotes the elasticity of substitution between varieties. b is the parameter that governs the extent

of habit persistence. $0 < \beta < 1$ refers to a subjective discount factor, σ measures the coefficient

of relative risk aversion, and the reciprocal of χ indicates the wage elasticity of labor supply. The

parameter $\varphi > 1$ denotes the elasticity of substitution between home and imported consumer

goods, and γ measures the home bias. Household i maximizes Eq. (1) subject to Eq. (2) and the

following flow budget constraint

$$C_t^i + \left(\frac{S_{CD,t}}{P_t\omega_t}\right)\left(\frac{B_t^D}{R_t^D}\right) + \frac{B_t}{P_tR_t} + K_t = W_t^iN_t^i + \Pi_t + (1+r_{K,t})K_{t-1} + \left(\frac{S_{CD,t}B_{t-1}^D + B_{t-1}}{P_t}\right) \tag{3}$$

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[1] See Liao et al. (2012) for an interesting treatment of three-country interaction within a two-country setting.

[2] For variable x_{ij}, where $i \neq j$, i denotes the source country or origin of production, while j denotes destination of export. When $i = j$, we simplify the notation to x_i.

where $W_t^i \left(= \left[\int_{i \in I} (W_t^i)^{\rho_n} di \right]^{\frac{1}{\rho_n}} \right)$, $r_{K,t}$, and Π_t, respectively, denote real wage compensation for labor of variety i, return on capital stock, and profit as the firm's owner. Household holds domestic B and foreign bond denominated in U.S dollar $B^{\mathcal{D}}$. An i.i.d exchange-rate risk ω_t exists in the foreign asset market for fluctuation between the home currency and the U.S. dollar $S_{\mathcal{CD}}$. Solving for the utility maximization problem yields the optimal demand schedules for the varieties and composite varieties from Eqs. (4) to (7), the marginal rate of substitution between work and consumption (8), the consumption Euler equation (9), and the uncovered interest rate parity (UIPC) (10).

$$C_{\mathcal{C},t}^i(i) = \left(\frac{P_{\mathcal{C},t}(i)}{P_{\mathcal{C},t}} \right)^{-\frac{1}{1-\rho_t}} C_{\mathcal{C},t}^i \tag{4}$$

$$C_{\mathcal{AC},t}^i(i) = \left(\frac{P_{\mathcal{AC},t}(i)}{P_{\mathcal{AC},t}} \right)^{-\frac{1}{1-\rho_t}} C_{\mathcal{AC},t}^i \tag{5}$$

$$C_{\mathcal{C},t}^i = \gamma \left(\frac{P_{\mathcal{C},t}}{P_t} \right)^{-\varphi} C_t^i \tag{6}$$

$$C_{\mathcal{AC},t}^i = \gamma \left(\frac{P_{\mathcal{AC},t}}{P_t} \right)^{-\varphi} C_t^i \tag{7}$$

$$\left(N_t^i \right)^{\chi} \left(C_t^i - bC_{t-1}^i \right)^{\sigma} u_t^N = W_t^{MRS} \tag{8}$$

$$\frac{\left(C_t^i - bC_{t-1}^i \right)^{-\sigma}}{P_t} u_t^C = \beta(1 + r_t) \frac{\left(E_t C_{t+1}^i - bC_t^i \right)^{-\sigma}}{E_t P_{t+1}} E_t u_{t+1}^C \tag{9}$$

$$S_{\mathcal{CD},t} = E_t S_{\mathcal{CD},t+1} \left(\frac{1+r_t^{\mathcal{D}}}{1+r_t} \right) \omega_t \tag{10}$$

where ω_t can also be interpreted as the i.i.d UIPC shock, and P_t is the utility-based consumer price index (CPI) that features the price of domestic and Asian-exported final goods weighted with the degree of home bias.

$$P_t = \left[\gamma P_{\mathcal{C},t}^{1-\varphi} + (1-\gamma) P_{\mathcal{AC},t}^{1-\varphi} \right]^{1/(1-\varphi)} \tag{11}$$

Households are differentiated into types, $i \in I$, and are thus a monopolistic supplier of labor effort sought in upstream production. In each period, a fraction of the household, $1 - \theta_w$, can reset their posted nominal wage to approximate the welfare-maximizing wage level compatible with the marginal rate of substitution between the labor supply and consumption (8) whereas another fraction of households $\theta_w \gamma_w$ can readjust their wages for last-period inflation[3]. Hence, the nominal wage inflation equation can be derived as

$$\pi_{w,t} = \left\{ \frac{\gamma_w}{1+\beta\gamma_w\theta_w} \right\} \pi_{w,t-1} + \left\{ \frac{\beta}{1+\beta\gamma_w\theta_w} \right\} E_t \pi_{w,t+1} + \left\{ \frac{(1-\theta_w)(1-\theta_w\beta)}{\theta_w(1+\beta\gamma_w\theta_w)} \right\} (\varpi_t + u_{w,t}) \qquad (12)$$

where $\varpi_t = \widehat{w}_t^{MRS} - \widehat{w}_t$. $u_{W,t}^C$ is the i.i.d wage markup shock, and $\hat{x}_t (\equiv lnx_t - ln\bar{x})$ is defined as a variable log-linearized around the steady state value.

2.2. Input-output linkage: From downstream to midstream and upstream firms

The final goods consumed by households are manufactured by a continuum of monopolistically competitive downstream producers j of measure J that combines a variety of home $Y_{2C,t}^j \left(= \left[\int_{j \in J} Y_{2C,t}^j(j)^\rho dj \right]^{\frac{1}{\rho}} \right)$ and Asian-exported intermediate goods $M_{2\mathcal{AC},t}^j \Big(= \left[\int_{j \in J} M_{2\mathcal{AC},t}^j(j)^\rho dj \right]^{\frac{1}{\rho}} \Big)$ in a constant-elasticity-of-substitution (CES) technology.

$$Y_{3t}^j = \left[(1-\kappa_3)^{\frac{1}{\vartheta}} \left(Y_{2C,t}^j \right)^{\frac{\vartheta-1}{\vartheta}} + \kappa_3^{\frac{1}{\vartheta}} \left(M_{2\mathcal{AC},t}^j \right)^{\frac{\vartheta-1}{\vartheta}} \right]^{\frac{\vartheta}{\vartheta-1}} \qquad (13)$$

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[3] One can associate this Calvo-type staggered wage setting with the analogy of performance-linked wage setting. In every period, the "outperforming" fraction of households $1 - \theta_w$ is rewarded with compensation that matches the welfare-maximizing wage level. Another fraction of households that achieves the "meet expectation" performance $\theta_w\gamma_w$, will receive compensation adjusted only for cost of living. The remaining "underperforming" fraction of households $\theta_w(1 - \gamma_w)$ will receive no wage adjustment in any form. Because the performance assessment normally takes place when a certain time interval has elapsed, it is thus not inappropriate to assume a time-dependent wage-setting mechanism.

The parameter κ_3 denotes the share of imported intermediate inputs in downstream production, and $\vartheta > 0$ indicates the elasticity of substitution between the domestic and imported intermediate inputs. In addition to domestic and foreign consumption, the downstream output is also purchased and reinvested by the upstream producers as capital stock for production, $Y_{3t}^j \equiv C_{\mathcal{C},t}^i + Y_{3\mathcal{C}\mathcal{A},t}^i + I_t^j$.

The use of domestic intermediates in both local and foreign downstream production constitutes the demand for the home midstream output, $Y_{2t}^j \equiv Y_{2\mathcal{C},t}^j + Y_{2\mathcal{C}\mathcal{A},t}^j$. To comply with the demand, a mass continuum of midstream monopolistically competitive firms $j \in J$ processes a variety of domestic $Y_{1\mathcal{C},t}^j \left(= \left[\int_{j \in J} Y_{1\mathcal{C},t}^j(j)^\rho dj \right]^{\frac{1}{\rho}} \right)$ and imported intermediates at c.i.f $M_{1\mathcal{A}\mathcal{C},t}^j \Big(=$

$\left[\int_{j \in J} M_{1\mathcal{A}\mathcal{C},t}^j(j)^\rho dj \right]^{\frac{1}{\rho}} \Big)$ manufactured at an earlier stage of production in CES technology into the midstream output

$$Y_{2t}^j = \left[(1 - \kappa_2)^{\frac{1}{\vartheta}} \left(Y_{1\mathcal{C},t}^j \right)^{\frac{\vartheta-1}{\vartheta}} + \kappa_2^{\frac{1}{\vartheta}} \left(M_{1\mathcal{A}\mathcal{C},t}^j \right)^{\frac{\vartheta-1}{\vartheta}} \right]^{\frac{\vartheta}{\vartheta-1}} \tag{14}$$

