Regional Production Network, Asian Trade Integration, and Optimal Monetary Policy Coordination

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Production chains are vertically globalized, instigating back-and-forth trade in intermediates

- One of the defining characteristics of today's international trade is the flow of intermediates across countries.
- Underlying this fast-growing trade is the vertically sliced and fragmented production chains across countries with different factor endowments.

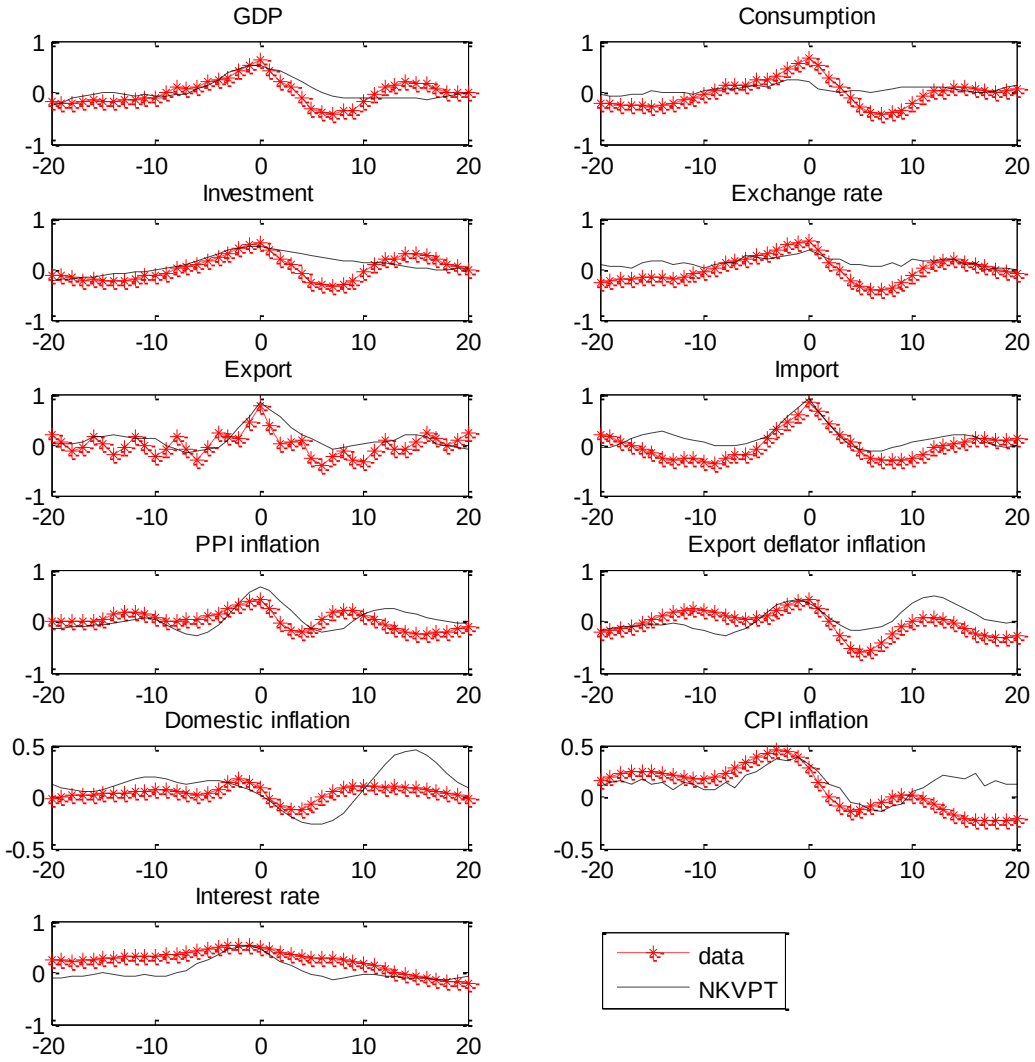
East and Southeast Asia demonstrates the most established production network

- The depth and complexity of vertical production network and trade in East and Southeast Asia are unrivalled.
- Amador and Cabral (2009) studying 79 countries over 121 categories of goods within 1967-2005: Of top 10 vertically most specialized countries, eight are in East Asia (Koopman et al. 2010, Sawyer et al. 2010, Athukorala and Yamashita 2009).

