An Empirical Test on Regional Spillovers through Intra- and International Trade

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Abstract

In my previous publication with a model to illustrate the key role of intra-national trade in developing countries, it was established that intra-national trade, together with international trade, form a network in which high growth achieved by the developed regions spills over to the less developed regions. This study aims at providing econometrical evidence to support this theoretical conjecture. Using China's 2007 foreign trade data and provincial input-output tables, the key variables on intra- and international imports of technological inputs are made for estimating their impacts over the outputs in production functions at the province and sector levels. It is found that in the less developed regions, intra-national imports rather than international ones made significant contribution to production. In the developed regions, these impacts were just inversed. These results confirm the existence of the trade network in which mainly the former benefited from the spillovers via intra-national trade, while the latter gained this benefit via international trade.

Key words: intra-national trade; intra-national spillovers; regional input-output tables; regional disparity.

JEL: F1, R1, O1, O3, O4.

I. Introduction

In a previous study (He 2017), the author provided a dynamical model to analyze the nature of intra-national trade in developing countries. There is a developing country, within which there are multiple regions ranked by technological capability at the starting time. There is also a developed foreign country that has a technological level higher than all of the regions in the developing country. A region must choose between inventing, or importing and then imitating new intermediate goods. If importing, a region must also choose how much to import, and then importing from where: other developed regions or the developed country. The model gives rise to two main results:

First, the less developed regions take higher intra-national trade shares. At the steady state, the lower a region's technological level, the higher is its intra-national import ratio of new intermediates. This implies that relating to international trade, intra-national trade has a particular importance to the less developed regions. They benefit more from intra-national trade.

Second, regional spillovers occur within the trade network in which regions choose to import technological inputs from the regions with which they have narrower technological distance. The number of layers depends on the degree of regional inequality, geographical, and other factors. At any layer of the trade network, the optimal number of varieties of intermediates will be altered by that of the highest layer. Or, even though in the beginning, the less developed regions have low growth rates, the highest growth rate from the foreign country will be transmitted to all levels of the trade network.

The above theoretical results lead to two empirically testable predictions:

Prediction 1:

In a developing country, the developed regions are the main international importers of technological inputs, and intra-national import ratios of technological inputs are much higher in the less developed regions than in the developed regions.

Prediction 2:

The developed regions mainly benefit from spillovers through international imports of technological inputs. Inversely, the less developed regions mainly benefit from spillovers coming from intra-national imports of technological inputs.

For confirming the Prediction 1, in He (2017, section IV.B), several tables with descriptive statistics on the differences in share of intra-national trade over total trade were made. The main drawback of this study is the lack of an econometrical test on the regional technological spillover effects to validate the Prediction 2. For this purpose, descriptive statistics are no longer enough, He (2017) only made a literature review on regional spillover via the foreign direct investment, human capital, on the convergence of the growth rates among regions, and on the effects of a shock in one region on other regions in terms of the interregional industrial multipliers and of backward and forward linkages.

The empirical tests of spillovers via intra- as well as international imports of technological inputs remain a challenge because they meet at once methodological obstacles and data availability. Testing on intra-national spillover effects, in a strict sense, requires panel data with multiple periods and various trade levels. On this, intra-national trade data at the regional level are scarce. The time series data on intra-national trade are much scarcer. In the face of this constraint, we reason that a static state could be the outcome of the dynamical spillover effects: if technological spillovers occur from the developed foreign countries to the developed regions via international imports; and then these spillovers prolong from the developed regions to the less developed regions via intra-national imports, then these dynamic spillover effects could give rise to a result that is observed: we construct two variables: international imports and intra-national imports of technological inputs, and estimate theirs effects on the outputs in the production function for regions of different development levels. If international imports have stronger impacts in the developed regions than in the less developed regions, and intra-national imports have stronger impacts in the less developed regions than in the developed regions, we could indirectly confirm the Prediction 2.

In this study, we first derive an econometrically testable equation of production function including distinct intra-national and international imports of technological inputs, then we constitute the variable of international imports of equipment inputs by province and sector on the basis of the foreign trade data, and the variable of intra-national imports of equipment input by province and sector on the basis of 2007 provincial input-output tables, and other variables necessary for the tests. As expected, the estimation results strongly support the Prediction 2.