Formally speaking, firms at both the downstream and midstream stages first choose $Y_{s\mathcal{C},t}^j(j)$ and $M_{s\mathcal{A}\mathcal{C},t}^j(j), s = 2,3$, to minimize the cost of each variety. Next, given the Lagrange multiplier $\mathcal{R}_{st}$ that denotes the real marginal cost, the firms choose $Y_{s\mathcal{C},t}^j$ and $M_{s\mathcal{A}\mathcal{C},t}^j$ to minimize the overall cost of production subject to the production function (13) and (14) in the downstream and midstream stages, respectively. The optimal demand schedules for varieties and for home and imported intermediate goods at $s = 2,3$ can be easily obtained by:

$$Y_{s\mathcal{C},t}^j(j) = \left(\frac{P_{s\mathcal{C},t}^j(j)}{P_{s\mathcal{C},t}^j} \right)^{-\frac{1}{1-\rho}} Y_{s\mathcal{C},t}^j \tag{15}$$

$$M_{s,\mathcal{AC},t}^{j}(j) = \left(\frac{P_{s,\mathcal{AC},t}^{j}(j)}{P_{s,\mathcal{AC},t}^{j}}\right)^{-\frac{1}{1-\rho}} M_{s,\mathcal{AC},t}^{j} \tag{16}$$

$$Y_{s-1,\mathcal{C},t}^{j} = (1-\kappa_s)\left(\frac{P_{s-1,\mathcal{C},t}^{j}}{P_{s-1,t}^{j}}\right)^{-\vartheta} Y_{s,t}^{j} \tag{17}$$

$$M_{s-1,\mathcal{AC},t}^{j} = \kappa_s \left(\frac{P_{s-1,\mathcal{AC},t}^{j}}{P_{s-1,t}^{j}}\right)^{-\vartheta} Y_{s,t}^{j} \tag{18}$$

where $P_{s-1,t}^{j}$ is the producer price index for producers at stage s, derived as the weighted average price of domestic $P_{s-1,\mathcal{C},t}^{j}$ and imported foreign intermediates $P_{s-1,\mathcal{AC},t}^{j}$ manufactured at the earlier stage $s-1$.

$$P_{s-1,t}^{j} = \mathcal{R}_{st} = \left[(1-\kappa_s)\left(P_{s-1,\mathcal{C},t}^{j}\right)^{1-\vartheta} + \kappa_s\left(P_{s-1,\mathcal{AC},t}^{j}\right)^{1-\vartheta}\right]^{\frac{1}{1-\vartheta}} \tag{19}$$

This input-output linkage can be traced further backward as the intermediates used in midstream production are churned out by a unit mass of competitive firms in upstream production. The upstream firms adopt the Cobb-Douglas production technology (20) that blends plant-specific capital $K_{t-1}^{j}, j \in J$, with differentiated labor $N_t^i, i \in I$, to produce plant-specific intermediates Y_{1t}^{j}.

$$Y_{1t}^{j} = e^{A_t}\left(K_{t-1}^{j}\right)^{\alpha}\left(N_t^i\right)^{1-\alpha} \tag{20}$$

The output is used for midstream production at home and in foreign economy, $Y_{1t}^{j} \equiv Y_{1\mathcal{C}t}^{j} + Y_{1\mathcal{C}\mathcal{A}t}^{j}$, and A_t is the first-order autoregressive Hicks-neutral total factor productivity (TFP) shock. The upstream firms vary the purchase of investment goods from downstream firms I_t^{j} at a cost to accumulate capital stock for production. Specifically, capital stock accumulation with quadratic investment adjustment cost evolves as

$$K_t^j = (1 - \delta)K_t^j + u_t^I I_t^j \left\{ 1 - \frac{\Psi}{2} \left(\frac{u_{t-1}^I I_{t-1}^j}{u_t^I I_t^j} \right) \left(\frac{u_t^I I_t^j}{u_{t-1}^I I_{t-1}^j} - \mathfrak{I} \right)^2 \right\} \tag{21}$$

where u_t^I is the investment-specific technology (IST) shock, which follows a first-order autoregressive process. The parameter Ψ governs the investment adjustment cost, and $\mathfrak{I}$ determines to what extent the investment decision is forward-looking. The upstream firm optimally chooses the path of K_t^j and N_t^i to minimize the cost of production $(r_{K,t} + \delta)K_{t-1}^j + W_t^i N_t^i$ subject to the production net of the investment adjustment cost

$$\mathcal{R}_{1t} \left\{ e^{A_t} (K_{t-1}^j)^\alpha (N_t^i)^{1-\alpha} - \frac{\Psi}{2} \left(\frac{u_{t-1}^I I_{t-1}^j}{u_t^I I_t^j} \right) \left(\frac{u_t^I I_t^j}{u_{t-1}^I I_{t-1}^j} - \mathfrak{I} \right)^2 = 0 \right\}$$

where $\mathcal{R}_{1t}$ is a Lagrange multiplier that acts as a proxy for the upstream real marginal cost. For the optimal demand for labor of varieties i, the marginal productivity of capital and labor, and the dynamic investment decision, we obtain

$$N_t^i(i) = \left(\frac{W_t^i(i)}{W_t^i} \right)^{-\frac{1}{1-\rho_n}} N_t^i \tag{22}$$

$$r_{K,t} = \alpha \mathcal{R}_{1t} \left(\frac{Y_{1t}^j}{K_t^j} \right) - \delta \tag{23}$$

$$W_t^i = (1 - \alpha)\mathcal{R}_{1t} \left(\frac{Y_{1t}^j}{N_t^i} \right) \tag{24}$$

$$\mathcal{R}_{1t} \left(\frac{u_t^I I_t^j}{u_{t-1}^I I_{t-1}^j} - \mathfrak{I} \right) = \mathcal{R}_{1t+1} \left\{ \left(\frac{u_{t+1}^I I_{t+1}^j}{u_t^I I_t^j} - \mathfrak{I} \right) \left(\frac{u_{t+1}^I I_{t+1}^j}{u_t^I I_t^j} \right) - \frac{1}{2} \left(\frac{u_{t+1}^I I_{t+1}^j}{u_t^I I_t^j} - \mathfrak{I} \right)^2 \right\} \tag{25}$$

Inserting the marginal product of capital (23) and of labor (24) into the Cobb-Douglas production function (20) yields the real marginal cost of the upstream firm.

$$\mathcal{R}_{1t} = \frac{(r_{K,t} + \delta)^\alpha (W_t^i)^{1-\alpha}}{e^{A_t} \alpha^\alpha (1-\alpha)^{1-\alpha}} \tag{26}$$

For the sake of simplicity, we assume a perfectly competitive market for upstream goods. The elasticity of substitution between varieties is thus close to infinity, and as a consequence, the output price approximates the real marginal cost, $P_{1,t}^j = \mathcal{R}_{1t}$, and is symmetric across all manufacturing plants.

2.3. Optimal pricing decisions with U.S dollar pricing in exports

Pricing decisions are assumed to be time dependent. The ability of domestic firms in midstream and downstream production to re-optimize the price is subject to the signal received at probability $1 - \theta_{Ps}$, for s = 2,3. Firm j that receives the signal chooses $\mathbb{P}_{s\mathcal{C},t}^j$ and $\mathbb{P}_{s\mathcal{C}\mathcal{A},t}^D$ to maximize the expected discounted profits $E_t\Pi_t$ for sales in the home and export markets, respectively. For the home market, the pricing decision is formulated as

$$E_t\Pi_t = E_t \sum_{i=0}^{\infty} (\theta_{Ps}\beta)^i \Lambda_{t+i} \left[\frac{\mathbb{P}_{s\mathcal{C},t+i}^j(j) - \mathcal{R}_{s,t+i}^n}{P_{s,t+i}^j} \right] \left[\frac{\mathbb{P}_{s\mathcal{C},t+i}^j(j)}{P_{s\mathcal{C},t+i}^j} \right]^{-\frac{1}{1-\rho}} Y_{s\mathcal{C},t+i}^j(j) \tag{27}$$

Another important feature of the model is the assumption of U.S dollar pricing in exports and imports motivated by the fact that international trade is mostly priced in U.S dollars (Goldberg and Tille, 2008). The formation of a regional production network with the United States as a final destination, at least for the case of Japanese firms, has indeed contributed to the pervasive practice of trade invoicing in dollars (Ito et al., 2012).

The dollar pricing mechanism interestingly resembles the closed movement between nominal exchange rates and the relative price of imports and exports, while producing incomplete exchange rate pass-through into the output price. Nominal depreciation, as the argument goes, raises the unit import price in the local currency. Nonetheless, local-currency-denominated export revenue has expanded as well, helping firms to absorb the negative impact

of depreciation on markup without the need to raise the output price for the home and export markets proportionally. As a result, nominal depreciation is associated with less-than-proportional deterioration in terms of trade and an incomplete exchange rate pass-through.

