Quantifying Upstreamness in East Asia: Insights from a Coasian Model of Production Staging

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Objectives in this paper

- Calculate some stylized facts about the degree of production fragmentation in Asia and its evolution over time.
  - We build on prior work by Fally (2012)
- Build and calibrate a quantitative trade model that can match these stylized facts
- Undertake counterfactual exercises
  - Reduce international trade costs
  - Reduce interfirm trade costs everywhere
  - Raise Chinese productivity
  - Reduce transaction costs in China
  - Remove China from East Asian production

Data on East Asian Input Trade

- Japan's Institute for Developing Economies (IDE) produces unique input-output tables for 9 countries in East Asia + US.
  - Most IO data does not distinguish industries' use of imported vs domestic intermediates
  - The IDE data track use of intermediates for importing country x use sector x exporting country x make sector (i.e. use of Chinese steel in Japanese autos)
  - This provides an opportunity to investigate production chains in more comprehensive and detailed way.
- Coverage
  - We have data from years 1975, 1990, and 2000.
  - Countries in the data set are China, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand and the United States.
  - Trade with the rest of the world (ROW) is documented, but internal movements in ROW are not.

Measuring production fragmentation

- To document changes in international production fragmentation we devise a number of indexes
- We follow Fally (2012); one measure is equivalent to 'upstreamness' measure of Antras et al. (2012)
- We derive multinational analogues of these measures
  - Domestic measure indicates the average number of plant boundaries that are crossed in production
  - International measure indicates the average number of international boundaries crossed.
- Jointly the two measures are informative of a key question:
- What are the technological limits to international fragmentation that arise as a result of production chains that are of finite length?

Number of stages index, Fally (2012)

- Measure of the number of stages embodied in sector i's output:

$$N_{is} = 1 + \sum_r \sum_j \mu_{ijsr} N_{jr}$$

  where μ_{ijrs} is the direct IO coefficient of input j from country r for the production of i in country s.
- This is a recursive measure. If the upstream production that appears in my output embodies many stages of production, my output will embody many stages of production.
- The system generally has a unique solution and defines N_{is}. If A is the IO matrix, we need $(I - A)$ to be invertible to solve the the index for each element N_{is}
- A stage in this context represents a flow from an IO cell to an IO cell.
  - If several plants from a sector-country pair ship to a sector country-pair, that is still only a single stage (i.e. the index does not tell us about 'complexity').
  - Diagonal elements are included, however, so within-sector shipments are counted as a stage.

Distance to final demand index ('upstreamness'

- The distance index asks how far an industry is from final demand

$$D_{ir} = 1 + \sum_{s} \sum_{j} \phi_{ijrs} D_{js}$$

  where ϕ_{ijrs} is the share of production of i in r that corresponds to input purchases by industry j in s.
- As with the staging index....
  - This is a recursive system.
  - This can be solved as an invertible system.

International versions of the index

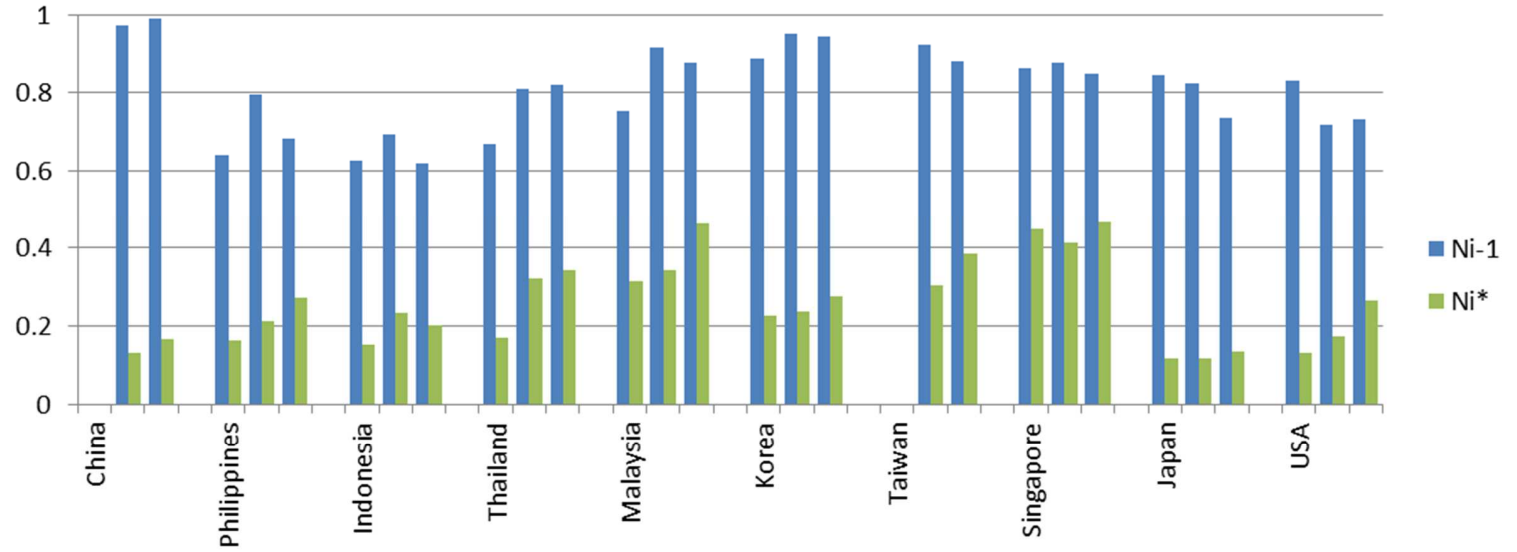
- The indices as constructed count the average number of plants involved in production
  - The IO data document plant-to-plant movements, and aggregate (raw data is usually survey data)
  - One interpretation of the indexes is that they document the average number of plants involved in sequential production
- International shipments are also plant-to-plant movements
- We can reconstruct these indices so as to ask how many nations are involved in sequential production.