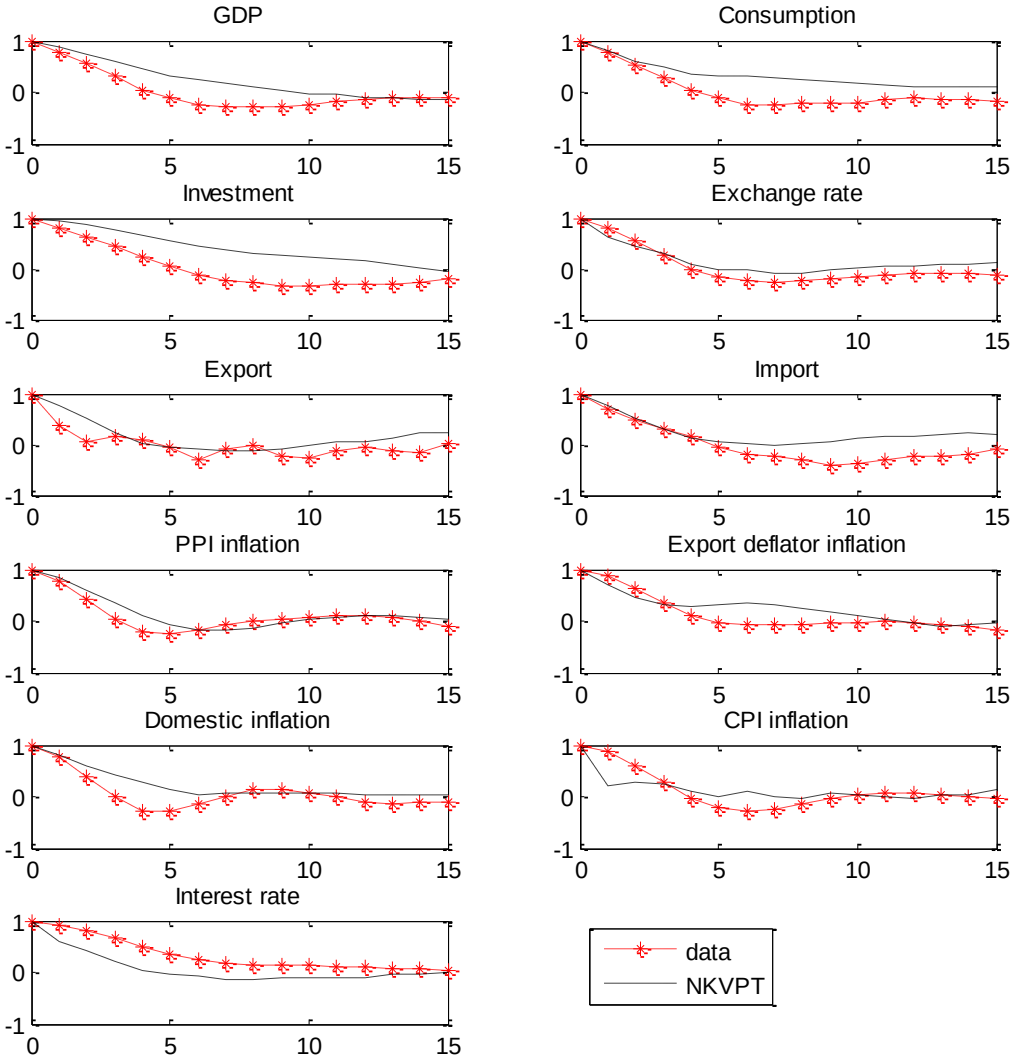
What does it imply for macroeconomic dynamics?

- That interests us is the macroeconomic implications of such vertically and sequentially connected production and trade.
- Wong and Eng (2012) show that neither trade in intermediate input *per se* nor *non-sequential* trade in both intermediate input and final goods is able to account for the macroeconomic interdependence between East and Southeast Asia. The burden falls on the *vertical and sequential trade in intermediates and final goods*.

Vertical, sequential trade in intermediates and final goods can account for East/Southeast contemporaneous and cross correlations



… as well as the autocorrelations (Southeast Asia)

