Trade and Development Review
Vol. 12, Issue 1-2, 2019, 1 - 22.
http://www.tdrju.net

An Empirical Test on Regional Spillovers through Intra- and Inter-national Trade

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This study aims at providing econometrical evidence to support a theory predicting that in developing countries, 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. Using China's 2007 foreign trade data and provincial input-output tables, the key variables on intra- and international imports of technological inputs are built for estimating their impacts over outputs 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. This result confirms the theory on the existence of the trade network.

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

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

1. Introduction

Within a developing country with huge regional inequality, intra-national trade must play a decisive role for regional development. It can be observed that the developed regions have stronger trade connections with foreign countries, while the less

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developed regions could mainly resort to intra-national trade with the developed regions. This observation gives rise to the necessity to build a theoretical framework enabling to deal with several issues: what is the difference in driving forces of intra-national trade between developing and developed countries? What makes that some regions choose a high share of intra-national trade while others resort to larger extent to international trade? Is the relationship between inter- and intra-national trade substitute or complementary? As technological spillovers are key determinant for regional development, does intra-national trade produces network effects of spillover? These questions, albeit important, lack theoretical modelling and the gathering of empirical evidence.

Intra-national trades could be driven by either comparative advantage or increasing returns and agglomeration. Ohlin (1933) and new economic geography (Krugman [1991a, 1991b]) have respectively described interregional trade on these bases. Even though these approaches have addressed the causes and effects of intra-national trade, they expose serious limitations for extending to the analysis of intra-national trade in developing countries, and an adoption of a technological spillover model is necessary. With these theoretical developments as background, He (2017) builds a dynamic model for analyzing technological spillovers of intra-national trade. It shows that, at the steady-state, 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.

The main drawback of this study is the lack of an econometrical test on the regional technological spillover effects. 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. In the face of this constraint, we reason that the dynamic spillover effects could give rise to an observable result: international imports will have stronger impacts on production in the developed regions than in the less developed regions, and intra-national imports will have stronger impacts in the less developed regions than in the developed regions. This result could confirm the existence of spillovers of intra-national trade.

The term spillover is used here in a very general sense. If, for instance, among the less developed regions, a higher share of intra-national imports of technological inputs allows a significant improvement of their productions, it implies that their imports from more advanced regions enhance their technology. This is an indicator of spillovers. This understanding is in line with most works on North-South spillovers. For instance, Coe et al. (1997) examined the extent to which developing countries that do little, if any, research and development themselves benefit from R&D that is performed in the industrial countries by importing a larger variety of intermediate products and capital equipment.

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 construct the variable of international imports of equipment inputs by province and sector based on foreign trade data, and the variable of intra-national imports of equipment input by province and sector based on 2007 provincial input-output tables. As expected, the estimation results strongly support the theoretical predictions.

This paper is organized as follows: following this introduction, section 2 introduces the background from which the theoretical model is derived and the main predictions of the model to be tested. Section 3 exposes the estimation method. In Section 4, I present the data and the construction of the variables. Section 5 analyzes the results before concluding.

2. Theoretical Background and Issue

This section introduces the main intellectual sources that inspire and support the construction of the theoretical framework on spillovers of intra-national trade, which constitutes the basis for our empirical test. We first present the two types of intra-national trade: the one driven by comparative advantage, and the other driven by increasing returns and agglomeration among regions, and then provide arguments on why the former, albeit its limitations, is more appropriate for a developing economy. Afterward, we explain the necessity for choosing a model of technological spillovers with an expanding variety of intermediates to describe regional development through intra-national trade in developing countries. In the end, we introduce the issue for testing.

As Krugman (2015) puts it, there are two driving forces to intra-national trade: the comparative advantage, and increasing returns and agglomeration. On the one side, Ohlin (1933) on interregional trade is a more general approach that covers at once intra- and inter-national trade. In Ohlin's view, "regions have different factor endowments, while the factors within a region are essentially similar. …it is assumed that the factors of production are inter-regionally immobile but intra-regionally freely mobile." (op. cit., p.5) Each region specializes in the productions for which its factors are relatively abundant and cheap, and then all regions gain from trade than staying in autarchy.

One the other side, a region could be defined as a district à la Tünen in which individuals and firms relocate to where increasing returns are higher (Isard [1956]). In new economic geography, both interregional and international trade are described from the point of view of location theory and agglomeration.

