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ESTIMATING CHINESE INTERPROVINCIAL OUTPUT SPILLOVERS WITH PROVINCIAL INPUT-OUTPUT TABLES

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Abstract. This paper aims at estimating productivity improvement of Chinese 17 relatively backward provinces in manufactures through importing manufactured intermediates from advanced provinces on the basis of just published 2002 national and provincial input-output tables. As Chinese regional inequality remains large, North-South spillover models of trade are appropriate to guide this study. Applying reliable methods to approximate net interprovincial imports by province and sector and the allocation of imported manufactured inputs among sectors within each province, we use a Cob-Douglas production function incorporating Dixit-Stiglitz type increasing returns to variety to deal with the manufactured inputs, and treat the output spillovers as one part of total factor productivity. According to our estimations, as expected, interprovincial imports of manufactured inputs have significant impacts on industrial sectors as well on all sectors of these provinces.

Key Words: Chinese interprovincial trade, North-South spillovers, input-output tables, regional inequality, imported intermediates.

JEL Classification: O14, O18, R11, R15.

1. INTRODUCTION

In most models on North-South spillovers (Findlay, 1978; Krugman, 1979; Dollar, 1986; Grossman and Helpman, 1991), through FDI, trade and migration, technological transfers occur and the technologically backward countries catch up with the developed countries and thus their gap tends to be narrowed. Owing to its open-door policy, China's remarkable development performance has been one of the best examples of the North-South spillovers. These international spillover effects on China have been extensively studied through the impacts of FDI (to cite some papers with their different views on these impacts, Cheung and Lin, 2004; Liu, 2007; Hale and Long, 2007; Lin *et al.*, 2009). Another line of thoughts: spillover effects via human capital in China, also gives rise to interesting work (Kuo and Yang, 2008; Fleisher *et al.*, 2010).

These models of North-South spillovers also have a direct implication into Chinese regional development. As a large-sized country, China has 30 provinces and municipalities directly under the jurisdiction of the Central Government. These provinces and municipalities are conventionally classified into three large regions: the coastal region, the central region and the western region. One factor that explains both China's development dynamism and its difficulties is its increasing regional inequality (Kanbur and Zhan, 2005). The coastal region is the most developed and the main exporter of China to the world. It is followed by the central region, and the western region is the less developed. Although the Central Government retains political control over the regions, due to their variations in terms of geography, competitive advantage and economic priority, and some other factors, decision-making powers for major policies are shifting to the local governments. The provinces are becoming economic and political agents with their own economic and social agendas and distinct political and cultural identities (Hendrischke and Feng, 1999). Viewing from this perspective, conventional international economics is fairly applicable to Chinese interprovincial trade.

However, only a handful of work has directly devoted towards the topic of Chinese interregional spillovers. Ying (2000) used spatial data analysis to show growth correlations between Guangdong and four of the five contiguous provinces. Zhang and Felmingham (2002) addressed to the issue of relationship between exports, FDI and growth and find evidence of spillovers from the Coast to the West. Brun *et al.* (2002) asked the question of growth convergence and find evidence of spillovers from the Coast to the Centre. Groenewold *et al.* (2008) used a vector autoregressive (VAR) model with six regions as a framework for dynamic simulation of the effects of a shock to one region on the other regions. Finally, another work that is noteworthy is National Information Center (2005). In collaboration with Japanese IDE, they built Chinese 8 regions input-output table of 1997 and calculated interregional industrial multipliers incorporating backward and forward linkages on the basis of Rasmussen (1956).

This paper uses 2002 Chinese national and 30 provincial input-output tables to estimate impacts of imports of manufactured intermediates from advanced provinces on productivities of relatively backward provinces in manufactures. To our knowledge, there has not yet been any study using the same approach to this issue. Its originality lies in four points: (1) while most previous studies put stress on spillover effects of FDI and human capital in China, this paper deals with the trade impact, and specifically interprovincial trade impact; (2) while previous studies were either on regional impacts (among six to eight regions in the earlier cited papers) or impacts of some individual provinces on others, our study uses total provincial input-output data to measure the overall output impacts; (3) methodologically we adopt a new approach from North-South spillover literature: the improvement of production performance of less developed countries or regions through the imports of intermediate goods; (4) this study on the basis of the just issued 2002 provincial input-output tables is an attempt to measure the most updated overall output spillover effects in China.

Given that in this work our task is to measure the interregional output spillover impacts, one might be wary if the results on the basis of 2002 data are at the risk of being out-of-date, since after 2002 China's GDP has largely increased and in particular exportation performance have been significantly enhanced. We argue that the purpose of this study being the technological impact of advanced provinces on backward provinces, and there is no evidence that since 2002, the balance of power in term of economic development among these provinces has significantly evolved. This fact is showed in table 1 with the relative weights of three regions in terms of GDP and of net outputs of three industries of the three regions. Our study helps to quantitatively measure the impact of interprovincial trade on backward regions, in particular on western region. Although measured on the basis of 2002 data, these impacts should persist to now given the basic structure of regional development in China keeps unchanged.