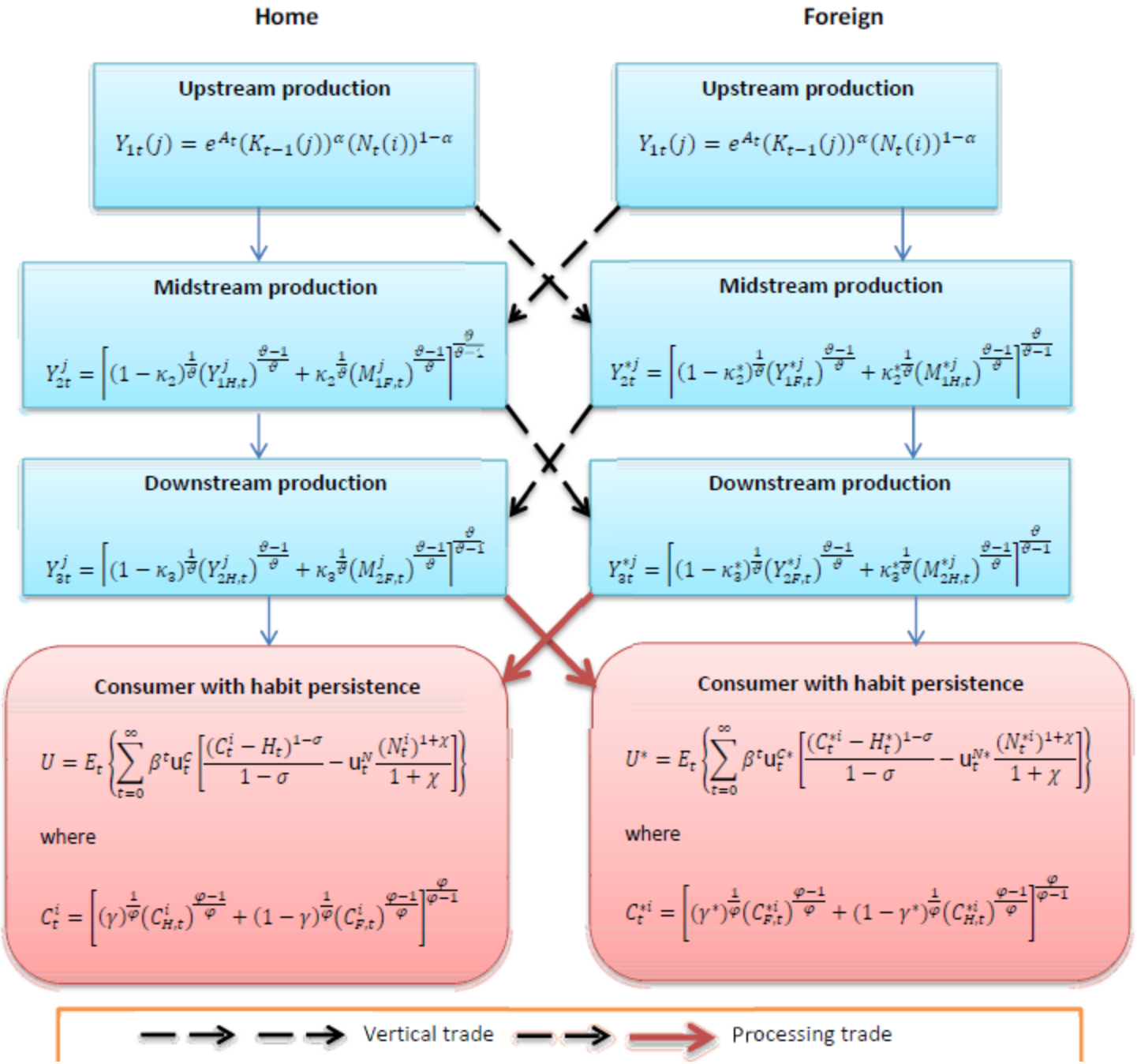


The goal of this paper

- To provide an unified framework to shed lights on
  - the magnitude of production sharing in East and Southeast Asia;
  - the measure of vertical specialization between China, East, and Southeast Asia;
  - the propagation mechanism demonstrating how these economies are interdependent; and
  - the welfare-maximizing monetary policy rule.

The model

- We set up a two-region New Keynesian model with three processing stages: *upstream-midstream-downstream* (Wong and Eng 2012).
- The most important advantage of this model is to be able to account for vertical and processing trade simultaneously.
  - Vertical trade: back-and-forth trade in intermediate inputs
  - Processing trade: importing intermediates for remanufacturing and reexporting as consumer goods


Home
Foreign
Upstream production
$Y_{1t}(j) = e^{A_t}(K_{t-1}(j))^{\alpha}(N_t(i))^{1-\alpha}$
Upstream production
$Y_{1t}(j) = e^{A_t}(K_{t-1}(j))^{\alpha}(N_t(i))^{1-\alpha}$
Midstream production
$Y_{2t}^{j} = \left[(1-\kappa_2)^{\frac{1}{\vartheta}}(Y_{1H,t}^{j})^{\frac{\vartheta-1}{\vartheta}} + \kappa_2^{\frac{1}{\vartheta}}(M_{1F,t}^{j})^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}$
Midstream production
$Y_{2t}^{*j} = \left[(1-\kappa_2^{*})^{\frac{1}{\vartheta}}(Y_{1F,t}^{*j})^{\frac{\vartheta-1}{\vartheta}} + \kappa_2^{*\frac{1}{\vartheta}}(M_{1H,t}^{*j})^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}$
Downstream production
$Y_{3t}^{j} = \left[(1-\kappa_3)^{\frac{1}{\vartheta}}(Y_{2H,t}^{j})^{\frac{\vartheta-1}{\vartheta}} + \kappa_3^{\frac{1}{\vartheta}}(M_{2F,t}^{j})^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}$
Downstream production
$Y_{3t}^{*j} = \left[(1-\kappa_3^{*})^{\frac{1}{\vartheta}}(Y_{2F,t}^{*j})^{\frac{\vartheta-1}{\vartheta}} + \kappa_3^{*\frac{1}{\vartheta}}(M_{2H,t}^{*j})^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}$
Consumer with habit persistence
$U = E_t\left\{\sum_{t=0}^{\infty}\beta^t \mathrm{u}_t^{C}\left[\frac{(C_t^i - H_t)^{1-\sigma}}{1-\sigma} - \mathrm{u}_t^{N}\frac{(N_t^i)^{1+\chi}}{1+\chi}\right]\right\}$
where
$C_t^i = \left[(\gamma)^{\frac{1}{\varphi}}(C_{H,t}^{i})^{\frac{\varphi-1}{\varphi}} + (1-\gamma)^{\frac{1}{\varphi}}(C_{F,t}^{i})^{\frac{\varphi-1}{\varphi}}\right]^{\frac{\varphi}{\varphi-1}}$
Consumer with habit persistence
$U^{*} = E_t\left\{\sum_{t=0}^{\infty}\beta^t \mathrm{u}_t^{C*}\left[\frac{(C_t^{*i} - H_t^{*})^{1-\sigma}}{1-\sigma} - \mathrm{u}_t^{N*}\frac{(N_t^{*i})^{1+\chi}}{1+\chi}\right]\right\}$
where
$C_t^{*i} = \left[(\gamma^{*})^{\frac{1}{\varphi}}(C_{F,t}^{*i})^{\frac{\varphi-1}{\varphi}} + (1-\gamma^{*})^{\frac{1}{\varphi}}(C_{H,t}^{*i})^{\frac{\varphi-1}{\varphi}}\right]^{\frac{\varphi}{\varphi-1}}$
Vertical trade
Processing trade