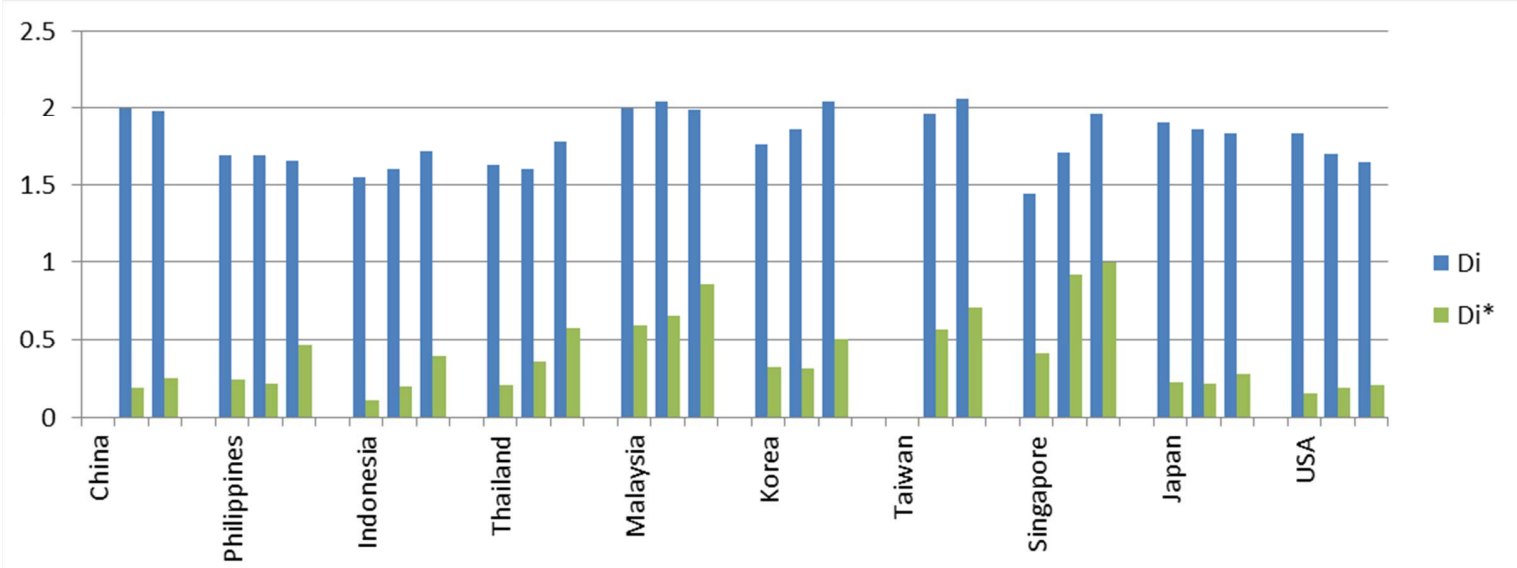
$$D^*_{ik} = \frac{X_{ik}}{Y_{ik}} + \sum_{jl} \varphi_{ikjl} D^*_{jl} \tag{1}$$