The firm's expected export profit in the home currency under a dollar pricing strategy is formulated as

$$E_t\Pi_t^{export} = E_t \sum_{i=0}^{\infty}(\theta_{P,s\mathcal{CA}}\beta)^i \Lambda_{t+i} \left[\frac{S_{\mathcal{CD},t}\mathbb{P}_{s\mathcal{CA},t+i}^{\mathcal{D}}(j)-\mathcal{R}_{s,t+i}^n}{P_{s,t+i}^j}\right] \left[\frac{S_{\mathcal{AD},t}\mathbb{P}_{s\mathcal{CA},t+i}^{\mathcal{D}}(j)}{P_{s\mathcal{CA},t+i}^j}\right]^{-\frac{1}{1-\rho}} Y_{s\mathcal{CA},t+i}^j(j) \quad (28)$$

In the following expressions, we assume that all firms are symmetric in price setting. Solving for optimal reset price yields

$$\mathbb{P}_{s\mathcal{C},t+i} = \left(\frac{1}{\rho_t}\right)\sum_{i=0}^{\infty}\left[(\theta_{Ps}\beta)^i \Lambda_{t+i}\mathcal{R}_{s,t+i}^n\right] \quad (29)$$

$$\mathbb{P}_{s\mathcal{CA},t+i}^{\mathcal{D}} = \left(\frac{1}{\rho_t}\right)\sum_{i=0}^{\infty}\left[\frac{(\theta_{P,s\mathcal{CA}}\beta)^i \Lambda_{t+i}\mathcal{R}_{s,t+i}^n}{S_{\mathcal{CD},t+i}}\right] \quad (30)$$

Firms allowed for price re-optimization will reset their log-linearized price to approximate the optimal reset price (29) and (30), resulting, respectively, in

$$\hat{p}_{s\mathcal{C},t} = \theta_{Ps}\beta E_t\hat{p}_{s\mathcal{C},t+1} + (1-\theta_{Ps}\beta)\widehat{\mathbb{P}}_{s\mathcal{C},t} \quad (31)$$

$$\hat{p}_{s\mathcal{CA},t} = \theta_{P,s\mathcal{CA}}\beta E_t\hat{p}_{s\mathcal{CA},t+1} + (1-\theta_{P,s\mathcal{CA}}\beta)\widehat{\mathbb{P}}_{s\mathcal{CA},t}^{\mathcal{D}} \quad (32)$$

The remaining firms that do not receive the signal for re-optimization will maintain the last-period price, out of which a fraction γ_p will adjust the price for inflation. Hence, the log-linearized aggregate price level at each date can be written as a probability-weighted average of the non-optimized and re-optimized prices:

$$\hat{p}_{s\mathcal{C},t} = \theta_{Ps}\left(\hat{p}_{s\mathcal{C},t-1} + \gamma_p\pi_{s\mathcal{C},t-1}\right) + (1-\theta_{Ps})\hat{p}_{s\mathcal{C},t} \quad (33)$$

$$\hat{p}_{s\mathcal{CA},t} = \theta_{P,s\mathcal{CA}}\left(\hat{p}_{s\mathcal{CA},t-1} + \gamma_{p,s\mathcal{CA}}\pi_{s\mathcal{CA},t-1}\right) + (1-\theta_{P,s\mathcal{CA}})\hat{p}_{s\mathcal{CA},t} \quad (34)$$

By, respectively, inserting the aggregate price level (33) and (34) and its forward iteration together with the log-linearized optimal reset price (29) and (30) into the re-optimized price level (31) and (32), we can obtain four New Keynesian Phillip curves: the producer price inflation, the GDP deflator inflation, and the export price inflation for both intermediate and final goods.

$$\pi_{s\mathcal{C},t} = \left(\frac{\gamma_{Ps}}{1+\theta_{Ps}\beta\gamma_{Ps}}\right)\pi_{s\mathcal{C},t-1} + \left(\frac{\beta}{1+\theta_{Ps}\beta\gamma_{Ps}}\right)E_t\pi_{s\mathcal{C},t+1} + \lambda_{\mathcal{C}}\left(\hat{\mathcal{R}}_{s,t} + u_{s\mathcal{C},t}^{\pi}\right) \tag{35}$$

$$\pi_{s\mathcal{C}\mathcal{A},t} = \left(\frac{\gamma_{p,s\mathcal{C}\mathcal{A}}}{1+\theta_{P,s\mathcal{C}\mathcal{A}}\beta\gamma_{p,s\mathcal{C}\mathcal{A}}}\right)\pi_{s\mathcal{C}\mathcal{A},t-1} + \left(\frac{\beta}{1+\theta_{P,s\mathcal{C}\mathcal{A}}\beta\gamma_{p,s\mathcal{C}\mathcal{A}}}\right)E_t\pi_{s\mathcal{C}\mathcal{A},t+1} + \lambda_{\mathcal{C}\mathcal{A}}\left(\hat{\mathcal{R}}_{s,t} - \hat{s}_{\mathcal{C}\mathcal{D},t} + u_{s\mathcal{C}\mathcal{A},t}^{\pi}\right)$$

$$\tag{36}$$

where

$\lambda_{\mathcal{C}} = (1 - \theta_{Ps})(1 - \theta_{Ps}\beta)/\left(\theta_{Ps}(1 + \theta_{Ps}\beta\gamma_{Ps})\right),$

$\lambda^{*} = \left(1 - \theta_{P,s\mathcal{C}\mathcal{A}}\right)\left(1 - \theta_{P,s\mathcal{C}\mathcal{A}}\beta\right)/\left(\theta_{P,s\mathcal{C}\mathcal{A}}\left(1 + \theta_{P,s\mathcal{C}\mathcal{A}}\beta\gamma_{p,s\mathcal{C}\mathcal{A}}\right)\right). \, u_{s\mathcal{C},t}^{\pi}$ and $u_{s\mathcal{C}\mathcal{A},t}^{\pi}$ are the i.i.d

price markup shock for $s = 2,3$.

2.4. Summing up the model

The aggregate value-added of the economy $\mathbb{Y}$, which corresponds to the gross domestic product (GDP) in the national account, is summed up as

$$\mathbb{Y}_t = C_t + I_t + \mathbb{T}_t \tag{37}$$

where the trade balance $\mathbb{T}$ is defined as the balance between the aggregate f.o.b exports and the aggregate c.i.f imports.

$\mathbb{T}_t \equiv$

$Y_{1\mathcal{C}\mathcal{A},t} + \int_{j\in J} Y_{2\mathcal{C}\mathcal{A},t}(j)dj + \int_{j\in J} Y_{3\mathcal{C}\mathcal{A},t}(j)dj - M_{1\mathcal{A}\mathcal{C},t} - \int_{j\in J} M_{2\mathcal{A}\mathcal{C},t}(j)\,dj - \int_{i\in I} C_{\mathcal{A}\mathcal{C},t}(i)\,di$(38)

The model is closed by considering a general form of monetary policy reaction as shown below:

$$r_t = \rho_R r_{t-1} + (1 - \rho_R)\left(r_t^n + V_\pi \pi_{CPI,t} + V_{\mathbb{Y}}\hat{\mathbb{Y}}_t + V_{\Delta S}\Delta s_{\mathcal{C}\mathcal{D},t}\right) + u_t^R \tag{39}$$

where $r_t^n\left(= u_t^C + \sigma(u_t^I + \hat{a}_t)\right)$ is the natural rate of interest determined by efficient shocks, and

ρ_R measures the interest rate persistence. The central bank's willingness to stabilize CPI inflation, aggregate demand variability, and the rate of change in nominal exchange rates between the home currency and the U.S. dollar is captured by $V_\pi, V_\mathbb{Y}$, and $V_{\Delta S}$, respectively. u_t^R refers to the i.i.d white noise in the conduct of monetary policy.

3. Bayesian estimation

3.1. Implementation

The model is taken to the data using a Bayesian methodology. The intuition is attractively simple (See, for instance, the influential Smets and Wouters (2003) and Fernandez-Villaverde (2010) for in-depth discussion on implementation). The model parameters are stacked in a vector of $\mathbb{X}$, and is drawn by the a priori probability density $\mathcal{P}(\mathbb{X}, \mathcal{M})$. Together with a set of observed data, $\mathcal{Y}^T = \{\mathbb{R}^1, ..., \mathbb{R}^T\}$, where T denotes the number of periods, the log-linearized model can be estimated by a Kalman filter to yield a log likelihood function, $\mathcal{L}(\mathcal{Y}|\mathbb{X}, \mathcal{M})$, that describes the density of the data. The likelihood function is thus identical to $\mathcal{P}(\mathcal{Y}|\mathbb{X}, \mathcal{M})$. Given the prior density $\mathcal{P}(\mathbb{X}, \mathcal{M})$ on the one hand, and the likelihood function $\mathcal{P}(\mathcal{Y}|\mathbb{X}, \mathcal{M})$ on the other hand, we are able to infer the posterior density according to Bayes's theorem:

$$\mathcal{P}(\mathbb{X}|\mathcal{Y}, \mathcal{M}) = \frac{\mathcal{P}(\mathcal{Y}|\mathbb{X},\mathcal{M})\mathcal{P}(\mathbb{X},\mathcal{M})}{\mathcal{P}(\mathcal{Y},\mathcal{M})} \tag{40}$$

where $\mathcal{P}(\mathcal{Y}, \mathcal{M})\left(= \int_\mathbb{X} \mathcal{P}(\mathcal{Y}|\mathbb{X}, \mathcal{M})\mathcal{P}(\mathbb{X}, \mathcal{M})\, d\mathbb{X}\right)$ is the marginal density of the data given a specific model $\mathcal{M}$.