… Bayesian estimation

- We take the model to the data using Bayesian method.
- The procedure is principally built around the likelihood function of the data derived from the model in conjunction with the prior belief on the probability distribution of the parameters.
- Bayesian estimation is about finding a set of parameters that maximizes the posteriors.

… and the data

- We study nine East and Southeast Asian economies, in addition to China, of which we categorize into
  - Advanced East Asian economies (EA5): Japan, Korea, Taiwan, Hong Kong, and Singapore.
  - Developing Southeast Asian economies (SEA4): Indonesia, Malaysia, Thailand, and Philippines.
- 19 trade-weighted observable series from 1987Q1 to 2008Q4 are used

Equal probability is allowed for uncertain values

Table 1. The priors for parameters and shocks

	Prior distribution		
	Probability distribution function	Mean	Standard deviation
Parameters			
Risk aversion coefficient σ	Uniform	1	0.577
Reciprocal of wage elasticity of labor supply χ_N	Gamma	2	1.000
Habit persistence b	Beta	0.7	0.100
Forward looking-ness of investment decision Λ	Uniform	0.5	0.289
Els btw. home and imported intermediate goods ϑ	Normal	1.5	0.500
Home bias in consumption γ	Beta	0.7	0.100
Share of imported materials at intermediate production κ_2	Uniform	0.5	0.289
Share of imported intermediate goods at final production κ_3	Uniform	0.5	0.289
Employment indexation γ_w	Uniform	0.5	0.289
Producer price indexation γ_{p2}	Uniform	0.5	0.289
Final goods price indexation γ_{p3}	Uniform	0.5	0.289
Intermediate export price indexation γ^*_{p2}	Uniform	0.5	0.289
Final goods export price indexation γ^*_{p3}	Uniform	0.5	0.289
Employment stickiness θ_e	Uniform	0.75	0.144
Producer price stickiness θ_{p2}	Uniform	0.75	0.144
Final goods price stickiness θ_{p3}	Uniform	0.75	0.144
Intermediate export price stickiness θ^*_{p2}	Uniform	0.75	0.144
Final export price stickiness θ^*_{p3}	Uniform	0.75	0.144
Policy inertia ρ_R	Beta	0.7	0.100
Policy response to inflation V_π	Gamma	1.5	1.000
Policy response to GDP fluctuation V_Y	Gamma	0.125	0.050
Policy response to exchange rate variability $V_{\Delta S}$	Gamma	0.5	0.100
TFP shock persistence ρ_a	Beta	0.8	0.100
IST shock persistence ρ_I	Beta	0.7	0.100

1. Production in East and Southeast Asia are sequentially bonded

2.SEA depends more heavily on EA in the aftermath of China's WTO accession, but not the vice versa

Table 2. Selected posterior distributions for SEA4-EA5 model

	1987Q1-2000Q4								2001Q1-2008Q4							
	Southeast Asia				East Asia				Southeast Asia				East Asia			
	Mode	5%	Mean	95%	Mode	5%	Mean	95%	Mode	5%	Mean	95%	Mode	5%	Mean	95%
Parameters																
σ	0.392	0.291	0.352	0.416	0.392	0.291	0.352	0.416	0.503	0.370	0.481	0.585	0.503	0.370	0.481	0.585
γ	0.758	0.725	0.773	0.821	0.941	0.925	0.941	0.957	0.659	0.614	0.667	0.746	0.889	0.861	0.889	0.920
ϑ	1.548	1.483	1.551	1.611	1.548	1.483	1.551	1.611	1.577	1.521	1.592	1.663	1.577	1.521	1.592	1.663
Λ	1.000	0.976	0.946	1.000	1.000	0.976	0.946	1.000	0.963	0.926	0.965	1.000	0.963	0.926	0.965	1.000
κ_2	0.620	0.527	**0.649**	0.745	0.854	0.729	**0.843**	0.995	1.000	0.814	**0.921**	1.000	0.577	0.511	**0.622**	0.743
κ_3	0.173	0.087	**0.148**	0.217	0.786	0.687	**0.811**	0.943	0.510	0.328	**0.511**	0.667	0.768	0.621	**0.735**	0.858
θ_{p2}	0.620	0.592	0.619	0.646	0.871	0.843	0.867	0.890	0.602	0.572	0.621	0.685	0.691	0.634	0.680	0.722
θ_{p3}	0.776	0.750	0.777	0.805	0.943	0.936	0.944	0.952	0.851	0.808	0.841	0.873	0.910	0.892	0.914	0.933
$\theta^{\star}_{p2}$	0.955	0.932	0.946	0.960	0.587	0.520	0.590	0.662	0.703	0.640	0.737	0.860	0.734	0.650	0.715	0.780
$\theta^{\star}_{p3}$	0.639	0.604	0.637	0.678	0.699	0.671	0.699	0.727	0.652	0.605	0.644	0.683	0.770	0.740	0.772	0.802
ρ_a	0.809	0.760	0.820	0.882	0.947	0.936	0.944	0.952	0.890	0.855	0.897	0.937	0.902	0.840	0.886	0.944
ρ_l	0.799	0.739	0.771	0.801	0.640	0.559	0.630	0.698	0.705	0.628	0.662	0.698	0.597	0.556	0.597	0.645