$$N^*_{ik} = \frac{M_{ik}}{Y_{ik}} + \sum_{jl} \mu_{ikjl} N^*_{jl} \tag{2}$$

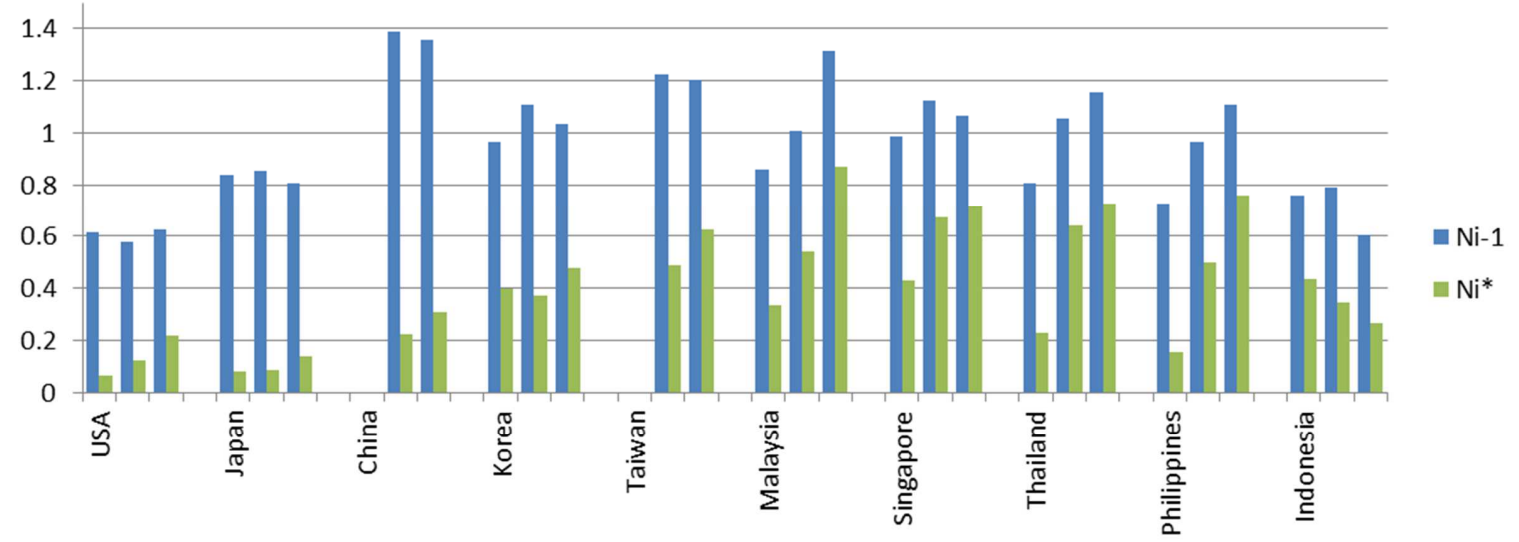
where X_{ik} is exports by sector k from region i, M_{ik} imports, and Y_{ik} gross output.