This paper is organized as follows: following this introduction, section 2 exposes the data and estimation method. Section 3 analyzes the results. Section 4 concludes.

II. Data and Estimation Method

As a large country and having experienced lasting economic growth and technological progress, China is an appropriate case for evaluating the effects of intra-national trade for regional development. China's 31 provinces are conventionally classified into three large regions: Costal region (10 provinces), Central region (9 provinces), and Western region (12 provinces, with Tibet ruled out in this study due to data missing). Coastal region is the most developed and the main exporter of China to the world. It is followed by Central region, and Western region is the less developed. Their population shares were 36.6%, 35.6% and 27.8%, and their GDP shares 55.3%, 27.4% and 17.3% in 2007.

In face of the difficulties to gather the published data on intra-national trade by sector and province, one possibility for empirically dealing with intra-national trade is the use of the provincial input-output tables. Till now, China has published 2002 and 2007 provincial input-output tables. Those of 2007 are exploitable for our purpose, because in them, there are "inflow" (international imports plus inter-provincial imports) and "outflow" (international exports plus inter-provincial exports) by province and sector. With the data on international trade 2007 by sector and province, which are found in the statistic yearbooks 2008 of these provinces, "inflow" is potentially usable for constituting the inter- and intra-national imports variables. The 2002 provincial input-output tables are not exploitable because in them there is only a "net flow" without the distinction of "inflow" and "outflow".

Note that we are conscious of some unavoidable limitations of the input-output data. First, in comparison with the data at the firm level, their aggregations at the province level may bring about substantial loss in microeconomic value. Second, the trade data: "inflow" and "outflow" are collected without distinguishing their origins and destinations. Furthermore, the aggregated nature of the data is often associated with omission, subjective arbitration and smoothness. We judge acceptable, though, to use them for testing our theoretical propositions only, rather than applying the model for forecasting purpose.

The first possibility was using the data on manufactured inputs, and testing the impacts of inter- and intra-national imports of manufactured goods on regions' outputs. This method, however, meets a serious concern on the bias coming from the fact that China's manufactured imports are to very large extent for the purpose of processing.[1] As the consequence of the processing, a large volume of inter- and intra-national imports of manufactured goods are driven by the re-exportation of their final goods. This is not desirable for testing the impact of the imports motivated by enhancing technological capabilities. That is why we choose to make our tests with the data of equipment goods. We reason that as a developing country, China's imports of equipment goods have a limited processing nature, and a substantial share of them is for fitting their technological gaps. We simply assume that inter- and intra-national imports of equipment goods may be distinct in technological content and hence can be of different impacts on productions.

The production function of the province h's output of sector i takes the following form:

$$Y_{ih} = A_{ih} K_{ih}{}^{\beta_k} L_{ih}{}^{\beta_l} R_{ih}{}^{\beta_r} S_{ih}{}^{\beta_s} O_{ih}{}^{\beta_o} [\theta Me_{ih} + Ma_{ih}]^{\beta_x} \quad (1)$$

where Y is the output of sector h of province i. K, L, R, S and O are respectively capital, labor, raw material and energy, service, and other manufacturing inputs. The last term concerns equipment inputs, with $Me_{ih}$and Ma_{ih} refer to international imports and intra-national imports of equipment inputs, respectively. θ is a parameter reflecting the extent to which international imports of equipment is different to intra-national imports of equipment in technological content,

[1] According to *China Statistic Yearbook* 2008, the volume of processing trade represented 58% of the foreign trade of manufactured goods in 2007.

hence in impact to output. If $\theta = 1$, they make equal contribution to output. But in accordance with our theoretical framework, θ for the developed regions could be larger than for the less developed regions. So the key of the tests is to know if in the developed regions the value of θ is higher than that of the less developed region.