3. Productions in China and East Asia are tied equally strong.
4. China's WTO accession has reorganized the production structure in that China imports more intermediates from EA in downstream processing while EA in midstream processing

Table 3. Selected posterior distributions for CN-EA5 model

	1987Q1-2000Q4								2001Q1-2008Q4							
	China				East Asia				China				East Asia			
	Mode	5%	Mean	95%	Mode	5%	Mean	95%	Mode	5%	Mean	95%	Mode	5%	Mean	95%
Parameters																
σ	0.350	0.297	0.352	0.414	0.350	0.297	0.352	0.414	0.349	0.285	0.344	0.404	0.349	0.285	0.344	0.404
γ	0.763	0.720	0.751	0.778	0.888	0.851	0.880	0.904	0.457	0.410	0.444	0.478	0.706	0.671	0.702	0.728
ϑ	1.409	1.384	1.428	1.470	1.409	1.384	1.428	1.470	1.557	1.484	1.528	1.576	1.557	1.484	1.528	1.576
Λ	1.000	0.968	0.986	1.000	1.000	0.968	0.986	1.000	0.997	0.953	0.977	1.000	0.997	0.953	0.977	1.000
κ_2	0.841	0.749	**0.851**	0.968	0.523	0.455	**0.555**	0.712	0.490	0.405	**0.519**	0.623	1.000	0.941	**0.973**	1.000
κ_3	0.439	0.370	**0.436**	0.503	0.762	0.715	**0.805**	0.901	0.841	0.775	**0.869**	0.969	0.391	0.346	**0.406**	0.461
θ_{p2}	0.591	0.578	0.610	0.642	0.845	0.829	0.848	0.865	0.670	0.632	0.663	0.691	0.663	0.630	0.670	0.710
θ_{p3}	0.899	0.892	0.903	0.913	0.932	0.926	0.935	0.944	0.940	0.936	0.950	0.964	0.917	0.907	0.922	0.933
$\theta^{\star}_{p2}$	0.938	0.930	0.942	0.954	0.769	0.691	0.738	0.780	0.740	0.711	0.780	0.850	0.925	0.920	0.940	0.962
$\theta^{\star}_{p3}$	0.726	0.707	0.732	0.753	0.555	0.532	0.558	0.588	0.648	0.619	0.653	0.700	0.729	0.719	0.739	0.758
ρ_a	0.940	0.934	0.939	0.945	0.940	0.934	0.942	0.950	0.940	0.930	0.938	0.946	0.713	0.681	0.725	0.771
ρ_l	0.644	0.667	0.702	0.734	0.681	0.642	0.676	0.713	0.752	0.730	0.768	0.812	0.659	0.644	0.664	0.682

5. But tales are different for Southeast Asia and China. The production connectedness of both regions has shifted toward downstream production in post China's WTO accession