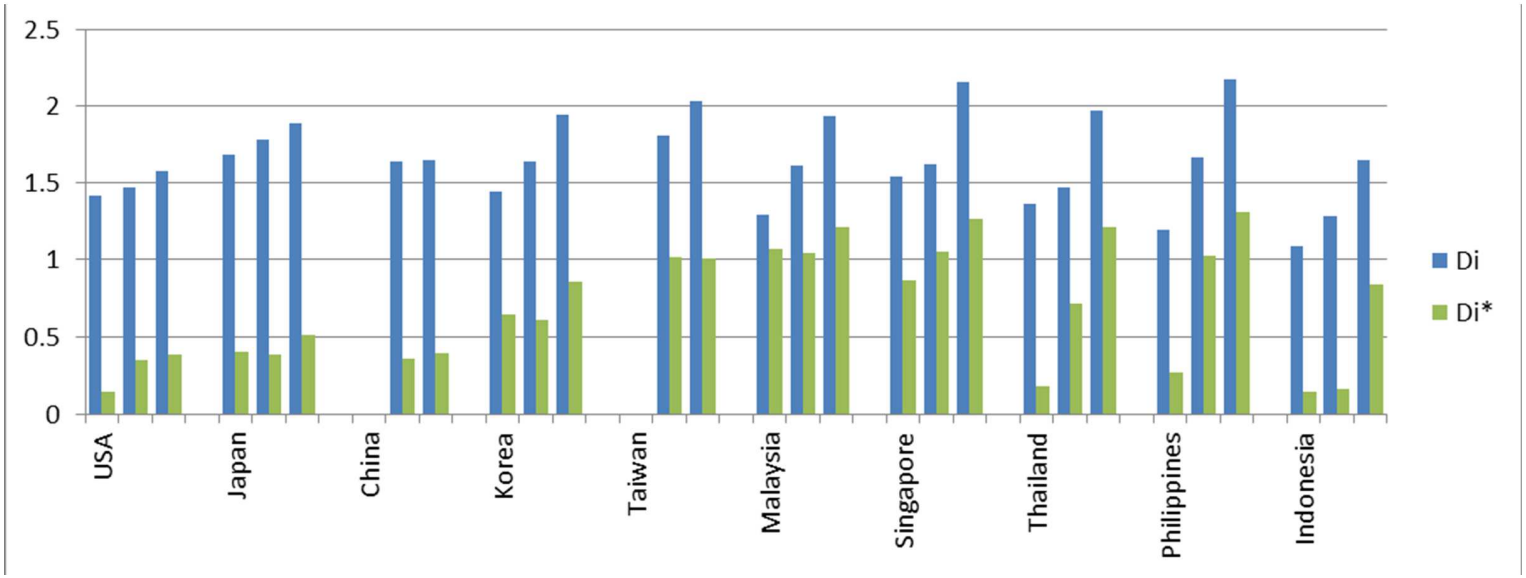
Indices for manufacturing





Indices for electronics





Lessons?

- Magnitudes
  - There are roughly 2 stages (inclusive) between value added and industry output.
  - There are roughly 2 stages (inclusive) from industry output to final consumption.
  - This is true even in sectors where we might expect substantial fragmentation - i.e. Electronics
  - Perhaps we do not need large numbers of stages in our model.
- Direction of change
  - In broad terms it seems that multistage production is moving from developed to developing countries. But for Singapore, the indices are falling in the richer countries. They tend to rise in the poorer countries.

Theory - discussion

- The index is useful for evaluating models of 'snakes' (i.e. vertical production chains)
- Most theory assumes away sequential production, employs Leontief production of stages instead.
- Costinot Vogel and Wang - CVW (2011) employ sequential production but assume infinite stages
- Production chains appear to be rather short. We would like a theory that allows allocates activities across finite stages of production
- Kakuchi, Nishimura and Stachusrki (2012) provide such a theory (in partial equilibrium)
- We adapt the model to general equilibrium (and trade). NOw firms are chooing what activities to undertake, and where to undertake them.

Outline of model

- The model formalizes the insights of Coase in the context of a vertical production chain.
- The cost to firm f of producing stages s_f are convex in the number of stages produced $c(s_f) = e^{\theta s_f} - 1$
  - θ is a parameter that defines diseconomies of scope.
- δ represents an iceberg cost of outsourcing activities
- Firm 1 sell final output , and chooses to produces stages s_1, at which point it becomes cheaper to buy inputs at market prices, gross of δ, than to produce more stages in house.
- Firm 2 sells its output to firm 1, and chooses s_2, and follows suit.
- The number of firms in the market are the number necessary to accomplish $\sum_f s_f = 1$.
- Zero profit conditions are imposed throughout, this is a competitive model.