The explanatory power of the new economic geography depends crucially on the extent of possible factor mobility and an agglomeration process to take place. In a developed economy, as factor mobility is high and agglomeration process occurs well, regional disparity becomes endogenous. Exogenous regional disparity refers to what Cronon (1991) distinguishes endogenous inequality from the exogenous one, which he also calls first nature inequalities; there are natural differences in resource endowment, climate feature, and geographical characteristics among regions. In contrast, endogenous, or second-nature inequalities, are the result of human actions to improve upon first-nature inequalities. Combes et al. (2008, p15) claim that the new economic geography is more appropriate to approach to endogenous regional disparity for the developed world.

When applied to developing countries, this approach exposes serious limitations, because in these countries, the industrialization process is relatively new. Conglomeration, which parallels this process, is not yet a major force. Due to the high costs of mobility associated with the backwardness in transport infrastructure and institutional impediments, factor movement, labor, and capital meet serious obstacles.

Ohlin's comparative advantage approach is more apt to characterize the intra-national trade in developing countries, because one of the intrinsic features that distinguish a developing country from a developed one is that while in the former, regional disparity remains wide, in the latter, agglomeration and factor relocation have made it much smaller. Using Krugman's (2015) expression, "America is flat" and "Americans are doing pretty much the same thing everywhere". In developing countries, however, in the absence of consequential agglomeration forces, exogenous regional disparity keeps dominant. This distinction is supported by some well-known studies such as Williamson (1965) which shows that during the development stages of a country, regional disparity tends to be larger and will increase up to a certain point. After this point, it will decrease due to labor mobility that reduces income inequality between regions. More recently, Lessmann (2014) makes use of a unique panel data set of spatial inequalities in 55 countries at different stages of economic development, covering the period 1980-2009, and provides strong support for the existence of an inverted U relationship of within-country regional inequality.

Whereas Ohlin's view accommodates better developing countries, it has a major limitation in dealing with the issue of technological spillovers through intra-national trade. Spillovers on the basis of regional differences in factor endowment are difficultly modeled. On the contrary, as in most developing countries, regional disparity is also in accordance with differences in technology, always keeping the spirit of Ohlin's comparative advantage-based intra-national trade, there is a need to assign it a new form: a technological spillover model.

A vast literature on international technological spillovers provides a spur for our approach (Findlay [1978], Krugman [1979], Dollar [1986], Grossman [1991]). To extend these models to regional analysis, the marked regional disparity within developing countries implies that, first, there is a strong internal technological demand and, second, the less developed regions have a relatively low technological absorption capability. The most important argument justifying intra-national spillovers is technological distance. Fu et al. (2008) have shown that within developing countries, regional technology transfer takes place more effectively when technological distance is small. In connection with this argument, relating to international trade, intra-national trade can be conjectured to offer lower but more appropriate technology and to be less costly in transport and more efficient in technology transfer. This is due to the proximity in language, institutions and culture, and facilities in labor and capital mobility, knowledge communication, and learning and formation.

Two kinds of models have been generally applied to delineate technological spillovers: those with an expanding variety of intermediates, and those of quality ladders. We choose the first approach (grounded on the seminal work by Ethier [1982] and Romer [1990]) for its facility of adaptation to a trade model. Owing to the use of higher technological input, the final products are upgraded in quality, in design, and in variety even without necessarily buying sophistical equipment or changing production process. A stream of econometric papers such as Feenstra et al. (1992), Blalock and Veloso (2007), Fernandes (2007), Kasahara and Rodrigue (2008), and Amiti and Konings (2008) have shown that importing intermediate goods raises productivity via learning, variety, or quality effects.

Grounded on all these theoretical developments, in He (2017), a dynamical model is built 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 and characterized by their differences in number of varieties of intermediate goods at the starting time. There is also a developed foreign country with a technological level higher than all regions in the developing country. A region, as its production is a function of the number of varieties of intermediates, 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 advanced regions or a developed country. Intra-national trade shares of the regions are shown to be endogenously determined in the light of a theory of choice between intra- and international trades. This choice is contingent on the differentials in trade costs and in assimilation costs between intra- and international imports, with the focus on high assimilation costs of new intermediates from foreign trade for the less developed regions. In our approach, the one-to-one dynamical analysis is extended to multiple regions in which their choices on the basis of different technological capabilities lead to the formation of a network connecting inter- and intra-national trades. Within the network, intra-national trade network prolongs the technological spillover effects emanating from international trade, through the advanced regions, to the least developed regions, so that all the partners involved in the trade network, originally with various growth rates, reach the highest growth rate benefited initially by the foreign country.

The main result of the model is that regional spillovers occur within the trade network in which regions choose to import technological inputs from the regions (or the foreign country) 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. Even though in the beginning, the less developed regions have low growth rates, the highest growth rate benefitted by the foreign country will be transmitted to all levels of the trade network.