In logarithm form, Equation (1) becomes

$$lnY_{ih} = \alpha_{ih} + \beta_k lnK_{ih} + \beta_l lnL_{ih} + \beta_r lnR_{ih} + \beta_s lnS_{ih} + \beta_o lnO_{ih} + \beta_x ln[\theta Me_{ih} + Ma_{ih}] \quad (2)$$

The last term is dealt with using linear expansion around $Me_{ih} = a$ and $Ma_{ih} = b$. It becomes

$$\beta_x(\ln(a + \theta b) - 1) + \theta \frac{a+b}{a+\theta b} \beta_x \frac{Me_{ih}}{a+b} + \beta_x \frac{a+b}{a+\theta b} \frac{Ma_{ih}}{a+b} \quad (3)$$

Collecting the first term into the intercept, we get the equation for testing:

$$lnY_{ih} = A_{ih} + \beta_k lnK_{ih} + \beta_l lnL_{ih} + \beta_r lnR_{ih} + \beta_s lnS_{ih} + \beta_o lnO_{ih} + \beta_{xe} \frac{Me_{ih}}{a+b} + \beta_{xa} \frac{Ma_{ih}}{a+b} + \varepsilon_{ih} \quad (4)$$

where a is set as the mean value of international imports of equipment input by sector across 30 provinces, and b is the mean value of intra-national imports of equipment input by sector across 30 provinces. Thus $\frac{Me_{ih}}{a+b}$ and $\frac{Ma_{ih}}{a+b}$, named *Rate_inter_equip* and *Rate_intra_equip*, are the shares of international and intra-national imports of equipment inputs by province and sector in the sum of their mean values by sector, respectively. Comparing Equations (3) and (4), with $\theta = \beta_{xe}/\beta_{xa}$, the difference between β_{xi} and β_{xa} is determined by the value of θ. With the observations clustered into Costal, Central and Western regions, and operating the regressions with Equation (4), the θ of the three regions must be decreasing according to the theoretical framework. If θ is very large (small), the contribution of intra-national imports of equipment inputs (international imports of equipment inputs) could become so small that the variable becomes statistically insignificant.

For the purpose of providing evidence on the positive spillover effects of intra-regional trade, intuitively, one of the two outcomes are required: 1) intra-national imports of equipment inputs have a statistically significant positive impact to the production function for the less developed regions whereas they are insignificant for the developed regions; 2) international imports of equipment inputs have a statistically significant impact to the production function for the developed regions whereas they are insignificant for the less developed regions. These results could confirm Prediction 2.

Another possibility is that if both variables are positively significant for both regions, the comparison of the levels of the coefficients will be needed. To be in accordance with Prediction 2, the coefficient of international imports of equipment inputs must be larger for the developed regions than for the less developed regions, and the coefficient of intra-national imports of equipment inputs must be larger for the less developed regions than for the developed regions.

In 2007 provincial input-output tables, most variables necessary for estimating Equation (4) are available. The labor income reflected by the item: compensation of employees is used as labor inputs. The capital returns are treated as capital inputs, and are computed by the sum of three items: net taxes on production, operating surplus, depreciation of fixed capital.[2] In total there are 42 sectors: 26 in industrial sector (including 17 in manufacturing sector, in them there are 6 in equipment sector, 6 in raw-material sector, and 3 in energy sector),[3] 15 in service sector,

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[2] Usually the amount of labor hired and the book value of capital are used as labor and capital variables. These data are, however, absent in input-output tables. Here assuming that labor and capital inputs are remunerated according to their marginal productivities, these items provide a convincing measurement of these inputs.

[3] The equipment sector includes: 1) manufacture of metal products; 2) manufacture of machinery; 3) manufacture of transport equipment; 4) manufacture of electric machinery and instrument; 5) manufacture

plus agricultural sector. The distinctions of inputs by their natures (service, raw material and energy, and manufactured inputs) are made on this basis. In what follows, the issue is how to constitute the two last explanatory variables.

The first task is to approximate the international equipment imports by sector and province. From the statistic yearbooks 2008 of 30 provinces, their international imports of equipment goods are gathered. For estimating their distribution as inputs among sectors, a weighting method must be found. First, only a share of these goods was employed as inputs and the other as final consumption. Thus the total international equipment imports time the ratio: the equipment input/(equipment input + final consumption of equipment) result in the international imports of equipment inputs by province. Second, the obtained international imports of equipment inputs are partitioned among the 42 sectors according to the shares of their equipment inputs in the total equipment inputs of the province.[4]

Once having the estimated international equipment imports by sector and province, with the existence of only the equipment inflow by province, their partition by sector must be estimated. First, using the ratio at the province level: the equipment input / (equipment input + final consumption of equipment), the equipment inflow used as inputs is estimated. Then the following formula is employed to distribute the equipment inputs among the 42 sectors. There are in total 6 equipment sectors. For one of the 42 sector, h, its equipment inflow is

$$(Equipment\ inflow\ as\ inputs)_h = \sum_{j=1}^{6} inflow\ as\ inputs_j * (input\ weight)_{hj} \quad (5)$$

of electronic and communication equipment; and 6) manufacture of instruments, meters and other measuring equipment.