Operationalizing the model

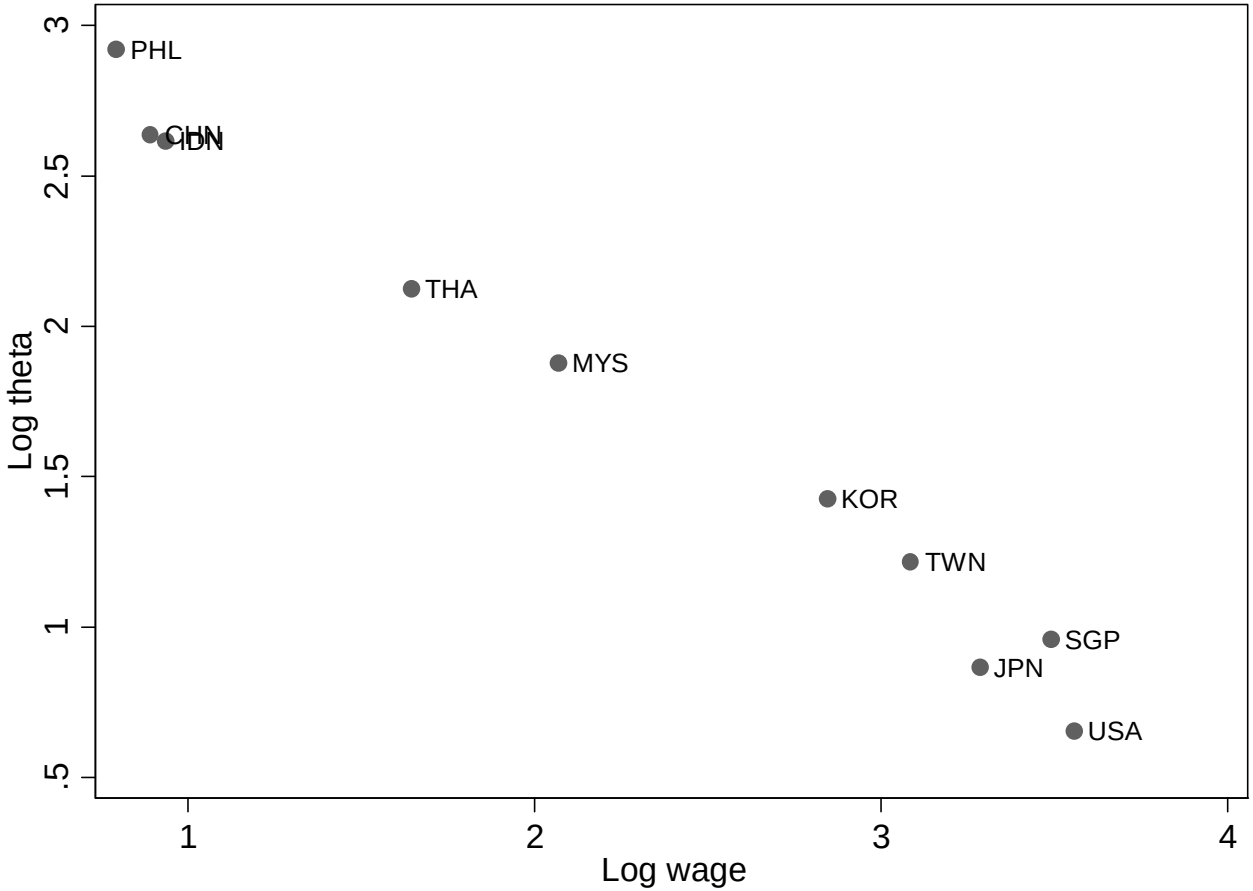
- The problem can be operationalized as a constrained optimization problem (minimize price of final good, subject to technology constraints).
  - KNS solve for the entire price function (also proving existence), but we only want a quick solution procedure
- The Kuhn-Tucker representation of the solution to the constrained optimisation problem can be used to embed the solution in general equilibrium.
- For the moment we simply reinterpret the cost function as a unit demand for labor
- We add labour market clearance, income expenditure balance, and consumer optimisation over multiple varieties.
- Each country receives a variety specific shock to θ, drawn from a Frechet distribution, so that countries can produce different stages of different varieties.
- An iceberg trade cost τ affects international trade.
- At the moment we are still not able to solve the model for large numbers of varieties. Results are preliminary.