Table 1 inserted here

This paper is organized in the followings: Section 2 presents some descriptive statistics of Chinese interprovincial trade. Section 3 consists of the most important part of the paper. It first lays out the theoretical framework of the spillover effects of importing intermediate goods and exhibits the estimation methodology. Second, it presents the data and the methods to approximate (1) the international net exports and interprovincial net exports by province and sector; (2) the allocation of manufactured inputs imported from other provinces among sectors within each province. At last, before concluding, it shows the regression results and discusses the findings.

2. SOME FEATURES OF CHINESE INTERPROVINCIAL TRADE

There exist few statistics on Chinese interprovincial trade. According to Poncet (2005) from provincial IO tables, domestic trade was large but declining over the period 1992–97. Average Chinese interprovincial imports amounted to 50% and 38% of GDP, respectively, and interprovincial trade made up 80% and 66% of total trade in 1992 and 1997. The value of interprovincial trade in China increased between 1992 and 1997, yet at a lower rate than GDP, international trade or intra-provincial trade.

The 2002 provincial input-output tables do not allow us to draw a direct comparison with Poncet (2005), since in these tables, there are only the items “net-offs” that merge international net exports and interprovincial net exports, and the distinct importation and exportation values are absent. From websites, we found three provinces, Fujian, Anhui and Gansu, having provided 2002 input-output tables with some information on distinct importation and exportation. They are three provinces fairly representative of coastal, central and western regions, and thus are of interest for an assessment of national-level state. From the first half of table 2 on all sectors, we observe that, (1) the ratios of overall trade (defined as the sum of international plus interprovincial imports and exports) to GDP were 32.3% for Fujian, 75.6% for Anhui, and 42.8% for Gansu, and thus it is likely that these ratios are not just a linear function of development level, and are also determined by each province’s endowments of natural resources; (2) the “net-offs” in absolute value seem to be primarily determined by development level, since among them, Fujian is the largest net exporter, followed by Anhui, and Gansu is net importer; (3) the volume of interprovincial trade is significantly larger than international trade, and Anhui’s case reveals that interprovincial trade represents more than 90% of overall trade.

Table 2 inserted here

The second half of table 2 provides the same information of these provinces for manufacturing sectors. Relating to those for all sectors presented in the first half of table 2, the overall trade-output ratio of Fujian increased to 54%, that of Anhui to 130.1%, and that of Gansu to 98.9%. They confirm that the trade in manufactured goods was much more important. The overall net manufactured exports are also an increasing function of development level.

Table 3 is based on our calculations with 2002 national and provincial input-output tables. In the next section, the weighting methods with which we got provincial level international and interprovincial net exports by sector will be presented. table 3 reveals that (1) coastal region is the main exporter of manufactured goods to the world and also to other provinces; (2) all three regions are international net importers of agricultural goods and raw materials and central and western regions are also net importers of manufactured goods (it is likely that this situation is specific to 2002 and may have had some changes since then); (3) on interprovincial trade, the prevailing mode is that western region exports agricultural goods and raw materials and imports manufactured goods from coastal region, and central region was interprovincial net exporter of all three types of goods; (4) western region's interprovincial net imports of manufactured goods are almost ten times larger than international net imports, signifying that Chinese relatively backward provinces mainly relied on domestic trade to fill their technological gap in that period.[1]

Table 3 inserted here

3. ECONOMETRIC ESTIMATIONS

3.1. Methodology

In general, technology spillovers occur through three channels: (i) imitation, (ii) linkage, and (iii) workers' mobility (Sawada, 2010). Here we focus on one aspect of linkage: the

[1] Note that the sum of the three regions' interprovincial net exports is not zero since they also include the intraregional trade.

importation of intermediate goods. 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 equipments or changing production process. There are many examples in the real world of this kind of innovation: just by changing one or several components, a product is improved. Blalock and Veloso (2007) have provided a typical case: a shoe producer switches to imported leather because its better malleability and allows the creation of more intricate shapes, enabling the production of shoes with greater value added. A stream of papers has econometrically shown that importing intermediate goods raises productivity via learning, variety or quality effects (Feenstra *et al.*, 1992; Fernandes, 2007; Kasahara and Rodrigue, 2008; Amiti and Konings, 2008).