[4] The weighting method has also been generally used in the estimation of multi-regional trade relationship by official statistic bureaus (cf. e.g., National Information Center 2005 p.20).

where $(input\ weight)_{hj}$ is the sector h's share in the j inputs of the province.[5]

Finally intra-national imports of equipment inputs by sector are obtained by subtracting international equipment imports from their equipment inflow used as inputs.

On the basis of these estimated international and intra-national imports of equipment inputs by sector and province, we are able to calculate the *Rate_inter_equip* and *Rate_intra_equip* defined in Equations (3) and (4).

With 30 provinces of 42 sectors, in total 1237 observations are obtained (the sector "Scrap and waste" and exceptionally some other sectors had missing values, and 23 were dropped). In Table 1, it can be observed through *Rate_inter_equip* and *Rate_intra_equip* that even in absolute terms, Costal region employed at once more inter- and intra-national imports of equipment goods, in relative terms, Coastal region worked with more international imports than intra-national imports of equipment inputs. Western region employed much less international imports than intra-national imports of equipment inputs. Central region kept the intermediate level of them.

Table 1 descriptive statistics of the variables

	Coastal region Obs. 410		Central region Obs. 372		Western region Obs. 455	
	mean	S.D	mean	S.D	mean	S.D
Lnoutput (lnY_{ih})	15.197	1.814	14.672	1.415	13.580	1.739
Lncapital (lnK_{ih})	13.479	1.887	13.057	1.563	12.029	1.825
Lnlabor (lnL_{ih})	12.986	1.896	12.654	1.525	11.684	1.851
lnraw_energy (lnR_{ih})	12.244	2.126	12.003	1.908	10.762	2.269
Lnservice (lnS_{ih})	13.242	1.750	12.620	1.479	11.542	1.830
Lnothermanu (lnO_{ih})	13.651	2.214	12.962	1.991	11.701	2.011

[5] We believe that this mothed of estimation with more subdivided equipment sectors could give rise to a more faithful result. This method, however, could not be applied to the estimations of sectorial distribution of international imports of equipment inputs due to the incomplete detailed information on equipment sector.

Rate_inter_equip	0.711	.856	0.196	0.239	0.066	0.154
Rate_intra_equip	0.880	1.449	0.705	0.905	0.475	0.605

Notes: 1) international imports and exports of equipment goods and other goods are calculated on the basis of 2008 statistic yearbooks of the provinces; 2) intra-national imports and exports of equipment goods and other goods are computed on the basis of "inflow" and "outflow" by province and sector in China's 2007 provincial input-output tables and of international trade data in the 2008 statistic yearbooks of the provinces; 3) intra-national imports and exports are specified as inter-provincial imports and exports, and intra-provincial imports and exports are not included; 4) the provinces are clustered in three regions according to conventional method with 10 provinces in Coastal region, 9 provinces in Central region and 12 provinces in Western region, and with Tibet being ruled out; 5) the definitions of the variables are made in this section.

As the panel data by province and sector, applying pooled ordinary least squares might be overly restrictive and can have a complicated error process (e.g., heteroskedasticity across panel units, and (or) serial correlation within panel units). For this reason, panel-data estimation method is employed. On the choice between the fixed-effects (FE) and random-effects (RE) models, the latter is kept. Hausman tests favor the RE estimator, meaning that the sector effects are uncorrelated with the regressors, and FE estimator is still consistent, albeit inefficient, whereas the RE estimator is consistent and efficient.

III. Results and Analysis

Table 2 presents the regression results for three regions. The high values of R-squared, and of Wald chi2 on the significance of the regression relationship validate the chosen regression model. The values of Rho (fraction of variance due to individual effect) are, in general, fairly large, signifying that the individual effects of sectors are strong, and panel estimators are better than pooled estimators.