The above theoretical results give rise 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 Prediction 2.

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 intra-national spillover effects, in a strict sense, requires panel data with multiple periods and various trade levels. The best way to test the spillover effects will be employing the panel data covering a period enough long and a number of regions of different development levels. Nevertheless, 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 choose an alternative way that does not require time series database.

Given the objective is to find the evidence of the spillovers via intra-national trade for the less developed regions, and the spillovers via international trade for the more advanced regions, our econometric test is guided by the following reasoning. If among the less developed regions, a higher share of intra-national imports of equipment allows some regions improving their production relating to the others keeping a low share of these imports, this is a proof of the existence of intra-national spillovers. The same reasoning applies to the international imports of equipment by the advanced regions. This result could confirm the Prediction 2.

Therefore, in the following sections, we first derive an econometrically testable equation of production function including distinct intra-national and international imports of technological inputs. Then, for our test, we construct the variable of international imports of equipment inputs by province and sector based on foreign trade data, and the variable of intra-national imports of equipment input by province and sector based on 2007 provincial input-output tables.

3. 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. The key idea guiding our empirical tests is to check the differences in effects of international and intra-national imports of technological inputs over output in three regions, respectively. In other words, total sample will be divided into three sub-samples, and the regressions will be made with them separately.

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

$$Y_{ih} = AK_{ih}^{\beta_k} L_{ih}^{\beta_l} [\theta Ee_{ih} + Ea_{ih}]^{\beta_x} \qquad (1)$$

where, *Y*, *K*, *L*, are respectively output, capital and labor. The last term concerns technological inputs, with Ee_{ih} and Ea_{ih} refer to international imports and intra-national imports of technological input, respectively. θ is a parameter reflecting the extent to which international imports of technological input is different to intra-national imports of technological input in technological content. 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.

In logarithm form, Equation (1) becomes

$$lnY_{ih} = lnA + \beta_k lnK_{ih} + \beta_i lnL_{ih} + \beta_x ln[\theta Me_{ih} + Ma_{ih}] \qquad (2)$$

The last term is dealt with using linear expansion around $Me_{ih} = a_i$ and $Ma_{ih} = b_i$ in which a_i is set as the mean value of international imports of technological input by sector across 30 provinces, and b_i is the mean value of intra-national imports of technological input by sector across 30 provinces. This term becomes

$$\beta_x[ln(a_i + \theta b_i) - 1] + \beta_x \frac{\theta b_i}{a_i + \theta b_i}\frac{Me_{ih}}{a_i + b_i} + \beta_x \frac{b_i}{a_i + \theta b_i}\frac{Ma_{ih}}{a_i + b_i} \qquad (3)$$

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

$$lnY_{ih} = lnA + \beta_k lnK_{ih} + \beta_i lnL_{ih} + \beta_{xe}\frac{Me_{ih}}{a_i + b_i} + \beta_{xa}\frac{Ma_{ih}}{a_i + b_i} + \varepsilon_{ih} \qquad (4)$$

Thus $\frac{Me_{ih}}{a_i + b_i}$ and $\frac{Ma_{ih}}{a_i + b_i}$ are the shares of international and intra-national imports of technological inputs by province and sector in $a_i + b_i$, respectively.

Intuitively, to be able to affirm positive trade spillover effects, two outcomes are required. 1) Intra-national imports of technological input have a statistically significant positive impact to the output for the less developed regions whereas they are insignificant for the developed regions; 2) International imports of technological input have a statistically significant impact to the output for the developed regions whereas they are insignificant for the less developed regions. These results could confirm Prediction 2.

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 technological input must be larger for the developed regions than for the less developed regions, and the coefficient of intra-national imports of technological input must be larger for the less developed regions than for the developed regions.

4. Data and Construction of the Variables

In total, there are input-output tables of 30 provinces with 42 sectors: 26 industrial sectors (including 17 manufacturing sectors, in which there are 6 equipment sectors), 15service sectors, plus agricultural sector. [1]

Based on these provincial 2007 input-output tables and 2008 statistic yearbooks (containing 2007 data), we provide some descriptive statistics on Chinas inter- and intra-national trade and their distribution among the three grand regions. In 2007, China's intra-national trade (defined as inter-provincial trade volume, without taking into account of intra-provincial trade) account to 72.69% of the GDP, more than 2.21 times of foreign trade. Intra-national imports of manufactured products account to 1.91 times of international imports of manufactured products. Intra-national imports of equipment products were 1.42 times of international imports of equipment products. These numbers indicate the crucial importance of intra-national trade for such a country like China, albeit with high international openness.