Calibrating the model

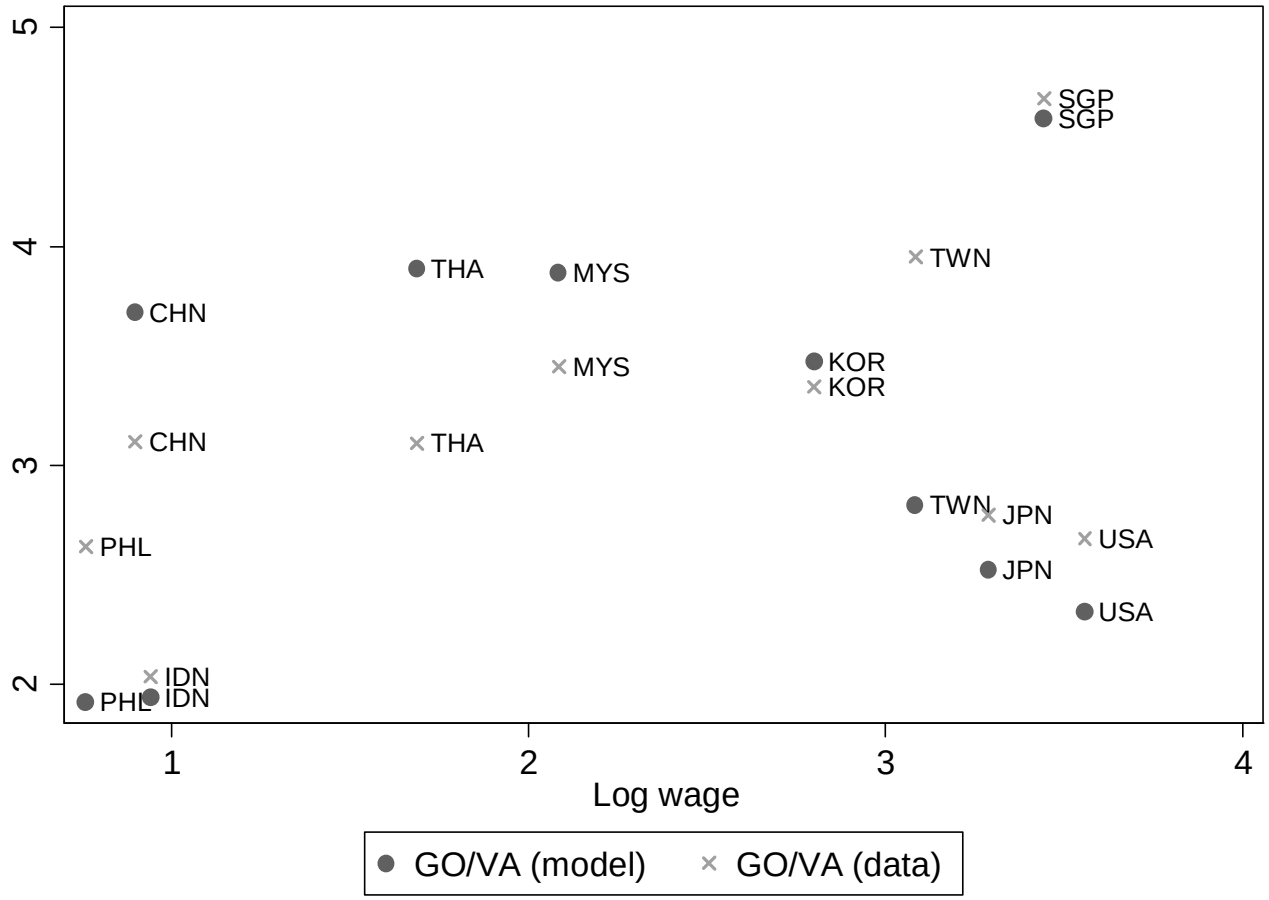
Table : Parameter choice and moments to match

Parameters:			*Moments to match:*		
Average $\bar{\theta}_i$	USA	1.93	GDP per capita	USA	35,080
by country	SGP	2.61	(PWT 7)	SGP	32,808
	JPN	2.38		JPN	26,721
	TWN	3.38		TWN	21,891
	KOR	4.16		KOR	17,208
	MYS	6.54		MYS	7,917
	THA	8.36		THA	5,178
	IDN	13.70		IDN	2,549
	CHN	13.96		CHN	2,442
	PHL	18.56		PHL	2,210
Dispersion coeff for θ_{ki}			Simonovska and		
across varieties k	All	6.14	Waugh (2010)	All	6.14
Labor supply	USA	53,551	Total value-added	USA	1878.6
in tradeable goods	SGP	735	in tradeable goods	SGP	24.1
(x1000 workers)	JPN	41,665	(in $M)	JPN	1113.3
	TWN	3,889		TWN	85.1
	KOR	10,491		KOR	180.5
	MYS	5,637		MYS	44.6
	THA	10,410		THA	53.9
	IDN	36,585		IDN	93.3
	CHN	266,707		CHN	651.3
	PHL	13,618		PHL	30.1
Transaction cost δ_i	All but SGP	15%	Distribution margin (US)	All but SGP	15%
	SGP	5%	GO/VA for SGP	SGP	4.66
Border cost	All	15%	Trade/output ratio	All	23%