One of the methods to incorporate the use of higher technological inputs is to treat it as increasing returns of variety through enlarging the range of intermediate goods. Here we follow Kasahara and Rodrigue (2008) with adaptations. Consider a provincial sectorial production function

$$Y_{ih} = e^{\beta_0} e^{\omega_{ih}} K_{ih}^{\beta_k} L_{ih}^{\beta_l} R_{ih}^{\beta_r} S_{ih}^{\beta_s} [\int_0^{N(d_{ih})} x(j)^{\frac{\gamma-1}{\gamma}} dj]^{\frac{\beta_x \gamma}{\gamma-1}} \quad (1)$$

Y is the province h's output of sector i. K, L, R and S are respectively capital, labor, raw material and energy, and service inputs. The last term is the manufactured intermediate goods that enjoy increasing returns of variety. X_{ih} is a composite input consisting of horizontally differentiated manufactured intermediate goods *x*(*j*) of variety *j*. $\gamma > 1$ reflects the elasticity of substitution between any two intermediate goods. The variable $N(d_{ih})$ denotes the range of manufactured intermediate inputs employed in the sector i and province h. d_{ih} is the sector of province h's discrete choice to import from other provinces or not.

$$N(d_{ih}) = \begin{cases} N_d, & for\ d_{ih} = 0 \\ N_f, & for\ d_{ih} = 1 \end{cases} \quad (2)$$

Where N_d is the range of the manufactured intermediate goods produced in the own province. N_f is the range of the manufactured intermediate goods after importing from other provinces. Assuming for relatively backward provinces, there are a range of inputs that exists in other provinces but not in own province, through imports, therefore, $N_f / N_d \geq 1$.

In equilibrium, all manufactured intermediate goods are symmetrically produced at level $\bar{x}$. Substituting x(j)=$\bar{x}$ into the equation (1) leads to

$$Y_{ih} = e^{\beta_0} e^{\omega_{ih}} N(d_{ih})^{\frac{\beta_x}{\gamma-1}} K_{ih}^{\beta_k} L_{ih}^{\beta_l} R_{ih}^{\beta_r} S_{ih}^{\beta_s} X_{ih}^{\beta_x} \quad (3)$$

where $X_{ih} = N(d_{ih})\bar{x}$. Following the equation (3), total factor productivity (TFP) is measured by

$$A_{ih} = \frac{Y_{ih}}{K_{ih}^{\beta_k} L_{ih}^{\beta_l} R_{ih}^{\beta_r} S_{ih}^{\beta_s} X_{ih}^{\beta_x}} \quad (4)$$

Then from equation (3),

$$lnA_{ih} = \beta^0 + \frac{\beta_x}{\gamma-1}\ln\left(N(d_{ih})\right) + \omega_{ih} \quad (5)$$

Equation (5) implies that the TFP is positively linked with the range of manufactured intermediate goods. Those provinces that import intermediate goods from other provinces have higher TFP than those provinces that only use their own manufactured intermediate goods. Assuming ω_{ih} is the same before and after importing manufactured intermediate goods across all sectors of all provinces, then $lnA_{ih}(1,\omega) - lnA_{ih}(0,\omega) = \frac{\beta_x}{\gamma-1}\ln[{}^{N(1)}/_{N(0)}] > 0$.

With this relation, we may use the ratio of total manufactured intermediate goods (own produced plus imported from other provinces) to own produced manufactured intermediate goods to measure the impacts of interprovincial imports of manufactured inputs, since

$$\frac{X_{ih}}{X_{ih}^d} = \frac{N(1)\bar{x}}{N(0)\bar{x}} = \frac{N(1)}{N(0)} \quad (6)$$

where X_{ih} is total manufactured intermediate goods and X_{it}^d is own produced manufactured intermediate goods by the province.

Thus from equations (3), (5), (6), we can use the following econometric specification to measure the impact of importing manufactured intermediates from other provinces on productivity.

$$y_{ih} = \beta_0 + \beta_n n_{ih} + \beta_k k_{ih} + \beta_l l_{ih} + \beta_r r_{ih} + \beta_s s_{ih} + \beta_x x_{ih} + \omega_{ih} + \varepsilon_{ih} \quad (7)$$

where $n_{ih} = ln[{}^{N(1)}/_{N(0)}]$, $k_{ih} = \ln K_{ih}$, $l_{ih} = lnL_{ih}$, $r_{ih} = lnR_{ih}$, $s_{ih} = lnS_{ih}$, and $x_{ih} = lnX_{ih}$. The equation (7) will be estimated with 2002 input-output data.

3.2. Data

From National Bureau of Statistics (2008), we get the 2002 input-output tables of 30 provinces and the national 2002 input-output. From them, most variables are available. The labor income reflected by the item: compensation of employees is used as labor input, and the capital returns are used as capital input and are reflected by the sum of three items: Net taxes on production, operating surplus, depreciation of fixed capital.[2] Thus we get all data necessary for estimating the equation (7) except the net interprovincial manufactured imports from other provinces by sector and province.