If the marginal density of the data is a constant or is equal to a certain parameter, then the posterior kernel can be derived from the numerator of the posterior density

$$\mathcal{K}(\mathbb{X}|\mathcal{Y},\mathcal{M}) \equiv \mathcal{P}(\mathbb{X}|\mathcal{Y},\mathcal{M}) \varpropto \mathcal{P}(\mathcal{Y}|\mathbb{X},\mathcal{M})\mathcal{P}(\mathbb{X},\mathcal{M}) \tag{41}$$

where $\varpropto$ denotes proportionality. The posterior kernel is simulated to generate draws using a Markov Chain Monte Carlo (MCMC) method. More specifically, we use the Metropolis-Hastings algorithm in Dynare 4.3.1 to generate twenty thousand draws, of which half are discarded to attain convergence. The number of Markov chains is adjusted to ensure that draws of the posterior sampling for the means, variances, and third moments for the model parameters finally converge within and across sequences. We also fine tune the variance of the jumps in $\mathbb{X}$ in the MCMC chain to ensure that the acceptance ratio is approximately 24%. The resultant findings provide the point estimates, standard deviations and confidence interval.

3.2. Data

We categorize nine Asian economies, consisting of Japan, the Republic of Korea, Hong Kong, Taiwan, Singapore, Malaysia, Indonesia, the Philippines, and Thailand, into two groups: the first five constitute the developed Asian economies (DA5) and the next four belong to the developing Southeast Asian economies (DESA4). By interpreting China (CHN) as the home country, DA5 and DESA4 become the foreign countries. Hence, two models exist for estimation: CHN-DA5 and CHN-DESA4.

Sourced from International Financial Statistics with supplementary data from the Economist Intelligence Unit (EIU) database (particularly for the case of Taiwan), nineteen macroeconomic time series are used in the estimation of each two-country model. This series includes data on the gross domestic product, consumption, investment, labor force, nominal interest rate, nominal exchange rates vis-à-vis the U.S. dollar, year-to-year PPI inflation, GDP deflator inflation and CPI inflation for the home and foreign economy, and lastly the U.S. federal

funds rate. All of the quantity variables are in the purchasing-power-parity-adjusted constant price, and all data except for inflation and interest rates are logged and de-trended using the Hodrik-Prescott Filter with smoothing parameter $\lambda = 1600$[4]. The de-trended series are subsequently weighted based on the time-varying fraction of the national total trades over the aggregate regional trades to construct the regional series for DA5 and DESA4. The data begins in the first quarter of 2001, the year in which China joined the WTO, and ends in the fourth quarter of 2008.

3.3. Prior and posterior distribution

Due to the limitation of the data points relative to the number of model parameters for estimation, a satisfactory implementation requires a restriction on the number of parameters for measurement. Hence, after numerous trial and error in obtaining the highest log marginal data density, we restrict the prior and posterior distributions for habit persistence, risk aversion coefficient, wage elasticity, the parameter governing how forward looking investment is, the elasticity of substitution between home and imported intermediate goods, and the U.S. monetary policy shock to be identical for the home and foreign economies.

Note that both efficient labor supply shock and inefficient wage markup shock affect the nominal wage inflation (12). This is problematic as monetary policy responds differently towards inefficient and efficient shocks (see Smets and Wouters, 2003). Additionally, the observable time series for the sample countries are largely incomplete at best and unavailable at worst. To minimize the potential identification problem, we choose not to estimate but to preset the nominal wage indexation at 0.5 and the Calvo wage stickiness at 0.75. Turning to the prior

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[4] Wong and Eng (2013) show that the choice of de-trending is not critical to the empirical relevancy of the estimated model.

distribution, we assume a Gamma distribution for the risk aversion coefficient, wage elasticity, and monetary policy reaction function that presume only positive value. The persistence of interest rate and the efficient TFP and IST shocks, which by definition should be within the range of $(0,1)$, is assumed to be beta distributed. The remaining parameters and shocks are assumed as uniformly distributed to allow for equal probability for all potential values within the theoretically reasonable range. Table 1 summarizes the prior distributions.

-- [INSERT TABLE 1 HERE]--

Table 1 also reports the posterior mode, mean, and the 5th and 95th percentiles of the posterior distribution of the parameters and shocks for the China-East Asia (CHN-DA5) and China-Southeast Asia (CHN-DESA4) models. The parameters are generally identified since the values of the mean and mode largely coincide. Overall, the estimates corroborate the theoretical intuitions and are generally identical over the two models. That said, two interesting observations deserve additional discussion.

First, the posterior risk aversion coefficient in the CHN-DA5 model is less than one, including the higher end of the probability distribution, whereas this value is approximately unity for the CHN-DESA4 model. When $\sigma < 1$, the substitution effect of the higher real wage made possible by a favorable productivity shock dominates the negative wealth effect following a smaller marginal utility of consumption on labor supply, causing employment to rise (see Eq. (8)). The substitution and wealth effects are counterbalanced, however, when $\sigma = 1$. A lower σ also implies a larger intertemporal elasticity of substitution between current and future consumptions in response to changes in the real interest rate (see Eq. (9)). As a consequence, the DA5 will be more responsive compared with the DESA4 to symmetric TFP, monetary policy and UIPC shocks originated in China.

Second, of all price setting mechanisms estimated in both models across all countries, the final output price has been the least re-optimized. Comparatively, the producer prices are more frequently re-optimized. These estimates fit the intuition that output prices further down the chains of production tend to be more persistent (Huang and Liu, 2004). Turning to the export price, the frequency of price re-optimization in China's midstream and downstream export prices is consistently less than four quarters across all models. The export prices of the DESA4 are even more flexible. The export prices of the DA5, however, are consistently more rigid across the value chains. For instance, the DA5 exporters re-optimize the export price for the final output in every 4.6 quarters $\left(= \frac{1}{1-0.781}\right)$ whereas the DESA4 exporters re-optimize within an interval of two quarters $\left(= \frac{1}{1-0.522}\right)$. We offer our intuition and explanation in the next section.

4.   **Assessing bilateral fragmentation in production and trade between China and Asia**

Following the methodology outlined in Wong and Eng (2012), we decompose the gross exports into the domestic value-added embodied in exports that remain in a foreign economy for local use (*DVA*) and in exports that are shipped back to the source (*VS1**) as well as the foreign value-added used in exports (*VS*):

$$\mathbb{x}_t = \sum_s DVA_{s,t} + VS1 *_{s,t} + VS_{s,t}$$

where

$$\sum_s DVA_{s,t} =$$

$$\underbrace{\underbrace{\left\{1 - \frac{M_{2\mathcal{AC},t}^j}{Y_{3t}}\left(1 - \frac{M_{1\mathcal{CA},t}^j}{Y_{2t}^{\mathcal{A}}}\right)\right\} Y_{3\mathcal{CA},t}^j}_{(i)}}_{1} +$$

$$\underbrace{\underbrace{\left(1 - \frac{M_{0\mathcal{AC},t}^j}{Y_{1t}}\right)\left(\frac{M_{1\mathcal{CA},t}^j}{Y_{2t}^{\mathcal{A}}}\right) Y_{2\mathcal{A},t}}_{(ii)} + \underbrace{\left(1 - \frac{M_{1\mathcal{AC},t}^j}{Y_{2t}}\right)\left(\frac{M_{2\mathcal{CA},t}^j}{Y_{3t}^{\mathcal{A}}}\right)\left(C_{\mathcal{A},t} + I_t^{\mathcal{A}}\right)}_{(iii)}}_{2} \qquad (42)$$

$$\sum_s VS1*_{s,t} = \underbrace{\underbrace{\left(1 - \frac{M_{0\mathcal{AC},t}^j}{Y_{1t}}\right)\left(\frac{M_{1\mathcal{CA},t}^j}{Y_{2t}^{\mathcal{A}}}\right) Y_{2\mathcal{AC},t}}_{(iv)} + \underbrace{\left(1 - \frac{M_{1\mathcal{AC},t}^j}{Y_{2t}}\right)\left(\frac{M_{2\mathcal{CA},t}^j}{Y_{3t}^{\mathcal{A}}}\right) Y_{3\mathcal{AC},t}}_{(v)}}_{4} \qquad (43)$$

$$\sum_s VS_{s,t} = \underbrace{\left(1 - \frac{M_{0\mathcal{CA},t}^j}{Y_{1t}^{\mathcal{A}}}\right)\left(\frac{M_{1\mathcal{AC},t}^j}{Y_{2t}}\right) Y_{2\mathcal{CA},t}^j}_{(vi)} + \underbrace{\left(1 - \frac{M_{1\mathcal{CA},t}^j}{Y_{2t}^{\mathcal{A}}}\right)\left(\frac{M_{2\mathcal{AC},t}^j}{Y_{3t}}\right) Y_{3\mathcal{CA},t}^j}_{(vii)} \qquad (44)$$

The decomposition is indeed compatible with the most comprehensive value-added break down empirically as by Koopman et al. (2010). Divided by the gross exports, Eq. (42) corresponds to the *VAX* ratio of Johnson and Noguera (2012), Eq. (43) is the *VS1** from Daudin et al. (2011), which also corresponds partly to the *VS1* in Hummels et al. (2001), and Eq. (44) matches the *VS* definition in Hummels et al. (2001).