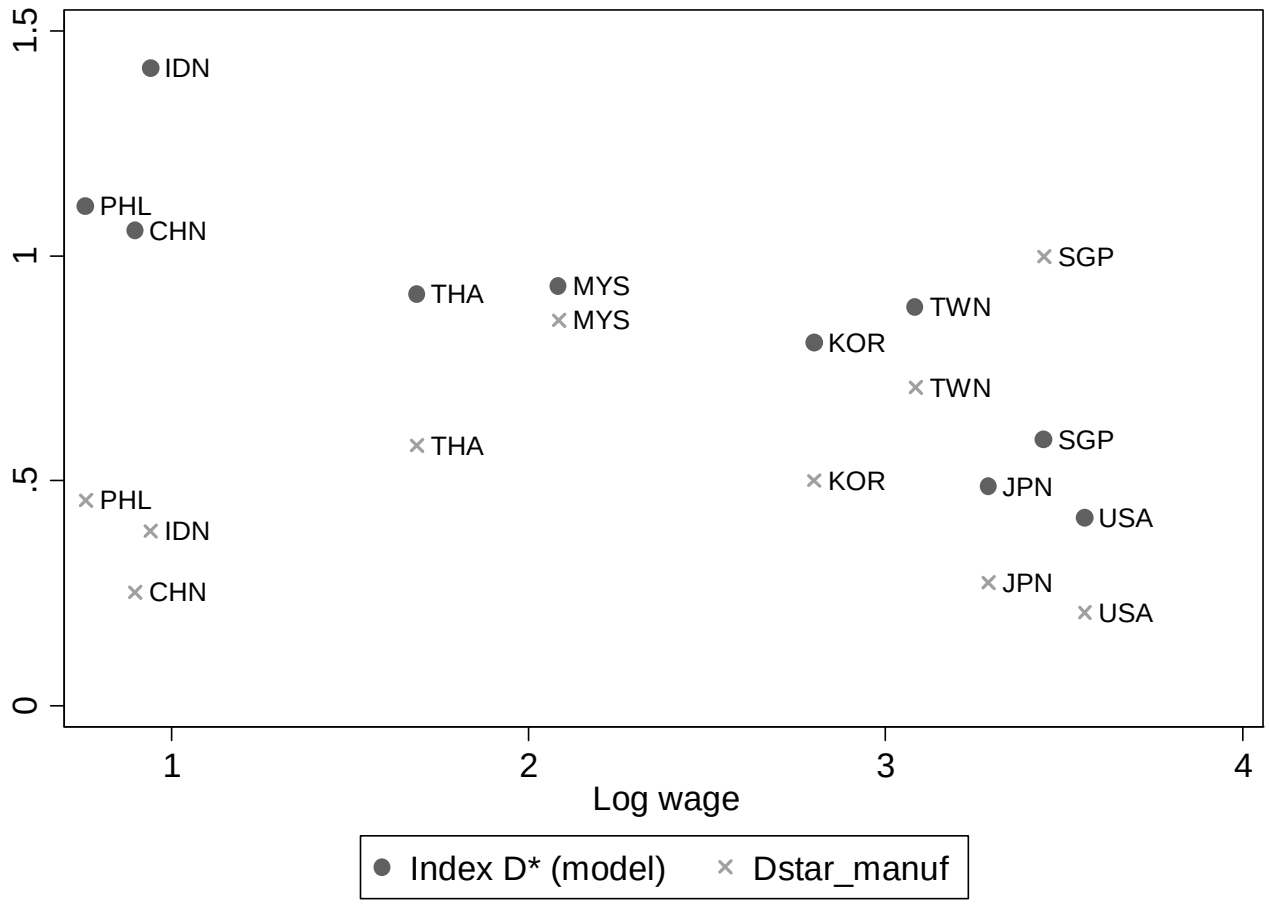
Average θ and wages



$\frac{GO}{VA}$ and wages



D^* and wages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Log wage
Index D* (model)
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Counterfactual exercises

- A 10% reduction in τ on every pair
- A 10% reduction in δ
- A 10% increase in Chinese average productivity
- A 10% decrease in Chinese transaction costs δ
- Remove China from Asian production networks.

Preliminary results: Reducing τ

Country	Welfare gains	GO/VA ratio	GO/VA ratio	D*	D*	Export share	Export share
	(% change)	Benchmark	Counterfact	Benchmark	Counterfact	Benchmark	Counterfact
USA	0.639	2.333	2.385	0.417	0.423	0.174	0.178
SGP	0.981	4.586	4.589	0.592	0.672	0.140	0.160
JPN	0.478	2.526	2.519	0.488	0.517	0.180	0.195
TWN	0.935	2.818	2.813	0.886	0.886	0.313	0.318
KOR	0.834	3.474	3.481	0.808	0.856	0.294	0.325
MYS	0.943	3.882	2.749	0.933	1.149	0.209	0.299
THA	0.938	3.900	3.898	0.915	0.915	0.204	0.207
IDN	1.9 53	1.940	1.982	1.418	1.403	0.448	0.445
CHN	1.561	3.699	3.608	1.057	1.126	0.188	0.202
PHL	1.953	1.921	2.278	1.110	1.022	0.453	0.387
					ALL:	0.223	0.233