In provincial input-output tables, there are only the items "net-offs": the net overall exports by sector that comprises net international exports plus net interprovincial exports, and there are not published data with distinct provincial-level imports and exports by sector. The first task, therefore, is to approximate the net international exports by sector and province in order to get their corresponding net interprovincial exports.

To estimate the net international exports by sector and province, we must find a method to partition the national net international exports in the national input-output table into provincial-level net international exports by sector. A logical way to apportion the national net exports towards the foreign countries among the provinces will be to use two weights: (1) the shares of output of the provinces in the national total output by sector; (2) the shares of input of the provinces in the national total input by sector. The export performance of a province is a function of its production performance, thereby being proportional to the share of its output in national total output. The second weight is also of interest because it reflects the "net" productive capability of the province. For instance, Beijing may have higher export potentiality with its output weights. However since, due to its population size and its predominant administration and service sectors, its outputs are to larger extent than other provinces to satisfy its final consumptions, measuring its export potentiality with input weights seems to be more appropriate. Another reason for the choice of two weights is that we get two substitutable and comparable variables and thus increase the robustness of the estimations.[3]

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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 weighting method has been generally used in the estimation of multi-regional trade relationship (cf. e.g., National Information Center, 2005, p.20). Another method National Information Center (2005) has used is employing unpublished data on province-level imports and exports from Chinese Customs. This method, however, has a lot of limits. First, these data are required to be very complete. Second, these data being recorded by product, they are required to be reclassified according to the sector classification in 2002 provincial input-output tables. Last, for the imports and exports of the

After having the estimated net international exports by sector and by province, we get the net interprovincial exports by subtracting the calculated net international exports from the net-offs by sector and province. Then since we only consider the impacts of the imports of manufactured goods from other provinces, we sum up interprovincial net exports of 16 manufacturing sectors by province, and thus enable to distinguish the net importers and exporters among provinces. Also since only the spillover impacts on relatively backward provinces that imported are considered, we drop the provinces that were net interprovincial exporters and only keep those provinces of which the calculated net interprovincial manufactured exports are equal or less than zero.

With this method in total 17 provinces are kept in the sample, with two of coastal region (Beijing and Hainan), five of central region (Shanxi, Jilin, Heilongjiang, Anhui and Jiangxi) and finally all provinces of western region except Guangxi (which was interprovincial net exporter) and Tibet (IO table absent). The two from coastal region and the five from central regions are all among the less developed in terms of their manufactured output in these regions. One might query why Beijing has been included in this list composed mostly of relatively backward provinces. At first, we have objectively applied some coherent criterion and feel unable to make exception to Beijing. At second, it is a fact that Beijing's manufacturing sectors are on average relatively weak in comparison with its other sectors, in particular with services, and also in comparison with most provinces classified in coastal region. At third, because of its political status and its population level, its final demands on manufactured goods are excessively stronger relating to its production capability. Table 4 shows the calculated interprovincial imports of manufactured goods with two weights (n_imanu_wo is those with output weight and n_imanu_wi with input weight) and their distributions among the 17 provinces classified in three regions. We observed that as expected, western region received a largest share of these imports. Presumably, these imports by coastal region are in large majority for Beijing rather than for Hainan, and a sizeable share of them is destined to final consumption.

Table 4 inserted here

service sectors the Customs data are absent, other approximating methods are always required. In the face of these constraints, we prefer to use the first method for our estimations.

Lastly, to measure the impact of these manufactured imports to importing provinces, we must find a reasonable way to estimate the distribution of these manufactured imports among different sectors within each province, since without resort to approximating method there is any other way to get this kind of information. To do this, we use the share of manufactured input of each sector in total manufactured input used within each province as weights to apportion the interprovincial manufactured imports as inputs among the sectors. For a given province, with the proportion of the inputs used by all sectors to the final demands of manufactured goods, we take out the part of these imports destined to consumption, and then the rest will be shared as inputs among the sectors proportional to their share of manufactured inputs in the total manufactured inputs of the province. For example, suppose Sichuan's textile sector uses a share of 0.05 of manufactured input in Sichuan's total manufactured input of all sectors, 5% of net interprovincial imported manufactured input will be distributed to its textile sector. With this method we get the calculated net interprovincial manufactured imports of 41 sectors of 17 provinces (among the 42 manufacturing sectors in the used input-output tables, the sector "Scrap and waste" is dropped due to missing values).