The *VAX* ratio contains the domestic value-added embodied in the export of final goods (item (i)) and in the export of intermediates for foreign local use in the midstream and downstream production (item (ii) & (iii)). Because the imported foreign materials used in final goods production may contain the domestic value-added embodied in an earlier stage of foreign production, we count this domestic value-added to avoid underestimation. In contrast, we deduct the foreign value-added embodied in the production of upstream and midstream outputs exported for foreign local use.

The *VS1** is composed of the domestic value-added embodied in the intermediates exported for foreign production that are re-exported back to the source as intermediates (item (iv)) or final goods (item (v)). Similarly, the foreign value-added may have been embodied in an earlier stage of domestic production of intermediates. To avoid double counting, we also eliminate the foreign value-added. Finally, the *VS* considers all foreign value-added embodied in domestic exports.

Figure 2 illustrates the evolution of the *VAX*, *VS1**, and *VS* as a share of the gross exports simulated from the estimated CHN-DA5 and CHN-DESA4 models over the period 2001Q1 to 2008Q4. The *VAX* ratio declines when the production value chains are unbundled and fragmented across borders. It is obvious that the production value chains of the DA5 are more fragmented and are increasingly so vis-à-vis China's production. In contrast, China's production is more fragmented than that of the DESA4. Different extents of bilateral production fragmentation have resulted in different patterns of trade. When a firm splits and relocates a portion of the value chain abroad, it improves its position in the value chain network by climbing the ladder of the production streams to produce additional intermediates. This is reflected in the higher domestic value-added embodied in the intermediates exported for foreign production that will be shipped back to the source for further processing. It is unsurprising then that the *VS1** ratio for China is lower (higher) than that of the DA5 (DESA4) in their bilateral trade. Furthermore, when a firm occupies a higher position in the value chain network, the probability that the export contains foreign-value added is lower. The *VS* ratio for China is thus higher than that for the DA5, though not compared with the DESA4.

-- [INSERT FIGURE 2 HERE]--

The bilateral production fragmentation is expected to leave a mark on the export price stickiness in the DA5 and DESA4 vis-à-vis China. When the advanced DA5 supplies intermediates to China for further processing, as the intuition goes, most of the trade occurs between a parent and its affiliates within a multinational firm's boundary (WTO and IDE-JETRO, 2011; Dean and Lovely, 2009). This is not necessarily the case, however, for trade between China and the developing DESA4 that compete in the downstream value chain where arm's length trade is the norm. Neiman (2008) finds that when products are complementary ($\vartheta < 1$), the price is stickier for arm's length trade. As goods become more substitutable ($\vartheta > 1$), the median price duration for arm's length trade decreases from approximately 5.3 quarters to 2 quarters whereas the median price duration for intra-firm trade remains at approximately 4 quarters. Put into our context, given the posterior average elasticity substitution between domestic and imported intermediates at 1.49 for the CHN-DA5 model and 1.56 for the CHN-DESA4 model, which indicates homogenous and substitutable intermediates, the findings that the DESA4 has more flexible export prices than the DA5 are coherent with the existing empirical results.

5. Impulse responses: Flexible versus fixed exchange rates

In this section, we analyze the dynamic responses of the DA5 and DESA4 to China's macroeconomic disturbances. In addition to the baseline analysis, we also consider two hypothetical cases. First, we assume China rigidly pegs its renminbi to the U.S dollar, and we set $\rho_R = V_\pi = V_{\mathbb{Y}} = 0$. Simultaneous solution of UIPC (10) and policy rule (39) yields

$$\begin{bmatrix} r_t \\ S_{\mathcal{CD},t} \end{bmatrix} = \frac{1}{1+V_{\Delta S}} \begin{bmatrix} -V_{\Delta S} & V_{\Delta S} & V_{\Delta S} & 1 & 1 & V_{\Delta S} \\ V_{\Delta S} & 1 & 1 & -1 & -1 & 1 \end{bmatrix} \mathbb{v}' \tag{45}$$

where $\mathbb{v}' = \begin{bmatrix} S_{\mathcal{CD},t-1} & S_{\mathcal{CD},t+1} & r_t^{\mathcal{D}} r_t^n & \mathrm{u}_t^R & \omega_t \end{bmatrix}'$. By setting $V_{\Delta S} = 1000$, $S_{\mathcal{CD},t} = S_{\mathcal{CD},t-1}$ all time, and r_t only responds to eliminate exchange rate changes and risk. In the second case, we assume that all Asian countries fix the currency to the dollar. The Asian dollar standard requires $\rho_R^{\mathcal{A}} = \rho_R = V_\pi^{\mathcal{A}} = V_\pi = V_{\mathbb{Y}}^{\mathcal{A}} = V_{\mathbb{Y}} = 0$ and $V_{\Delta S}^{\mathcal{A}} = V_{\Delta S} = 1000$. Figure 3 illustrates the impulse responses of the GDP and gross exports in the DA5 (the first two horizontal panels) and in the DESA4 (the last two horizontal panels) to 1% asymmetric shocks originated in China.

-- [INSERT FIGURE 3 HERE]--

Irrespective of the pattern of fragmentation, the DA5 and DESA4 respond almost identically to a variety of China-specific shocks. Favorable IST and preference shock stimulates the exports and the GDP of the DA5 and DESA4; a positive shock to the producer price markup and transportation cost raises the cost of exports, pulling down Asian gross exports to China as well as the GDP; UIPC shock that depreciates the Chinese renminbi is unsurprisingly contractionary to Asian exports and the GDP. Put another way, the demand and price shocks that benefit China also prosper-thy its Asian neighboring countries. Moreover, these responses are robust to the choice of exchange rate regime. The benign effect of China's IST shock on the DA5, however, turns short-lived if the currency is irrevocably fixed to the dollar by China or other countries.

Two important exceptions exist. As far as China's TFP shock is concerned, the responses of the DA5 and DESA4 are different. Although the DA5 gross exports and GDP (to lesser extent) respond positively to the shock, the DESA4 gross exports and GDP react negatively. In other words, China's expansion that is made possible by total factor productivity improvement can crowd out the developing DESA4 in terms of the GDP that competes in final goods export with China while crowding in the advanced DA5 that supplies intermediates to China. Although these

responses corroborate the empirical findings discussed earlier in the introduction, Figure 3 shows that the choice of exchange rate regime critically influences the responses to China's TFP shock. By adopting a dollar standard, even the DESA4 is crowded in by China's expansion, and the benign effect of China's TFP improvement felt by Asia is more sustainable.

Another notable exception is that the magnitude of the DA5 responses is systematically smaller than that of the DESA4. Intuitively, smaller quantity responses can be attributed to the smaller changes in prices made possible by stickier price and lower exchange rate pass-through. Neiman (2010) and Ando and Iriyama (2009), for instance, find that the exchange rate pass-through is smaller when trade occurs within the same firm's boundaries. Together with the estimates on price stickiness discussed previously, it is therefore unsurprising that the magnitude of the quantity responses will tend to be smaller for the DA5 that has larger share of intra-firm trade as the price is less frequently adjusted and the exchange rate pass-through is smaller.

5.1. Does the nature of the shock matter?

The results found thus far are cemented on the assumption of asymmetric shock originated in China. Will the responses differ if the shocks are symmetric? We seek the answer by contemplating the impulse responses of the DA5 and DESA4 to a 1% shock symmetrically originated in China and in the DA5 and DESA4, respectively, as illustrated in Figure 4.