Table 4. Selected posterior distributions for CN-SEA4 model

	1987Q1-2000Q4								2001Q1-2008Q4							
	China				Southeast Asia				China				Southeast Asia			
	Mode	5%	Mean	95%	Mode	5%	Mean	95%	Mode	5%	Mean	95%	Mode	5%	Mean	95%
Parameters																
σ	0.578	0.465	0.544	0.621	0.578	0.465	0.544	0.621	0.916	0.812	1.020	1.209	0.916	0.812	1.020	1.209
γ	0.734	0.657	0.697	0.737	0.677	0.626	0.664	0.712	0.844	0.808	0.862	0.902	0.603	0.579	0.618	0.663
ϑ	1.417	1.355	1.424	1.484	1.417	1.355	1.424	1.484	1.592	1.519	1.559	1.603	1.592	1.519	1.559	1.603
Λ	0.860	0.821	0.884	0.949	0.860	0.821	0.884	0.949	0.927	0.861	0.920	0.991	0.927	0.861	0.920	0.991
κ_2	0.828	0.816	**0.898**	1.000	1.000	0.947	**0.975**	1.000	0.512	0.377	**0.518**	0.709	0.732	0.424	**0.610**	0.771
κ_3	0.896	0.818	**0.899**	1.000	0.685	0.625	**0.684**	0.744	1.000	0.901	**0.949**	1.000	0.637	0.597	**0.752**	0.919
θ_{p2}	0.605	0.568	0.589	0.611	0.739	0.707	0.732	0.754	0.656	0.623	0.657	0.694	0.567	0.513	0.563	0.611
θ_{p3}	0.909	0.890	0.902	0.915	0.864	0.848	0.864	0.881	0.935	0.927	0.941	0.954	0.856	0.835	0.855	0.874
θ^*_{p2}	0.947	0.932	0.950	0.967	0.909	0.889	0.913	0.938	0.745	0.664	0.744	0.813	0.648	0.523	0.643	0.732
θ^*_{p3}	0.663	0.643	0.671	0.701	0.594	0.571	0.598	0.625	0.715	0.677	0.707	0.739	0.555	0.500	0.522	0.546
ρ_a	0.945	0.933	0.944	0.955	0.949	0.930	0.944	0.959	0.852	0.838	0.887	0.936	0.894	0.839	0.884	0.931
ρ_I	0.707	0.680	0.725	0.765	0.687	0.664	0.710	0.755	0.599	0.556	0.612	0.680	0.678	0.561	0.616	0.676

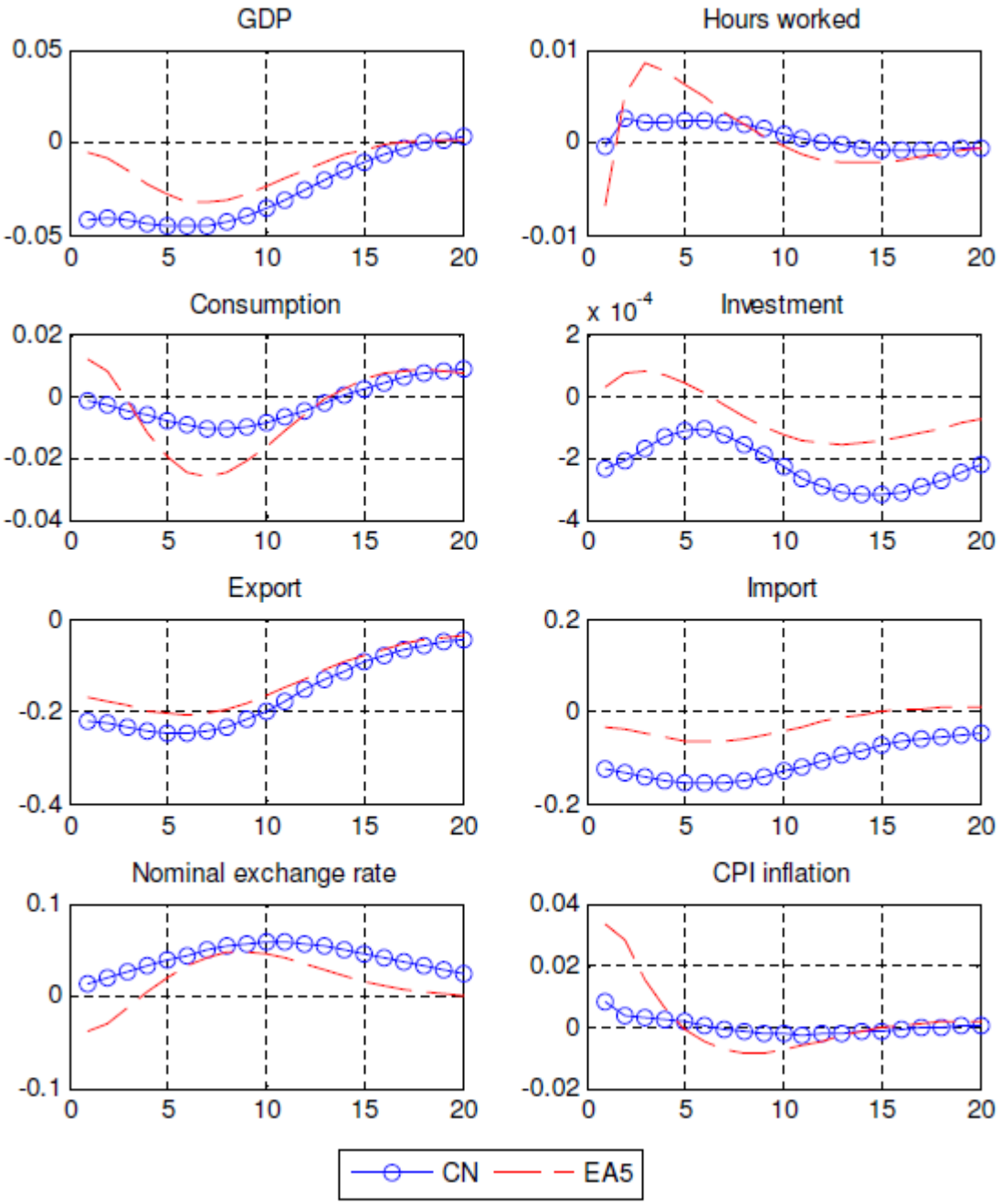
6. The corollary in trade pattern is that (i) vertical trade prevails for SEA-EA; (ii) the initial vertical-vertical pattern turns out to be vertical-processing trade between EA-China; (iii) though vertical-processing trade remains the predominant pattern between SEA-China, SEA has increasingly vertically specialized in downstream production, competing with China.