Table 5 presents the descriptive statistics of all variables necessary for the estimation of the equation (7). Ratio_imanu_wo and ratio_imanu_wi are respectively the calculated ratios of total to own produced manufactured inputs with output and input weights. With logarithm form they are n_{ih} in the equation (7). Some sectors have missing data or with negative values, hence treated as missing in logarithm form. In total 692 observations of 41 sectors are obtained. We also provide the statistics for 23 industrial sectors (41 sectors less 17 service sectors less agriculture), since the impacts of interprovincial manufactured imports on the productivities of the industrial sectors of these 17 provinces will be estimated. Among the 17 importing provinces, 10 are of western region and the descriptive statics of their corresponding variables are also presented.

Table 5 inserted here

From table 5, we note that: (1) for the 17 provinces that imported manufactured goods from other provinces and the 10 western provinces comprised in the 17 provinces, their means of output, capital and labor incomes, and service of all sectors are larger than these means of industrial sectors, while the means of raw material and energy, manufactured input and the ratios of total to own-made inputs of all sectors are larger than their corresponding means of industrial sectors; (2) for the means of all chosen variables, those of 10 western provinces are smaller than those of the 17 provinces, reflecting the differences of these indicators between the coastal and central regions on the one side and the western region on the other side.

3.3. Results and analysis

In what follows, table 6 presents the regression results with all sectors and with industrial sectors of all 17 importing provinces, and table 7 with all sectors and with industrial sectors of 10 importing western provinces.

In table 6, the difference between the columns (1), (3) and the columns (2), (4) is that the first two columns use the ratios of total to own produced manufactured inputs with output weight, and the second two columns use these ratios with input weight. The difference between the columns (1), (2) and the columns (3), (4) is that the first two columns use the observations of all regions while the second two columns only use those of industrial sectors. The numbers of observation in both tables 6 and 7 are smaller than those described in table 5 due to zero or negative values of some explanatory variables that in logarithm form are transformed in missing values.

What we are interested the most are the coefficients of the two ratios: ln_ratio_imanu_wo and ln_ratio_imanu_wi. We find significant output impacts of them, varying from 0.184 to 0.189 and implying that the increase of 1% of these ratios increased more than 0.18% productivity of all sectors of these provinces. These impacts (including the those of these ratios for industrial sectors of Western provinces that will be presented later in table 7 reaching as high as 0.352) seem unusually high. Recall, however, that they are defined as the ratio of total manufactured intermediate goods (own produced plus imported from other provinces) to own produced manufactured intermediate goods. These impacts can be easily converted as the output impacts of 1% increase of interprovincial imports of manufactured inputs. Referring to table 5 in which ln_ratio_imanu_wo and ln_ratio_imanu_wi are in average around 1.22 for all sectors and 1.26 for industrial sectors, the 0.189 and 0.352 mentioned above respectively correspond to 0.034% and 0.073% of output impacts of 1% increase of interprovincial imports of manufactured inputs.

The output impacts for industrial sectors are weaker and the coefficients are respectively 0.164 and 0.159. The robust t ratios are significant at 1% for first two and at 5% for the last two results.

Table 6 inserted here

Why are the output impacts of manufactured imports for industrial sectors weaker than those for all sectors? Since 10 of the 17 importing provinces belong to western region, one hypothesis we could put forward is that the inequality between the advanced and backward regions is narrower in industrial sectors than in the other sectors, in particular in service sectors. Since Mao's epoch China has followed big push industrialization and Maoist model was essentially characterized by pervasive militarization of the economy, the encouragement of rural industries, and relative autarky vis-à-vis to the outside world, and regions within China were expected to achieve as much self-sufficiency as possible (Naughton, 2007, p.76). All these may have favored the creation of autonomous industrial system within each province. In other sectors, however, especially in services, the gap between the advanced and backward provinces remains larger. The impacts of manufactured imports from advanced provinces could produce stronger catching-up effects in the sectors other than industries.

To test this hypothesis, we must check the output impacts of interprovincial imports of intermediate goods in all sectors and in industrial sectors for 10 western provinces. If they follow the same tendency, this hypothesis may be confirmed. The results are presented in table 7. The differences among the four columns are exactly the same as table 6. From columns (1) and (2), these impacts for all sectors were stronger than those for 17 provinces, varying from 0.226 to 0.236, proving that interprovincial technological spillover effects were stronger for western provinces than for other importing provinces. Another outcome is, however, different from that with the sample of 17 provinces: these impacts were stronger for industrial sectors than for all sectors. The coefficients of the ln_ratio_imanu_wo and ln_ratio_imanu_wi for industrial sectors are respectively 0.352 and 0.341, indicating that the rise of one percent of these ratios increased more than 0.3 percent in productivity of the western provinces (recall that converted into output impact of 1% increase of interprovincial imports of manufactured inputs, they are around 0.07%). The robust t ratios are significant at 1%. These results lead us to reject the hypothesis put forward above. The only alternative explanation seems to be that the productivities of the other sectors of the seven importing coastal and central provinces were to larger extent improved than their industrial sectors by their interprovincial manufactured imports. This assertion makes sense since their industrial technology gap with the highest technology provinces is narrower than this gap for the western provinces.