-- [INSERT FIGURE 4 HERE]--

Overall, two results remain: the responses of the DA5 and DESA4 to China's shocks ranging from the efficient IST and preference shock to the inefficient producer price markup, UIPC and transportation cost shocks remain synchronized, and the dollar peg is still the mechanism that magnifies the beneficial effect of China's TFP shock to the DESA4. However,

the other two results have been overturned. The gross exports and GDP of both the DA5 and DESA4 have been lifted when they encounter a symmetric TFP shock. China's expansion driven by symmetric productivity shock is now a comrade to both the DA5 and DESA4. Equally fascinating is the finding that the magnitude of the DA5 responses to all shocks is larger than those of the DESA4. This is compatible with the argument that countries positioned in the upstream value chains will be affected more severely by negative external demand shocks (see Wong and Eng (2012) and reference cited therein).

6.   Discussion and concluding remarks

Motivated by the inconclusive empirical findings on the influence of China's trade expansion on its neighboring countries, this paper delves into two important and interrelated questions: First, what is the bilateral production and trade relationship between China and the rest of Asia since China's accession into the World Trade Organization? Second, how do macroeconomic disturbances in China influence its Asian neighbors? We provide a general equilibrium view by laying out a two-country medium-scale New Keynesian model expanded to feature three stages of production. We estimate the model with data from ten East and Southeast Asian countries, including China, by using a Bayesian approach. With the two estimated models, we construct the bilateral production fragmentation and vertical specialization ratio for the China/developed Asia model and the China/developing Southeast Asia model and inspect the dynamic responses of developed and developing Asia to a variety of Chinese shocks. Our answers to some interesting questions are summarized as follows:

Does fragmentation in production and trade matter for China's influence on its Asian neighbors? It does, in fact, in two dimensions. First, although a China-specific positive TFP

shock that lifts its own exports and economy stimulates the gross exports and total economic activity of the developed Asia with a more fragmented production and positions itself as the source of intermediates, it did not equally lift the gross domestic product of the developing Southeast Asian countries that are mainly the consumers of intermediates in downstream production. Second, in the face of asymmetric shock, the magnitude of the responses of the developed Asian countries is much smaller than that of the developing Southeast Asian countries. We infer that the magnitude is influenced by ways in which firms organize the value chains across borders. The quantitative extent to which the firm's organizational form is associated with the position of the firm in the value chain network deserves additional investigation in the future.

Has the nature of the shock shaped the responses? Yes, very much indeed. China's expansion benefits all economies in the region when the shocks are symmetric. A better question is what causes symmetric shock? It is not unreasonable to associate symmetric shock to preference and relative prices with third-country effect. An expenditure-raising shock in the United States, for example, can boost demand for Chinese and Asian goods simultaneously, whereas U.S monetary contraction depreciates all Asian currencies vis-à-vis the dollar. However, what ties together all Asian total factor productivity? Apparently we need a theory of TFP in the presence of production fragmentation.

Is the choice of exchange rate regime important? Yes and no. A hard currency peg amplifies and sustains the beneficial effect of China's favorable TFP shock on all of Asia regardless of the nature of the shocks. However, the choice of exchange rate regime matters neither in the pattern nor in the magnitude of responses to other disturbances in China. Quantifying the welfare effect of the choice of exchange rate regimes in the presence of production fragmentation and vertical specialization is a promising venue for future research.

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Table 1
Priors and posterior distributions, 2001Q1-2008Q4

	Prior distribution			Posterior distribution							
				CHN-DA5				CHN-DESA4			
	Type	Mean	Std	Mode	Mean	5%	95%	Mode	Mean	5%	95%
Parameters											
Risk aversion coefficient	Uniform	1	0.577	0.606	0.637	0.499	0.787	0.916	1.02	0.812	1.209
Reciprocal of wage elasticity	Gamma	2	1	4.113	4.268	3.736	4.736	0.499	5.309	4.328	6.066
Habit persistence	Beta	0.7	0.1	0.606	0.625	0.594	0.652	0.652	0.627	0.59	0.664
Degree of forward-looking in investment	Uniform	0.5	0.289	0.922	0.905	0.846	0.971	0.927	0.92	0.861	0.991
Els. btw. home & imported intermediates	Normal	1.5	0.1	1.476	1.490	1.468	1.514	1.592	1.559	1.519	1.603
Home bias in consumption	Beta	0.7	0.1	0.479	0.480	0.443	0.517	0.844	0.862	0.808	0.902
				(0.788)	(0.791)	(0.754)	(0.833)	(0.603)	(0.618)	(0.579)	(0.663)
Share of imported intermediates											
Midstream production	Uniform	0.5	0.289	0.405	0.411	0.339	0.497	0.512	0.518	0.377	0.709
				(0.493)	(0.548)	(0.450)	(0.640)	(0.732)	(0.610)	(0.424)	(0.771)
Downstream production	Uniform	0.5	0.289	0.999	0.965	0.932	1.000	1.000	0.949	0.901	1.000
				(0.733)	(0.693)	(0.584)	(0.812)	(0.637)	(0.752)	(0.597)	(0.919)
Indexation											
Producer price	Uniform	0.5	0.289	0.893	0.928	0.862	1.000	0.681	0.747	0.605	0.920
				(0.615)	(0.564)	(0.401)	(0.697)	(0.707)	(0.769)	(0.626)	(0.883)
Final goods price	Uniform	0.5	0.289	0.663	0.624	0.571	0.675	0.704	0.739	0.655	0.816
				(0.620)	(0.617)	(0.550)	(0.681)	(0.231)	(0.276)	(0.140)	(0.411)
Midstream export price	Uniform	0.5	0.289	0.495	0.461	0.380	0.524	1.000	0.897	0.787	1.000
				(0.438)	(0.430)	(0.314)	(0.518)	(0.333)	(0.362)	(0.129)	(0.599)
Downstream export price	Uniform	0.5	0.289	0.670	0.635	0.509	0.734	0.731	0.753	0.562	0.982
				(0.990)	(0.893)	(0.788)	(0.999)	(0.622)	(0.687)	(0.590)	(0.779)
Stickiness											
Producer price	Uniform	0.75	0.144	0.849	0.842	0.824	0.859	0.656	0.657	0.623	0.694
				(0.797)	(0.802)	(0.781)	(0.825)	(0.567)	(0.563)	(0.513)	(0.611)
Final goods price	Uniform	0.75	0.144	0.931	0.922	0.902	0.940	0.935	0.941	0.927	0.954
				(0.925)	(0.923)	(0.914)	(0.931)	(0.856)	(0.855)	(0.835)	(0.874)
Midstream export price	Uniform	0.75	0.144	0.715	0.708	0.644	0.761	0.745	0.744	0.664	0.813
				(0.746)	(0.783)	(0.726)	(0.837)	(0.648)	(0.643)	(0.523)	(0.732)
Downstream export price	Uniform	0.75	0.144	0.729	0.733	0.705	0.759	0.715	0.707	0.677	0.739
				(0.784)	(0.781)	(0.761)	(0.805)	(0.555)	(0.522)	(0.500)	(0.546)