Table 5. Measuring vertical specialization of total export

	Pre China's WTO accession							Post China's WTO accession						
	Share of imported intermediate inputs		Export share		Vertical specialization			Share of imported intermediate inputs		Export share		Vertical specialization		
Model	Mid-stream	Down-stream	Mid-stream	Down-stream	Vertical trade	Processing trade	Index	Mid-stream	Down-stream	Mid-stream	Down-stream	Vertical trade	Processing trade	Index
SEA4-EA5														
SEA	0.649	0.148	0.411	0.178	**0.267**	0.026	0.293	0.921	0.511	0.411	0.178	**0.379**	0.091	0.469
EA	0.843	0.811	0.411	0.178	**0.346**	0.144	0.491	0.622	0.735	0.411	0.178	**0.256**	0.131	0.386
CN-EA5														
China	0.851	0.436	0.283	0.434	**0.241**	0.189	0.430	0.519	0.869	0.283	0.434	0.147	**0.377**	0.524
EA	0.555	0.805	0.411	0.178	**0.228**	0.143	0.371	0.973	0.406	0.411	0.178	**0.400**	0.072	0.472
CN-SEA4														
China	0.898	0.899	0.283	0.434	0.254	**0.390**	0.644	0.518	0.949	0.283	0.434	0.147	**0.412**	0.558
SEA	0.975	0.684	0.411	0.178	**0.401**	0.122	0.522	0.610	0.752	0.411	0.178	**0.251**	0.134	0.385

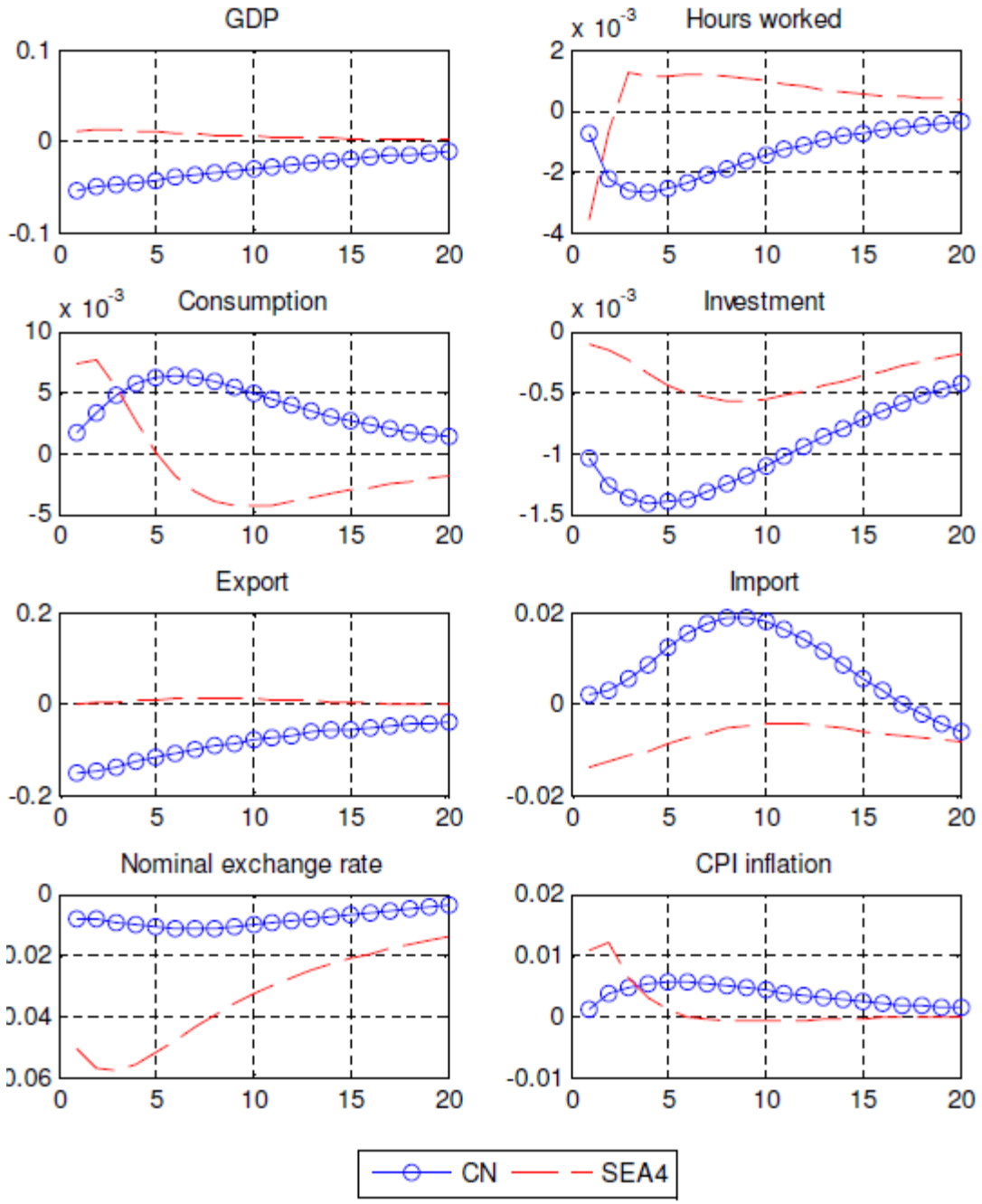
Notes: The formula for computing the vertical specialization of total export for country i is given by $VS_i = \underbrace{\kappa_2\left(\frac{Export_2}{\sum_2^3 Export_h}\right)}_{vertical\ trade} + \underbrace{\kappa_3\left(\frac{Export_3}{\sum_2^3 Export_h}\right)}_{processing\ trade}$. The share of midstream and downstream output in total export is inferred from Kim et al. (2011).