Table 7 inserted here

Finally, one important question on the validity of the above estimations is: In the above OLS estimations, should we suspect the presence of endogeneity? 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 the use 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 the international exports shocks as unobservable variable in error term may be correlated with the interprovincial imports of manufactured intermediates. In both cases, one of the conditions for unbiased and consistent estimation by OLS estimator is violated.

In most previous work on the measurements of the impacts of intermediate inputs on productivity, panel data are used to deal with the endogeneity problem. Tow-period data are 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) are employed to compare with OLS estimator. Here we only have one-year data and need to show that OLS estimation makes sense. Here we defend our OLS approach from three points of view.

First, unlike the previous studies exclusively on the basis of plant data, our data are at province level, and in China economic growth rates among provinces are unusually synchronized. In 2002, the mean growth and the coefficient of variance (SD/mean) among the 17 importing provinces were respectively 10.04% and 0.1222 for 17 importing provinces, and 10.01% and 0.1443 for 10 western provinces. Industry growth rates were slightly more divergent. Measured approximately in growth rate of secondary industry, the mean growth and the coefficient of variance (SD/mean) were 12.58% and 0.2302 for 17 importing provinces, and 12.80% and 0.2135 for 10 western provinces. Even though the growth rates by sector were likely to be more variant than GDP and average industrial growth rates among provinces, their variances, shaped by the latter, might be quite limited. Thus we can assume that productivity shocks on interprovincial manufactured imports, even existing, were more likely to be weak.

Second, as mentioned, another source of endogeneity may be that in unobservable error terms, international exportation is a variable that affects at once the output and the manufactured imports. It is true that for such main Chinese exporters as Guangdong and Shanghai, the impacts of international exports on output and manufactured imports must be extremely strong. Nevertheless, what we consider now is those provinces having weaker exports capability. One possible linkage between international exports and interprovincial imports is that the former results in a rise in demand for domestic inputs and thus interprovincial imports. This impact, however, could be trivial in our case. Unlike most advanced provinces capable to import more from other provinces for transformation and then export to other countries, in those provinces with weaker manufacture capability, international exports are mainly sourced by their local inputs and thus the linkage between their international exports and their interprovincial manufactured imports might be fairly weak. Table 3 has illustrated this fact: the coastal region realized most international exports and also most interprovincial imports of agricultural goods and raw-materials. On the contrary, western region was both net international and interprovincial importers of manufactured goods.

Last, in most studies that measure the output impacts of imported intermediates on the basis of plant level data, with different estimators, the obtained estimates were either close to those of OLS estimator, or a range of estimates that often includes the OLS estimate, and they cannot lead to conclude that the results with OLS estimator 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% with OLS estimator, and 17.7% 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% with OLS, 5.8% with GMM system, and 14.33% with Proxy Estimator.

With the above arguments, we conclude that the endogeneity is not a serious concern and we cannot suspect that our results are significantly biased. In order to reinforce the robustness of the above results with OLS estimator, we perform other tests with the regressions of the TFP on ln_ratio_imanu_wo and ln_ratio_imanu_wi. As TFP is a variable which accounts for effects in total output not caused by inputs, and technology growth and efficiency are regarded as two of the biggest sub-sections of TFP, we can reasonably assume that the TFP are less sensitive to productivity chocks or to international exportation chocks. Therefore the results are at most to a small extent affected by endogeneity and simultaneity.

The TFP by sector and province are calculated following the equation (4). In table 8, as in tables 6 and 7, the difference between the columns 1, 2 and the columns 3, 4 is that the first two columns are based on the observations of all sectors while the second two columns on those of industrial sectors. We observe that the parameters of the two ratios in different cases are all slightly lower, but comparable with the corresponding estimates presented in the two previous tables, and thereby enhancing the robustness of above estimations.

Table 8 inserted here

4. CONCLUSIONS

This paper has estimated the output impacts of Chinese interprovincial imports of manufactured intermediate goods on 17 provinces that are interprovincial net manufactured importers. Guided by the previous work on North-South spillovers and by the models to incorporate increasing returns of variety of intermediate goods, and using some reliable ways to apportion the international and interprovincial net exports among the provinces and then the interprovincial net imports of manufactured goods among different sectors within each province, we constructed a econometric model and find that 1% increase of the ratio of total manufactured inputs to own produced manufactured inputs through interprovincial importation of manufactured intermediates improved the productivities of all 41 sectors by more than 0.18% for these provinces and, by more than 0.22% for the 10 western provinces comprised in the 17 provinces. The impact on 23 industrial sectors was around 0.16%, lower than that of all sectors for these 17 provinces. But for the 10 western provinces, the impact on industries was higher than on all sectors.