The apportionment of inter- and intra-national imports is highly unequal. On international manufacturing imports, the shares were 91.09%, 6.13%, and 2.78% for the Coastal, Central and Western regions, respectively. Their shares on intra-national

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

manufacturing imports were 55.34%, 26.38% and 18.28%, respectively. These numbers indicated that while foreign trade is largely concentrated in coastal region (due to the central role of Chinese coastal region as "world factory"), intra-national trade is relatively more important for the less developed regions. The less developed regions have larger dependence on intra-national equipment imports. The net intra-national imports of equipment were -51.7, 91.4 and 87.6 billion USD for the three regions, respectively. Only the Coastal region is net exporter to other regions while the less developed regions are net importers.

Based on these provincial input-output tables and statistic yearbooks, we built all the variables for testing Equation (4) defined in Table 1. Afterward we introduce one by one their construction.

Table 1
The definitions of the variables

Variable name	Definition
Lnoutput	The output by province and sector in logarithm form.
Lncapital	Returns to capital by province and sector in logarithm form are used as the proxy of capital.
Lnlabor	Compensation of employees by province and sector in logarithm form is used as proxy of labor.
Rate_inter_equip	The share of international imports of equipment by province and sector in $a_i + b_i$ defined in note (4) of this table.
Rate_intra_equip	The share of intra-national imports of equipment by province and sector in $a_i + b_i$ defined in note (4) of this table.

Notes: 1) international imports of equipment goods are calculated based on 2008statistic yearbooks of the provinces; 2) intra-national imports of equipment 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 are specified as inter-provincial imports without intra-provincial imports included; 4) a_i is set as the mean value of international imports of equipment input by sector across 30 provinces, and b_i is the mean value of intra-national imports of equipment input by sector across 30 provinces.

Lnoutput is based on the output by province and sector that are found in all input-output tables. To build *Lncapital*, capital is surrogated by capital returns that are composed in three terms in input-output tables: net taxes on production, operating surplus, depreciation of fixed capital. For *Lnlabor*, labor income, used as labor inputs, is reflected by the item: compensation of employees. 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 valued according to their marginal productivities (capital price is the present values of the net cash flows), these items provide a convincing measurement of these inputs. One advantage of this method is that these values incorporating the differences in wage and capital returns as proxies reflect better regional disparity on capital and labor, because, labor amount in quantitative terms are comparable, but highly unequal in qualitative, or human capital term among the regions.

In what follows, the issue is how to construct the two last explanatory variables. The first Chinese provincial input-output tables were published in 2002. In 2007, for the first time, 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 can be found in the statistic yearbooks 2008 of these provinces, "inflow" is potentially usable for constructing the inter- and intra-national imports variables.[2]

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.[3] 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 appropriate for testing the impact of the imports motivated by enhancing technological capabilities. Instead, we choose to make our test with the

[2] 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, for example, applying the model for forecasting purpose.

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

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.

Based on available data on equipment imports from the statistic yearbooks 2008 of 30 provinces and of the equipment inflows from the input-output tables 2007 of 30 provinces, we must find some methods to apportion the intra- and internationally imported equipment goods among sectors within the same province. We leave the detailed presentation on methods of estimation in the Appendix. With these estimations, we get 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). Instead of testing the impact on 42 sectors, we merely test the impacts on 26 industrial sectors and 17 manufacturing sectors. In other 15 service sectors and the agricultural sector, the imported equipment inputs are either absent or very weak. Therefore, it would not be pertinent to test the impact of imported equipment in these sectors.

In Table 2, only the descriptive statistics of industrial sectors are presented. It can be observed through *Rate_inter_equip* and *Rate_intra_equip* that albeit 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.

Our one-year data is a panel of two dimensions: province and sector. Applying pooled ordinary least squares to panel data 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. Sectoral fixed effects are important, while as provinces are clustered into three grand regions according to their development levels, within one region, province fixed effects must be less important. Therefore, group variable is set as sector. On the choice between the fixed-effects (FE) and random-effects (RE) models, Hausman tests favor the former. Therefore, the fixed-effects (within) regressions are chosen.

