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Producers' Service Improvements and Manufacturing Agglomeration When Taking Trade Costs as a Mediator Variable: Mechanism and evidence from China

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Abstract

Most studies about the effects of producers' services on manufacturing agglomeration focus on the effects themselves while neglecting the mechanism that such effects spread. By stressing the key role of trade costs in the process of manufacturing agglomeration, this paper identifies a chain of effects from producers' service improvements to manufacturing agglomeration via changing trade costs and builds a simple model to enable empirical analysis. Both in the mechanism used to assess this chain of effects and in the empirical model, trade costs are dealt with as a mediator variable. Empirical tests using firm-level data from China support the hypothesis that producers' services affect manufacturing agglomeration via changing trade costs. Further tests at the two-digit sector level show that these types of mediator effects vary in accordance with differences in sector factor intensiveness. Specifically, the mediator effects are more significant in the technology-intensive manufacturing industries than they are in the labor- or capital-intensive manufacturing industries. The policy implication of this finding is that encouraging the development and regional concentration of producers' services would not only promote manufacturing agglomeration but also stimulate technology progress in related sectors.

***Keywords*:** Producer services, Manufacturing agglomeration, Trade costs, Mediator effects

JEL classification: F12, L8, L6, O53

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I. Introduction

The coagglomeration of producer services and manufacturing activities is a relatively new topic in regional/spatial economics research. Related researches are mainly done with two contrasting ways, namely (i) taking producer services as comparatively independent sectors and then focusing on the effects of their development on manufacturing agglomeration or (ii) taking both producer services and manufacturing industries as mutual promotion sectors and focusing on the interactions between them or on the effects of the coagglomeration of the two sectors.

Representative studies with the first way include Selya (1994) and Goe (2002). Based on data on Taiwan, Selya (1994) examines how developments in producer services affect manufacturing relocation in metropolitan areas. Meanwhile, Goe (2002) uses data on the US from 1980 to 1990 to show that the development of producer services stimulates or strengthens the agglomeration of manufacturing industries.

Representative studies with the second way include Anderson and Van Wincoop (2004) and Desmet and Fafchamps (2005). Anderson and Van Wincoop (2004) assess the tendencies towards the coagglomeration of producer services and manufacturing sectors in different regions of Sweden. They find that the origination and expansion of those sectors in terms of employment are determined simultaneously or mutually. In other words, the location and expansion of producer services influence manufacturing sectors and vice versa. Using employment data from a number of Swedish regions in 2000, they find that manufacturing and producer services are positively co-located in urban areas, namely the size of one sector can explain the size of the other in the regions examined. Further, in non-urban areas, a bidirectional location dependency between the two industries was found in traditionally low knowledge-intensive industries. In addition, they find that in urban regions (except for non-knowledge-intensive industries), manufacturing has a greater impact on the employment of producer services compared with other economic activities in the same region.

Desmet and Fafchamps (2005) compare the spatial distribution of employment at the state level in the US between 1972 and 2000 and find that aggregate employment tends to be concentrated geographically. This changing tendency is driven partially by the development of producer services. While non-service employment, especially in the manufacturing sector, has been spreading, most service jobs have become increasingly clustered in those areas that have a comparatively high degree of manufacturing agglomeration.

This research topic has also attracted scholarly interest from Chinese economists in recent years. The research covering Chinese cases can be roughly sorted into two types. Most studies use logical reasoning and analytical reviews of coagglomeration as well as quantitative analysis rather than systematic empirical research (e.g., Gao, 2006). However, the minority can be strictly viewed as empirical tests with a theoretical framework of coagglomeration (that is, Jiang and Liu, 2009; Chen, 2010). In addition, the rationale for most

of these studies rests on the assumption of input-output data between related sectors.

However, almost all these studies seem to be missing the related mechanism identified by NEG (new economic geography) researchers, namely the potential role played by trade costs in the coagglomeration of these two industries. In a standard NEG model (Fujita et al., 1999), trade costs are one of the most important exogenous variables. This variable influences and even determines the patterns and degrees of agglomeration in certain economic activities as well as in the manufacturing industry. Indeed, one important "upstream" element or variable in how producer services affect manufacturing industries is the trade costs of manufacturing activities. Specifically, the expansion and agglomeration of producer services in a specific area substantially reduces trade costs for the manufacturing industry in the same area, which is conducive to the agglomeration of manufacturing industries. Theoretically and logically, trade costs thus exist as a mediator variable in the coagglomeration of producer services and manufacturing sectors.

A *mediating variable* or *mediator variable* is a concept created and used in statistics. This variable describes how, rather than when, the effects of a change will occur by accounting for the relationship between the independent and dependent variables. In other words, it explains the relationship between the dependent variable and the independent variable (Baron and Kenny, 1986).[①] In this study, we use mediating variables to examine the effects of the development of producer services on manufacturing agglomeration as well as the coagglomeration of these two industries. The central objective is to test the mediator effects of the changes in trade costs caused by producer services.