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Table 1. GDP and Outputs of Three Industries of Three Regions

	GDP		Primary industry		Secondary industry		Tertiary industry	
	1998	2008	1998	2008	1998	2008	1998	2008
Coastal region	0.51	0.54	0.38	0.36	0.54	0.55	0.54	0.58
Central region	0.31	0.28	0.37	0.37	0.31	0.28	0.29	0.25
Western region	0.18	0.18	0.25	0.27	0.16	0.17	0.17	0.17

Note: Calculated on the basis of China Statistic Yearbooks 1999 and 2009. The classification of three large regions follows China Statistical Yearbooks.

Table 2. The Interprovincial Trade of Three Provinces in 2002 (in Million Yuan)

		Output	Overall exports	Overall imports	Net-off	Interprovincial exports	Interprovincial imports	Interprovincial net exports
	all sectors							
Fujian	volume	1297485	219820	199692	20128			
	% in output		16.9%	15.4%	1.6%			
Anhui	volume	877006	339840	322388	17452	320149	306858	13291
	% in output		38.8%	36.8%	2.0%	36.5%	35.0%	1.5%
Gansu	volume	294434	50180	76067	-25887			
	% in output		17.0%	25.8%	-8.8%			
	manufacturing sectors							
Fujian	volume	635653	189077	154593	34484			
	% in output		29.7%	24.3%	5.4%			
Anhui	volume	351755	213040	244471	-31431	196859	232572	-35713
	% in output		60.6%	69.5%	-8.9%	56.0%	66.1%	-10.2%
Gansu	volume	93778	39689	53103	-13414			
	% in output		42.3%	56.6%	-14.3%			

Table 3, Regional Distribution of International and Interprovincial Net Exports by Sector (in Million Yuan)

		Net_off	International net exports	Interprovincial net exports
Agriculture	Coastal region	-12390	-8598	-3792
	Central region	136890	-7253	144143
	Western region	94926	-4846	99772
Raw materials	Coastal region	-192582	-53476	-139106
	Central region	-17913	-45117	27204
	Western region	-11690	-23462	11771
Manufacture	Coastal region	534360	107940	426420
	Central region	7225	-12385	19609
	Western region	-267188	-25852	-241336

Note: Calculated on the basis of 2002 Chinese national and provincial input-output tables.

Table 4. Estimated Interprovincial Net Imports of Manufactured Goods by Importing Provinces Classified in Three Regions (in Million Yuan)

	n_imanu_wo	n_imanu_wi
Coastal region	39117.03	39727.40
Central region	43947.40	42883.12
Western region	100000	102000

Note: n_imanu_wo is estimated interprovincial net imports of manufactured goods by output weight. n_imanu_wi is estimated interprovincial net imports of manufactured goods by input weight. Number of importing provinces: 17.

Table 5. Descriptive Statistics of Variables

		Importing provinces					Importing western provinces				
	variable	Obs.	Mean	SD	Min.	Max.	Obs.	Mean	SD	Min.	Max.
All sectors	lnoutput	705	12.943	1.776	4.522	16.621	416	12.669	1.816	4.522	16.621
	lncapital	591	9.812	2.337	1.386	15.411	332	9.319	2.445	1.386	13.796
	lnlabor	690	11.209	1.936	3.045	16.039	407	10.891	1.999	3.045	16.039
	ln_raw_energy	690	10.227	1.609	2.212	15.025	408	9.955	2.239	1.609	15.025
	lnservice	691	11.177	1.804	2.485	15.141	408	10.965	1.736	4.394	14.576
	lnmanu	692	11.336	2.115	2.079	15.792	409	11.028	2.115	2.079	15.792
	ratio_imanu_wo	692	1.227	.3301	1	3.020	409	1.221	.262	1	2.247
	ratio_imanu_wi	692	1.231	.329	1	2.9997	409	1.228	.263	1	2.277
Industries	lnoutput	399	12.647	1.829	4.522	16.198	236	12.370	1.847	4.522	16.050
	lncapital	344	9.522	2.195	1.386	15.411	202	8.938	2.159	1.386	13.737
	lnlabor	386	10.643	1.854	3.045	14.132	229	10.299	1.885	3.045	14.132
	ln_raw_energy	386	10.542	2.132	3.219	14.895	229	10.311	2.167	3.526	14.895
	lnservice	385	10.648	1.854	2.485	14.558	228	10.522	1.745	4.394	14.200
	lnmanu	386	11.386	2.044	2.079	15.781	229	11.071	2.001	3.807	15.651
	ratio_imanu_wo	386	1.261	.3457	1.001	3.020	229	1.250	.263	1.009	2.239
	ratio_imanu_wi	386	1.265	.3439	1.002	2.9997	229	1.258	.263	1.009	2.269

Note: Number of importing provinces: 17. Number of importing western provinces: 10. Number of all sectors: 41. Number of industrial sectors: 23.