Table 2
Descriptive statistics of the variables (industrial sectors)

	Coastal region Obs. 250		Central region Obs. 228		Western region Obs. 280	
	mean	S.D	mean	S.D	mean	S.D
Lnoutput (lnY_{it})	15.291	2.011	14.736	1.535	13.471	1.919
Lncapital (lnK_{it})	13.566	1.973	13.150	1.578	11.980	1.915
Lnlabor (lnL_{it})	12.583	2.023	12.348	1.568	11.183	1.911
Rate_inter_equip	0.638	0.534	0.271	0.272	0.082	0.183
Rate_intra_equip	0.936	1.594	0.690	0.960	0.422	0.610

Notes: 1) international imports of equipment goods are calculated based on 2008 statistic yearbooks of the provinces; 2) intra-national imports of equipment 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 are specified as inter-provincial imports without intra-provincial imports 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 11 provinces in Western region (with Tibet being ruled out); 5) the definitions of the variables are made in this section.

5. Results and Analysis

Table 3 presents the regression results for three grand 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 large, signifying that the individual effects of sectors are strong, and panel estimators are better than pooled estimators. With 26 industrial sectors, the observation numbers are 250, 228, 280 for three regions, respectively. With 17 manufacturing sectors, the observation numbers are 169, 151, 184 for three regions, respectively.

Table 3
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	0.670***	0.550***	0.554***	0.687***	0.555***	0.555***
	(0.0359)	(0.0307)	(0.0931)	(0.0463)	(0.0376)	(0.125)
lnlabor	0.286***	0.397***	0.340***	0.272***	0.398***	0.321**
	(0.0262)	(0.0339)	(0.104)	(0.0320)	(0.0429)	(0.136)
Rate_inter_equip	0.174***	0.122**	0.0806	0.169***	0.0552	0.276
	(0.0330)	(0.0589)	(0.176)	(0.0336)	(0.0712)	(0.324)
Rate_intra_equip	0.00686	0.00838	0.175***	0.00680	-0.0191	0.216***
	(0.0109)	(0.0274)	(0.0376)	(0.0114)	(0.0648)	(0.0661)
_cons	2.482***	2.562***	2.960***	2.544***	2.618***	3.244***
	(0.252)	(0.307)	(0.540)	(0.312)	(0.356)	(0.760)
Wald chi2(7)	2470.92	470.94	419.78	2361.59	459.05	178.48
(prob<chi2)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R-sq						
(within	0.9724	0.9359	0.9002	0.9816	0.9371	0.8703
between	0.9471	0.9529	0.9583	0.9354	0.9774	0.9852
overall)	0.9611	0.9474	0.9296	0.9693	0.9565	0.9246
Rho	0.5762	0.5315	0.4007	0.5320	0.3318	0.2574
N	250	228	280	169	151	184

Notes:1) international imports of equipment goods are calculated based on 2008 statistic yearbooks of the provinces; 2) intra-national imports of equipment 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 are specified as inter-provincial imports without intra-provincial imports 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 11 provinces in Western region (with Tibet being ruled out); 5) the definitions of the variables are made in section IV; 6) fixed-effects (within) regressions are made with sector as group variable with 26 industrial sectors and 17 manufacturing sectors; 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 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.[4] For Western region, intra-national imports of equipment inputs had significant positive effects. In contrast, international imports of equipment inputs were not positively significant. The impact of intra-national imports of equipment input was stronger in manufacturing sectors than in industrial sectors. For Central region, while based on 26 industrial sectors, the international imports of equipment inputs are significant at the 5% level, based on 17 manufacturing sectors, this significance disappears, indicating that the impacts of these inputs were weaker for Central region than for Costal region. This is also in concordance with the theoretical prediction.

To summarize, 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 based on 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

[4] The coefficients of *Rate_inter_equip* and *Rate_inter_equip* cannot be interpreted in the same way relative to the coefficients of the other variables. According to Equations (2) and (3), the former is not comparable to the latter.

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 province-level data, instead of 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 based on 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.

6. 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.

Appendix

The method of apportioning international and intra-national imports across sectors

The first task is to approximate the international equipment imports by sector and province, because we have these data by province, but not by sector. 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 internationally imported equipment input by province. Second, the obtained internationally imported equipment inputs are apportioned among the 42 sectors according to the shares of their equipment inputs in the total equipment inputs of the province.[5]

Based on provincial input-output tables, we are able to compute the equipment inflow by province. Its repartition by sector must also be estimated. First, using the ratio: the equipment input/(equipment input + final consumption of equipment) at the

[5] 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).

province level, 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

$$(Equipment\ inflow\ as\ inputs)_h = \sum inflow\ as\ inputs_j * (input\ weight)_{hj} \qquad (5)$$

where, $(input\ weight)_{hj}$ is the sector *h*'s share in the *j* inputs of the province.[6]

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

Based on these estimated internationally and intra-nationally imported equipment inputs by sector and province, we are able to calculate the *Rate_inter_equip* and *Rate_intra_equip* defined in Equation (4).

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