Table 2 Regression results

	Industrial sectors			Manufacturing sectors		
	Coastal region	Center region	Western region	Coastal region	Center region	Western region
	lnoutput	*lnoutput*	*lnoutput*	*lnoutput*	*lnoutput*	*lnoutput*
lncapital	0.410	0.409	0.437	0.444	0.432	0.458
	(0.035)***	(0.036)***	(0.087)***	(0.044)***	(0.039)***	(0.091)***
lnlabor	0.112	0.168	-0.000	0.084	0.174	-0.026
	(0.023)***	(0.035)***	(0.084)	(0.018)***	(0.039)***	(0.095)
lnraw_energie	0.168	0.148	0.086	0.128	0.108	0.071
	(0.029)***	(0.033)***	(0.039)**	(0.039)***	(0.036)***	(0.046)
lnservice	0.193	0.186	0.173	0.200	0.215	0.161
	(0.038)***	(0.038)***	(0.024)***	(0.065)***	(0.035)***	(0.036)***
lnothermanu	0.137	0.071	0.266	0.161	0.042	0.296
	(0.039)***	(0.043)	(0.040)***	(0.102)	(0.035)	(0.060)***
Rate_inter_equip	0.082	0.096	-0.250	0.092	0.107	-0.283
	(0.024)***	(0.049)*	(0.080)***	(0.027)***	(0.083)	(0.171)*
Rate_intra_equip	0.005	-0.009	0.094	0.008	-0.010	0.124
	(0.009)	(0.017)	(0.020)***	(0.009)	(0.042)	(0.032)***
_cons	1.657	2.149	2.163	1.682	2.390	2.146
	(0.116)***	(0.205)***	(0.198)***	(0.140)***	(0.262)***	(0.265)***
Wald chi2(7)	21247.51	6465.58	31309.49	46851.93	8373.97	27053.71
(prob<chi2)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R-sq (overall)	0.985	0.970	0.980	0.987	0.976	0.976
Rho	0.454	0.323	0.299	0.245	0.049	0.137
N	250	228	280	169	151	184

Notes: 1) international imports and exports of equipment goods and other goods are calculated on the basis of 2008 statistic yearbooks of the provinces; 2) intra-national imports and exports of equipment goods and other goods are computed on the basis of “inflow” and “outflow” by province and sector in China’s 2007 provincial input-output tables and of international trade data in the 2008 statistic yearbooks of the provinces; 3) intra-national imports and exports are specified as inter-provincial imports and exports, and intra-provincial imports and exports are not included; 4) the provinces are clustered in three regions according to conventional method with 10 provinces in Coastal region, 9 provinces in Central region and 12 provinces in Western region, and with Tibet being ruled out; 5) the definitions of the variables are made in section II; 6) random-effects GLS regression are made with sector as group variable with 26 subsectors grouped in industrial sector and 17 grouped in manufacturing sector; 7) robust standard error is in parenthesis; 8) * p<0.10; ** p<0.05; *** p<0.01.

First, the variables reflecting both intra- and international imports of equipment inputs have their signs and significances in good accordance with the theoretical prediction: For Coastal region, international imports of equipment inputs exerted significant positive impacts on production, whereas intra-national imports of equipment inputs were insignificant. For Western region, intra-national imports of equipment inputs had significant positive effects. In contrast, international imports of equipment inputs were not positively significant. [6] Central region followed the same trend of Costal region, with insignificant impacts of intra-national equipment imports, but significant impacts of international equipment imports. Note that for Central region, on the basis of 26 industrial sectors, the international imports of equipment inputs are significant at 10%, and this significance disappears on the basis of 17 manufacturing sectors, indicating that the impacts of these inputs were, weaker for Central region than for Costal region. This is in concordance with the theoretical prediction.