Table 6. Regression Results: Impacts of Interprovincial Imported Manufactured Inputs on Productivity of All Sectors and of Industrial Sectors (with Sample of Importing Provinces)

	lnoutput	lnoutput	lnoutput	lnoutput
	(1)	(2)	(3)	(4)
lncapital	0.071	0.071	0.087	0.087
	(6.56)***	(6.57)***	(6.16)***	(6.17)***
lnlabor	0.170	0.170	0.152	0.152
	(7.09)***	(7.08)***	(7.01)***	(7.00)***
lnservice	0.386	0.386	0.257	0.257
	(16.19)***	(16.17)***	(13.78)***	(13.77)***
lnmanu	0.221	0.221	0.301	0.301
	(14.00)***	(13.99)***	(17.99)***	(18.00)***
ln_raw_energy	0.113	0.113	0.179	0.179
	(11.68)***	(11.66)***	(15.99)***	(15.96)***
ln_ratio_imanu_wo	0.189		0.164	
	(3.33)***		(2.56)**	
ln_ratio_imanu_wi		0.184		0.159
		(3.25)***		(2.49)**
constant	2.412	2.411	2 .207	2.207
	(25.63)***	(25.49)***	(27.49)***	(27.08)***
implied γ	2.17	2.20	2.84	2.89
observations	573	573	330	330
R-squared	0.97	0.97	0.98	0.98

Note: *-indicates significance at 10%; **-indicates significance at 5%; *** -indicates significance at 1%. Robust t statistics are in parentheses. Number of all sectors: 41. Number of industrial sectors: 23. Number of importing provinces: 17.

Table 7. Regression Results: Impacts of Interprovincial Imported Manufactured Inputs on Productivity of All Sectors and of Industrial Sectors (with Sample of Western Provinces)

	lnoutput (1)	lnoutput (2)	lnoutput (3)	lnoutput (4)
lncapital	0.058 (4.25)***	0.058 (4.25)***	0.072 (4.09)***	0.072 (4.07)***
lnlabor	0.152 (5.01)***	0.152 (4.99)***	0.104 (4.41)***	0.103 (4.39)***
lnservice	0.427 (11.66)***	0.427 (11.64)***	0.294 (10.15)***	0.295 (10.14)***
lnmanu	0.227 (9.52)***	0.227 (9.51)***	0.320 (15.65)***	0.321 (15.56)***
ln_raw_energy	0.106 (7.50)***	0.106 (7.47)***	0.183 (11.60)***	0.183 (11.52)***
ln_ratio_imanu_wo	0.236 (2.70)***		0.352 (3.49)***	
ln_ratio_imanu_wi		0.226 (2.59)**		0.341 (3.42)***
constant	2.269 (18.23)***	2.266 (18.10)***	2.149 (20.92)***	2.143 (20.82)***
implied γ	1.96	2.00	1.91	1.94
observations	321	321	194	194
R-squared	0.97	0.97	0.98	0.98

Note: *-indicates significance at 10%; **-indicates significance at 5%; *** -indicates significance at 1%. Robust t statistics are in parentheses. Number of all sectors: 41. Number of industrial sectors: 23. Number of importing western provinces: 10.

Table 8. Regression Results: Impacts of Interprovincial Manufactured Imports on TFP

	lnTFP (1)	lnTFP (2)	lnTFP (3)	lnTFP (4)
Importing provinces				
ln_ratio_imanu_wo	0.17(3.13)***		0.14(2.50)**	
ln_ratio_imanu_wi		0.17(3.06)***		0.14(2.42)**
constant	2.49(178.77)***	2.49(177.71)***	2.26(153.24)***	2.26(151.16)***
observations	573	573	330	330
F	9.92	9.37	6.23	5.84
Prob. > F	0.002	0.002	0.013	0.016
R-squared	0.019	0.017	0.019	0.018
Western provinces				
ln_ratio_imanu_wo	0.23(2.51)**		0.33(3.42)***	
ln_ratio_imanu_wi		0.22(2.47)**		0.32(3.33)***
constant	2.29(108.78)***	2.29(107.16)***	2.16(107.17)***	2.16(104.97)***
observations	321	321	194	194
F	6.60	6.08	11.70	11.11
Prob. > F	0.011	0.014	0.001	0.001
R-squared	0.022	0.020	0.075	0.069

Note: *-indicates significance at 10%; **-indicates significance at 5%; *** -indicates significance at 1%. Robust t statistics are in parentheses. Number of importing provinces: 17. Number of western provinces: 10. Number of all sectors: 41. Number of industrial sectors: 23.