TFP shock persistence	Beta	0.8	0.1	0.830	0.823	0.804	0.861	0.852	0.887	0.838	0.936
				(0.697)	(0.719)	(0.668)	(0.768)	(0.894)	(0.884)	(0.839)	(0.931)
IST shock persistence	Beta	0.7	0.1	0.643	0.631	0.579	0.673	0.599	0.612	0.556	0.680
				(0.707)	(0.699)	(0.674)	(0.725)	(0.678)	(0.616)	(0.561)	(0.676)
Monetary policy inertia	Beta	0.7	0.1	0.604	0.634	0.575	0.674	0.849	0.839	0.782	0.892
				(0.831)	(0.838)	(0.801)	(0.867)	(0.715)	(0.712)	(0.669)	(0.759)
Policy reaction to inflation	Gamma	1.5	1	1.382	1.397	1.350	1.450	1.392	1.416	1.357	1.480
				(1.622)	(1.610)	(1.570)	(1.681)	(1.351)	(1.362)	(1.294)	(1.454)
Policy reaction to lagged GDP fluctuation	Gamma	0.125	0.05	0.093	0.100	0.082	0.120	0.162	0.152	0.106	0.202
				(0.053)	(0.058)	(0.043)	(0.071)	(0.111)	(0.129)	(0.089)	(0.174)
Policy reaction to nominal depreciation	Gamma	0.5	0.1	0.513	0.551	0.469	0.629	0.473	0.474	0.412	0.544
				(0.427)	(0.455)	(0.418)	(0.490)	(0.741)	(0.719)	(0.670)	(0.768)
Shocks											
Total factor productivity	Uniform	0.5	0.289	0.027	0.029	0.019	0.038	0.025	0.022	0.014	0.030
				(0.026)	(0.026)	(0.016)	(0.036)	(0.041)	(0.046)	(0.030)	(0.061)
Labor supply	Uniform	0.5	0.289	0.391	0.422	0.347	0.504	0.392	0.370	0.236	0.512
				(0.642)	(0.594)	(0.497)	(0.696)	(0.000)	(0.077)	(0.000)	(0.167)
Preference	Uniform	0.5	0.289	0.022	0.025	0.018	0.031	0.029	0.030	0.022	0.037
				(0.019)	(0.023)	(0.015)	(0.031)	(0.060)	(0.064)	(0.047)	(0.081)
Investment-specific technology	Uniform	0.5	0.289	0.006	0.007	0.005	0.010	0.008	0.008	0.005	0.012
				(0.021)	(0.023)	(0.017)	(0.029)	(0.019)	(0.026)	(0.017)	(0.034)
Producer price markup	Uniform	0.5	0.289	0.696	0.647	0.528	0.761	0.062	0.065	0.042	0.086
				(0.337)	(0.366)	(0.270)	(0.477)	(0.089)	(0.098)	(0.056)	(0.138)
Final goods price markup	Uniform	0.5	0.289	0.481	0.36	0.136	0.650	0.972	0.855	0.727	0.994
				(0.774)	(0.734)	(0.616)	(0.873)	(0.996)	(0.956)	(0.901)	(1.000)
Midstream export price markup	Uniform	0.5	0.289	0.317	0.358	0.296	0.423	0.389	0.224	0.114	0.331
				(0.346)	(0.384)	(0.259)	(0.541)	(0.490)	(0.573)	(0.415)	(0.742)
Downstream export price markup	Uniform	0.5	0.289	0.509	0.537	0.445	0.625	0.311	0.326	0.253	0.407
				(0.301)	(0.276)	(0.218)	(0.350)	(0.059)	(0.056)	(0.029)	(0.082)
Monetary policy	Uniform	0.5	0.289	0.006	0.008	0.005	0.011	0.004	0.004	0.002	0.006
				(0.004)	(0.005)	(0.004)	(0.006)	(0.012)	(0.013)	(0.009)	(0.017)
UIPC	Uniform	0.5	0.289	0.023	0.017	0.001	0.029	0.041	0.045	0.024	0.066
				(0.004)	(0.008)	(0.000)	(0.015)	(0.032)	(0.036)	(0.027)	(0.045)
Transportation cost	Uniform	0.5	0.289	0.222	0.228	0.181	0.270	0.069	0.072	0.057	0.086
				(0.144)	(0.156)	(0.116)	(0.190)	(0.032)	(0.033)	(0.027)	(0.040)
U.S monetary policy	Uniform	0.5	0.289	0.009	0.01	0.007	0.011	0.009	0.013	0.009	0.017

Notes: The posterior distribution is obtained based on 4 parallel Markov chains of 50,000 draws each in Metropolis-Hastings sampling algorithm. The first half was discarded as burn-in. The average acceptance rate for each estimated model is 0.235 for CHN-DA5 and 0.251 for CHN-DESA4. DESA4 comprises Indonesia, Malaysia, the Philippines, and Thailand weighted by total trades, where DA5 comprises Japan, Hong Kong, Korea, Singapore, and Taiwan weighted by total trades.

(a) Southeast Asian exports to China and U.S.   (b) Southeast Asian imports from China and U.S.

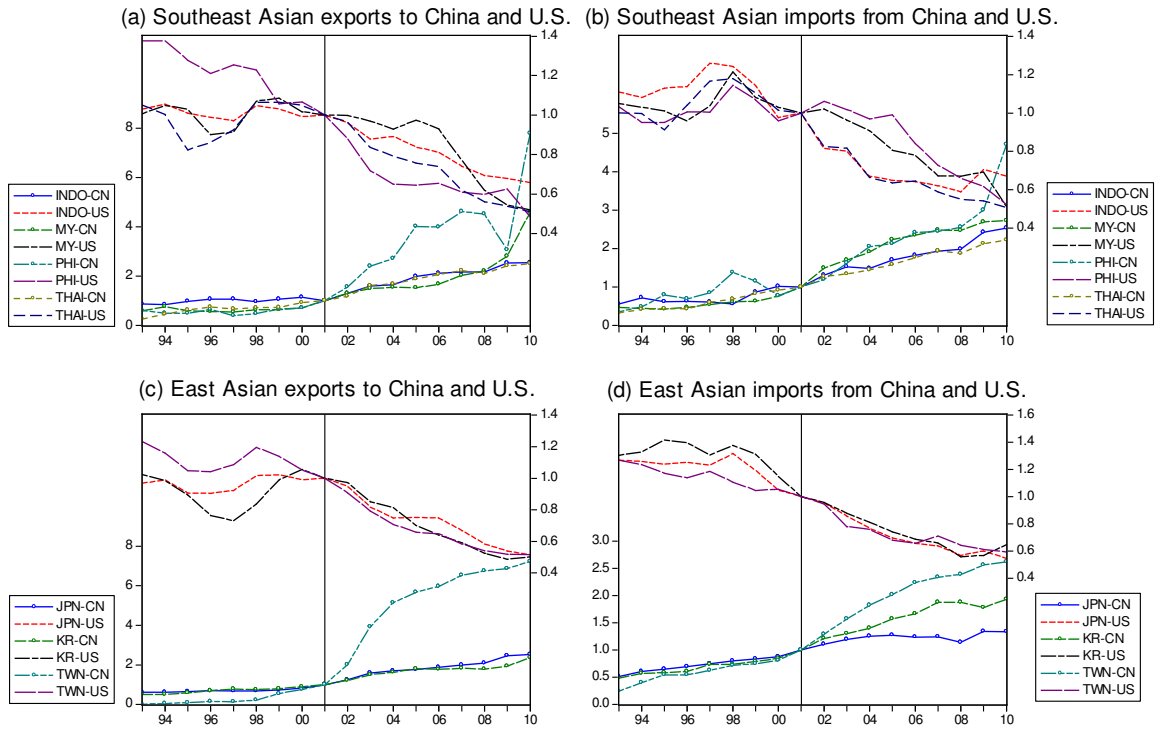(c) East Asian exports to China and U.S.   (d) East Asian imports from China and U.S.