Preliminary results: Reducing δ

Country	Welfare gains	GO/VA ratio	GO/VA ratio	D*	D*	Export share	Export share
	(% change)	Benchmark	Counterfact	Benchmark	Counterfact	Benchmark	Counterfact
USA	1.699	2.333	2.457	0.417	0.421	0.174	0.168
SGP	1.265	4.586	4.615	0.592	0.604	0.140	0.141
JPN	2.149	2.526	2.656	0.488	0.487	0.180	0.170
TWN	2.113	2.818	3.035	0.886	0.890	0.313	0.295
KOR	1.890	3.474	3.483	0.808	0.810	0.294	0.259
MYS	3.446	3.882	3.822	0.933	0.933	0.209	0.212
THA	4.491	3.900	4.190	0.915	0.914	0.204	0.190
IDN	3.601	1.940	2.069	1.418	1.402	0.448	0.420
CHN	3.839	3.699	3.761	1.057	1.019	0.188	0.185
PHL	3.601	1.921	2.087	1.110	1.162	0.453	0.417
					ALL:	0.223	0.213

Preliminary results: Increasing $\bar{\theta}_{CHN}$

Country	Welfare gains	GO/VA ratio	GO/VA ratio	D*	D*	Export share	Export share
	(% change)	Benchmark	Counterfact	Benchmark	Counterfact	Benchmark	Counterfact
USA	0.694	2.333	2.396	0.417	0.425	0.174	0.176
SGP	0.499	4.586	4.576	0.592	0.599	0.140	0.141
JPN	0.074	2.526	2.514	0.488	0.511	0.180	0.190
TWN	0.131	2.818	2.786	0.886	0.886	0.313	0.316
KOR	-1.555	3.474	3.476	0.808	0.810	0.294	0.304
MYS	-0.034	3.882	3.882	0.933	0.933	0.209	0.209
THA	0.057	3.900	3.844	0.915	0.933	0.204	0.211
IDN	-0.324	1.940	2.034	1.418	1.363	0.448	0.427
CHN	12.809	3.699	3.447	1.057	1.067	0.188	0.202
PHL	-0.324	1.921	2.090	1.110	1.153	0.453	0.416
					ALL:	0.223	0.231

Preliminary results:Decrease in China's internal trade costs

Country	Welfare gains	GO/VA ratio	GO/VA ratio	D*	D*	Export share	Export share
	(% change)	Benchmark	Counterfact	Benchmark	Counterfact	Benchmark	Counterfact
USA	0.060	2.333	2.398	0.417	0.420	0.174	0.171
SGP	0.030	4.586	4.360	0.592	0.605	0.140	0.161
JPN	0.338	2.526	2.494	0.488	0.492	0.180	0.182
TWN	0.385	2.818	2.819	0.886	0.886	0.313	0.314
KOR	-1.406	3.474	3.540	0.808	0.808	0.294	0.257
MYS	0.512	3.882	3.882	0.933	0.933	0.209	0.209
THA	0.453	3.900	3.844	0.915	0.933	0.204	0.211
IDN	1.134	1.940	1.942	1.418	1.418	0.448	0.448
CHN	2.929	3.699	3.863	1.057	1.012	0.188	0.180
PHL	1.134	1.921	1.907	1.110	1.122	0.453	0.456
					ALL:	0.223	0.219

Preliminary results: Remove China from Asian Production

Table : Counterfactual 5): Without China

Country	Welfare gains	GO/VA ratio	GO/VA ratio	D*	D*	Export share	Export share
	(% change)	Benchmark	Counterfact	Benchmark	Counterfact	Benchmark	Counterfact
USA	-3.933	2.333	2.279	0.417	0.357	0.174	0.142
SGP	1.739	4.586	4.323	0.592	0.660	0.140	0.177
JPN	-2.282	2.526	2.505	0.488	0.478	0.180	0.180
TWN	-9.922	2.818	2.674	0.886	0.867	0.313	0.282
KOR	10.165	3.474	2.887	0.808	0.882	0.294	0.266
MYS	0.240	3.882	1.916	0.933	0.933	0.209	0.424
THA	6.683	3.900	2.095	0.915	1.476	0.204	0.360
IDN	3.018	1.940	1.791	1.418	1.444	0.448	0.486
CHN	/	3.699	/	1.057	/	0.188	/
PHL	-1.906	1.921	2.060	1.110	1.000	0.453	0.422
					ALL:	0.223	0.210

Conclusion

- Asian Input-output table allows us to measure international production fragmentation
- On average, production chains seem short. Short chains put a lower bound on the gains from vertical specialization
- We develop a general equilibrium model that produces sequential production chains of finite length.
- We calibrate it to data on East Asia
- We are still working on operationalizing a large number of varieties