SEA4 consists of Indonesia, Malaysia, Thailand, and the Philippines, and EA5 consists of Japan, the Republic of Korea, Hong Kong, Taiwan, and Singapore. All are weighted by time-varying total trade share.



7. Such a shift in vertical specialization has critical influence on the macroeconomic interdependence between sub-regions in East Asia.

8. As a thought experiment: consider 1% shock to China's final export price markup. Driven by the complementary vertical-processing trade relationship, EA and China comove.



9. But tales turn different for the increasingly competing trade relationship between SEA and China. Both region respond to the shock diversely .

Production network and Asian trade integration

- It is beyond doubt that regional production network has tied East and Southeast Asia, including China, more closely through the corresponding vertical and processing trade.
- However, different vertical specializations – the complementary vertical-vertical and vertical-processing, or the competing processing-processing structure – would have different impacts on the macroeconomic interdependence

Finding optimal monetary coordination for Asia

- Of important question is, thus, can Asia gain from monetary policy coordination given the growing presence of vertical and processing trade?
- Would the lack of international monetary policy coordination result in substantial welfare loss?

	Game I			Game II		
	V-P	V-V	P-P	V-P	V-V	P-P
	Standard deviations					
GDP	0.163 (0.060)	0.169 (0.059)	0.147 (0.065)	0.142 (0.065)	0.109 (0.058)	0.128 (0.064)
C	0.266 (0.061)	0.277 (0.058)	0.162 (0.063)	0.199 (0.045)	0.166 (0.050)	0.170 (0.042)
I	0.116 (0.094)	0.116 (0.094)	0.116 (0.094)	0.112 (0.127)	0.145 (0.113)	0.112 (0.127)
Ex	0.258 (0.292)	0.260 (0.287)	0.368 (0.348)	0.270 (0.312)	0.289 (0.270)	0.412 (0.330)
Im	0.268 (0.230)	0.260 (0.232)	0.328 (0.348)	0.225 (0.242)	0.226 (0.276)	0.265 (0.394)
Tb	0.402 (1.681)	0.420 (1.713)	0.513 (1.741)	0.550 (2.270)	0.512 (2.193)	0.943 (2.895)
PPI inflation	0.080 (0.016)	0.089 (0.017)	0.038 (0.016)	0.070 (0.015)	0.061 (0.012)	0.045 (0.018)
Domestic inflation	0.076 (0.044)	0.072 (0.044)	0.036 (0.049)	0.048 (0.026)	0.031 (0.028)	0.028 (0.029)
Int. exp. inflation	0.004 (0.136)	0.004 (0.133)	0.004 (0.155)	0.004 (0.217)	0.004 (0.100)	0.004 (0.234)
Final exp. inflation	0.052 (0.075)	0.054 (0.076)	0.094 (0.077)	0.056 (0.085)	0.046 (0.089)	0.105 (0.083)
CPI inflation	0.060 (0.038)	0.058 (0.039)	0.040 (0.038)	0.064 (0.024)	0.077 (0.027)	0.040 (0.025)
Terms of trade	0.027 (0.085)	0.034 (0.086)	0.029 (0.126)	0.034 (0.088)	0.110 (0.113)	0.022 (0.136)
Exchange rate	0.191 (0.113)	0.210 (0.100)	0.128 (0.134)	0.196 (0.083)	0.174 (0.107)	0.169 (0.091)
	Welfare			Unconditional welfare gain measure (%)		
W	29.610	23.108	24.969	-0.004	0.293	-0.001

Is there sizeable welfare gain for Home economy by responding to foreign variables in monetary policy feedback rule (Game II)?
Nope, confirming the general consensus since Oudiz and Sachs (1984) and Obstfeld and Rogoff (2001).
But what about cooperative regime?