Fig. 1. Has Asian trade with the United States been diverted to or displaced by China?
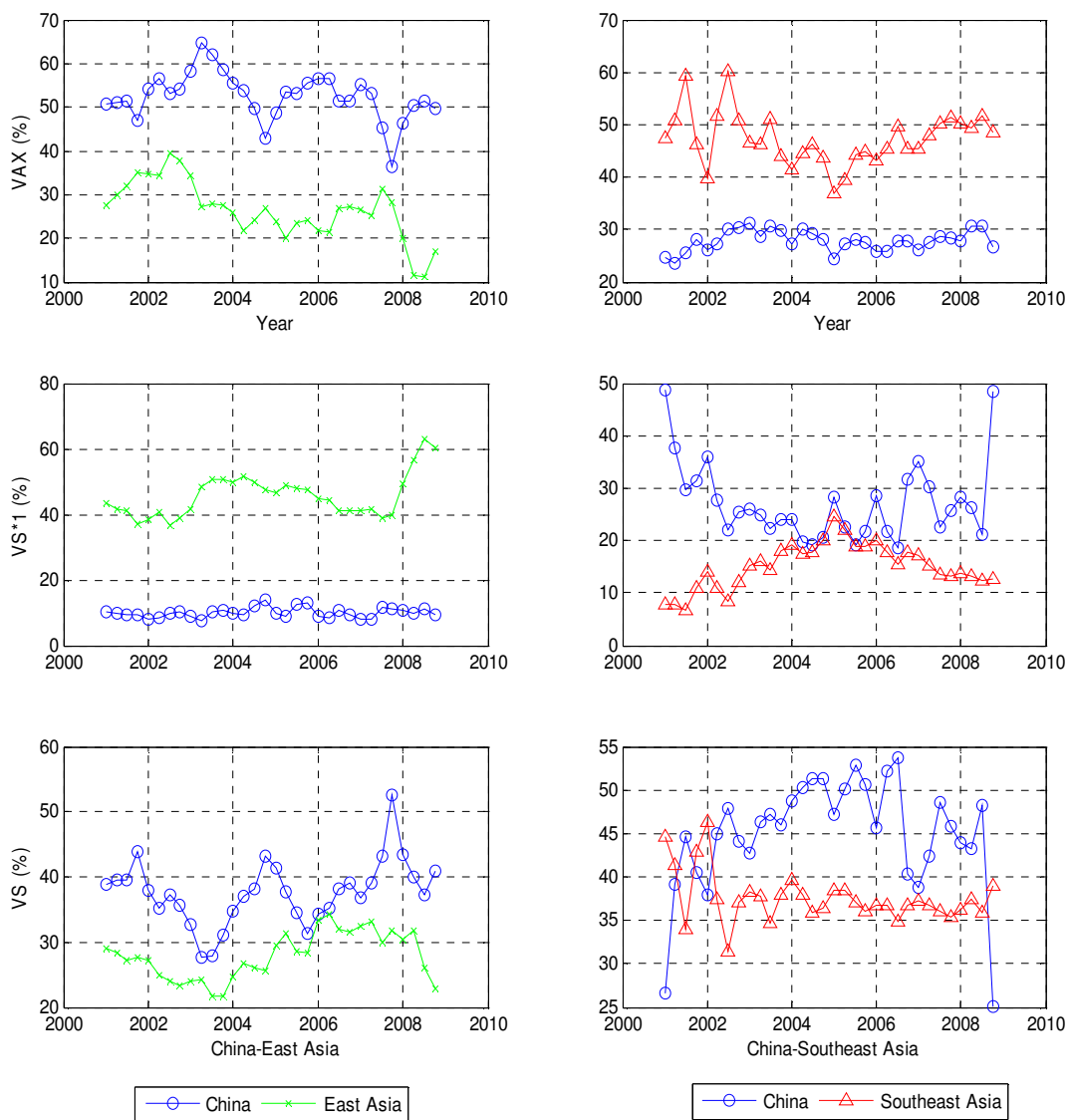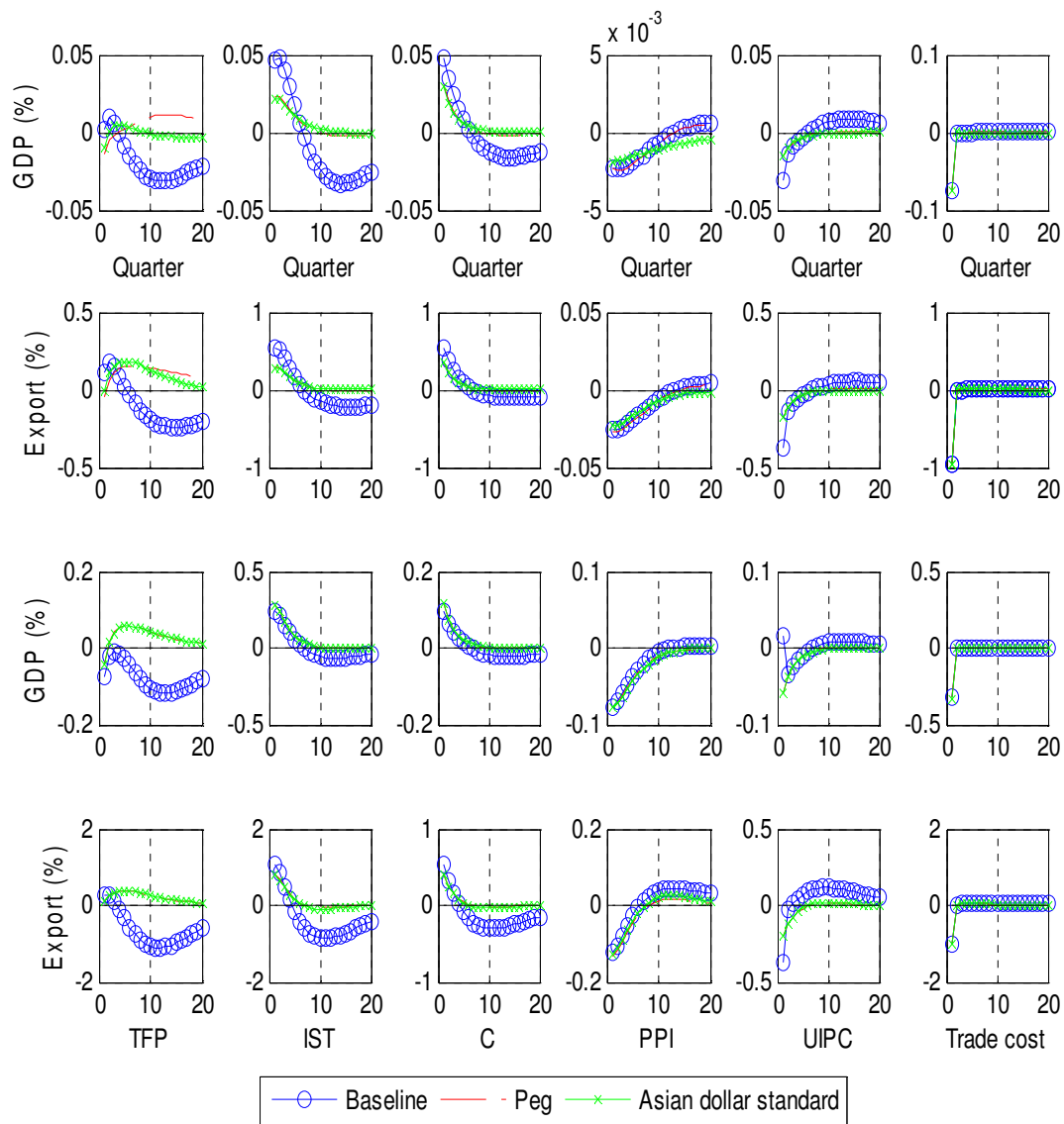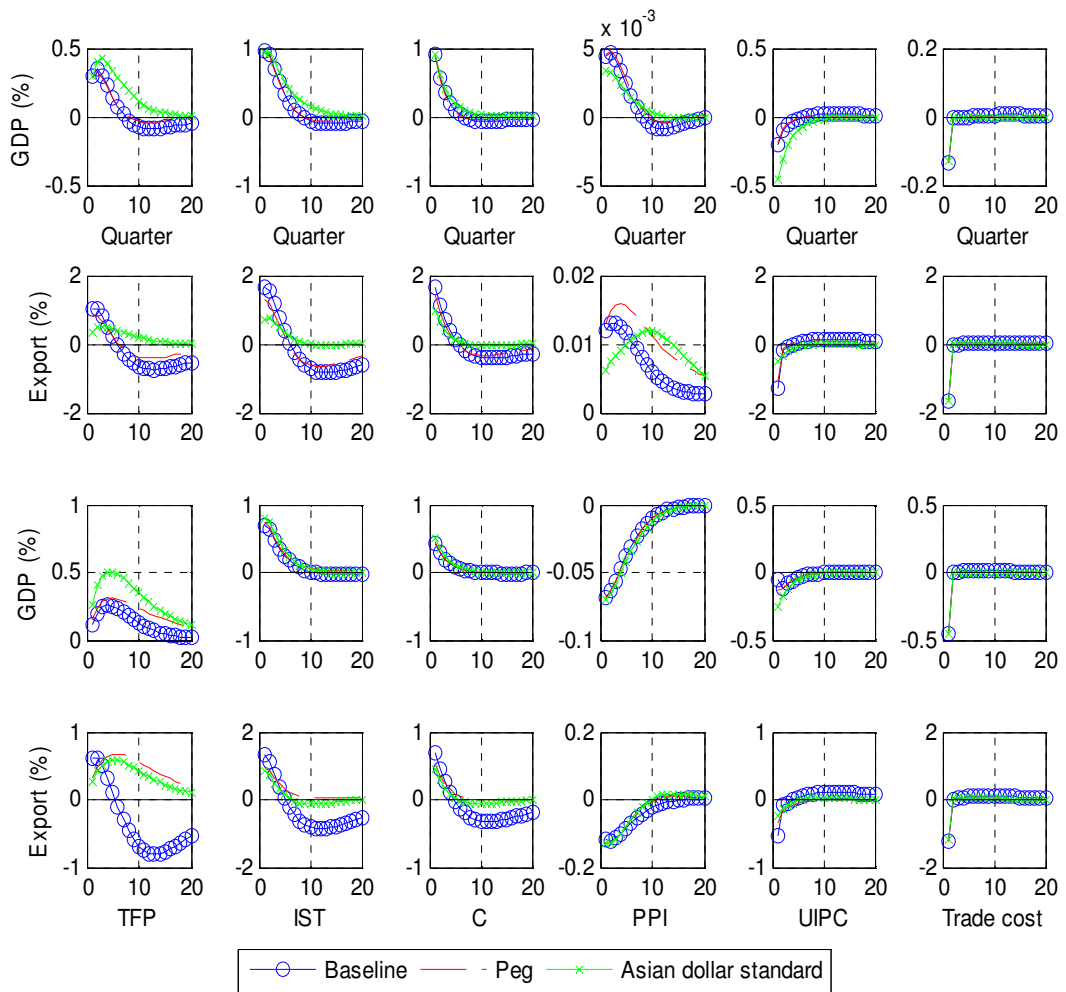
Fig. 2. Fragmentation in production and trade, 2001Q1-2008Q4

Notes: The first two rows are East Asian responses, followed by Southeast Asian responses

Fig. 3. Dynamic responses of Asia to idiosyncratic China's shocks

Notes: The first two rows are East Asian responses, followed by Southeast Asian responses

Fig. 4. Dynamic responses of Asia toward symmetric shocks