While the estimate results on intra-national imports of equipment inputs are quite well, one problem appears with the variable reflecting international imports of equipment inputs: referring to Equations (3) and (4), its coefficient must be positive, whereas this coefficient for Western region is significantly negative in the regression on the base of industrial sector, even though the significance is reduced to just at 10% in the regression on the base of manufacturing

[6] The coefficients of *Rate_inter_equip* and *Rate_inter_equip* cannot be interpreted in the same way with the coefficients of the other variables. According to Equation (3), the former is not comparable to the latter.

sector. This could happen if a number of sectors in Western provinces produced low outputs while they relied on important international imports of equipment inputs. We believe that this is the case for the Western region, because a massive military industry has been concentrated there. It was started during 1960s from the construction of the "Third Front", which was a massive construction program focused on China's remote and mountainous interior regions, particularly on such southwestern provinces as Sichuan and Guizhou (Naughton, 2007, pp.73-74). These firms were massively dependent on international imports of inputs, but, in their outputs, only the parts for civil use were accounted in the input-output tables. This may be an explanation on this unusual outcome.

To summarize, in spite the some biases associated with the problem of mismeasurement in data, the econometric results provide clear evidence that intra-national trade was more beneficial than international trade to the less developed regions in terms of the productive contribution whereas international trade was more beneficial than intra-national trade to the developed regions. Thus, with the validation of Prediction 2, we confirm the existence of a trade network within which there are technological spillovers from the developed to the less developed regions through both inter- and intra-national trade.

One concern on the validity of the above estimations is: should the presence of endogeneity be suspected? Olley and Pakes (1996) and Levinsohn and Petrin (2003) have extensively discussed the presence of simultaneity and endogeneity in the case of the measurement of the impacts of intermediates on productivity. If inputs are chosen on the basis of the productivity shocks, a province with a higher productivity shock may use more imported inputs. Another possible source of endogeneity is that international exports shock as unobservable variable in error term may be correlated with the interprovincial imports of intermediates. In both cases, one of the conditions for unbiased and consistent estimation is violated. To deal with the endogeneity problem, in most previous work on the measurements of the impacts of intermediate inputs on productivity, panel data with multiple years were used. Tow-period data were needed for testing Granger causality (Kim et al. 2007). More often GMM estimator and Proxy Estimator following Olley and Pakes (1996) and Levinsohn and Petrin (2003) were employed to compare with OLS estimator. Here as there is only one-year data, are the estimations still valid? Three arguments can be offered in favor of our approach.

First, in 2007, economic growth rates among provinces in China are unusually synchronized, with these rates for Coastal, Central and Western regions were 14.7%, 14.4%, and 13.7% respectively. Even though the growth rates by sector among provinces were likely to be more variable, these variances, shaped by the GDP variances, might be quite moderated. Thus it can be thought that productivity shocks on interprovincial equipment imports, even existing, were weak. Therefore, the estimations with the data at the province level, instead of with plant data, make sense.

Second, about another source of endogeneity: international exportation is a variable that affects at once the output and the manufactured imports, in such main Chinese processing and exporting provinces as Guangdong and Shanghai, this endogeneity caused by international exports must be strong. Therefore, there is a concern if measuring with manufactured inputs. Measuring with equipment inputs as we did, however, suffers from limited processing effects and reflects to large extent the demand for technological enhancement.

Last, most studies that measure the output impacts of imported intermediates on the basis of plant level data, with different estimators, cannot lead to conclude that the results with OLS estimator without tackling endogeneity were systematically under or over-biased. For instance, Halpern et al. (2009), employing all Hungarian manufacturing firms during 1992-2003, got productivity impact of imports of 16.9 percent with OLS estimator, and 17.7 percent with OP estimator following Olley and Pakes (1996), Kasahara and Rodrigue (2008) on the basis of 3598 Chilean manufacturing plants from 1979 to 1996, got productivity impact of imports of 9.6 percent with OLS, 5.8 percent with GMM system, and 14.33 percent with Proxy Estimator.

With the above arguments, it seems reasonable to conclude that the endogeneity is not a serious concern and the suspect that results are significantly biased could be ruled out in this study.

IV. Conclusion

This study used China's 2007 input-output tables and foreign trade data at the province level to test the existence of spillover effects via intra- and international trade analyzed in a theoretical model. It is found that in the less developed regions, intra-national imports rather than internationals imports of equipment inputs made significant contribution to the outputs in the production function. In the developed regions, these impacts are just inversed. These results confirm the existence of a trade network in which mainly the less developed regions benefited from spillovers via intra-national trade, while the developed regions gained this benefit via international trade.

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