This paper offers fresh empirical evidence on the connection between producer services and manufacturing sectors and their coagglomeration with certain characteristics of the Chinese economy as an emerging industrial and market-oriented one. Further, it suggests important policy implications for launching specific regional development strategies and governmental involvement with the aim of promoting industrial upgrading and transforming methods to promote economic growth.

The remainder of this paper is organized as follows. Section 2 traces the chain connections among producer services, trade costs, and manufacturing sectors in the real world and introduces a simple model to depict the mechanism of the transmission of effects from a change in the independent variable to the dependent variable via trade costs as the mediator variable. Section 3 describes simple models for empirical testing and designs a path for implementing these models. Section 4 describes the empirical tests. Section 5 presents our conclusions.

II. Producer services and manufacturing agglomeration: a trade costs view

Speaking strictly, producer services and the producer service sector are distinct concepts, although there are

[①] Also reference to "Mediator Variable", Statistic solutions, web page: http://www.statisticssolutions.com/resources/dissertation-resources/descriptive-statistics/mediator-variable

some overlaps. Specifically, the latter stems from the former, but differs from it by only including the services that exist as comparatively independent sectors. The term “producer services” is generally believed to have been first put forward by Machlup (1962), but its popularity as a subject for academic assessment seems related to the pioneering work of Greenfield (1966) and Browning and Singelman (1975) in the 1960s and 1970s. They defined producer services as services that provide intermediate inputs in the forms of services for other merchandise and services production. More recently, researchers have accepted a looser definition, understanding services as being provided or sold to a producer rather than to a consumer. In this sense, although separate from manufacturing industries, it is clear that producer services heavily depend on such industries for expansion.

One distinctive feature of service research in general is the lack of consensus on both the boundaries and the classification of services themselves, because services have traditionally been viewed as “tertiary” and were defined by means of exclusion (e.g., being neither manufacturing nor agriculture). However, Glasmeier and Howland (1994) rightly state “the problem with this scheme is that it does not reveal what services are, only what they are not.” Similar confusion also exists in the classification of producer services, although this is becoming a research topic.

UNCTAD classifies producer services into five categories: wholesale, commercial banking, non-banking finance and insurance, information services, and scientific and technical services. Further, OECT statistics suggests taking the “Rev. 3 sub-groups” of the “International Standard Industrial Classification” (ISIC) as core producer services, which covers four categories of service sectors, namely business and professional services, financial services, insurance services, and real estate services.[②] As our empirical study is based on Chinese data, it is sufficient that we roughly classify the main producer services using official data provided by the State Statistics Bureau of China, in accordance with the UNCTAD classification. Such a classification of producer services includes the following six service sectors:

- Transport, Storage, and Postal Services;
- Information Transmission, Computer Services, and Software Services;
- Wholesale and Retail Trades;
- Financial Intermediation Services;
- Business Services; and
- Scientific Research and Technical Services.

From the view of manufacturing industries, the existence and expansion of the producer service sector rely on providing the necessary inputs into manufacturing activities throughout the whole production chain. Moreover, each category of service activities is linked to a certain stage of the manufacturing chain. Thus,

[②] OECD, *glossary of Statistical terms*, OECD statistics portable (web): http://stats.oecd.org/glossary/detail.asp?ID=2440

producer services themselves exist in a chain process. At the top of the chain, the important producer services include R&D, market research, and employee training. In the middle of the chain, they include quality monitoring, equipment leasing, and raw materials transport, while at the bottom, they include sales, transport, and after-sales service. Therefore, although they do not directly participate in the production of products, producer services have a strong connection with manufacturers through their close input-output relations.

This real-world reality means that one way to distinguish producer services and value their relative importance for manufacturing industries is to assess their shares of inputs into manufacturing activities. The importance of producer services in China's manufacturing economy can thus be valued in two ways; one way is by calculating the share of each of the producer service sectors relative to total manufacturing input. Based on China's official statistics, we can easily identify the top 10 producer services (see Table 1).

Table 1. Percent of the input made by major producer services as the input of total manufacturing industry in China, 2002 and 2007

(the ten top service sectors）

2002		2007	
Sectors	Share (%)	Sectors	Share (%)
Wholesale and Retail Trades	34.31	Transport, Storage and Post	21.09
Transport, Storage and Post	25.57	Wholesale and Retail Trades	19.21
Business Services	9.77	Financial Intermediation	10.25
Financial Intermediation	8.28	Business Services	7.27
Information Transmission	5.35	Catering Services	3.53
Catering Services	3.67	Information Transmission	2.82
Resident services	3.12	Technology Services	2.74
Computer Services and Software	1.73	Real Estate	2.11
Real Estate	1.35	Research and experimental development industry	2.04
Technology Services	1.16	Insurance	1.11
Total	94.31	Total	72.17

Source：Calculated according to the related data from *Input-output Tables of Chin, 2002*，*Input-output Tables of China, 2007*. China Statistics Press, 2006, 2009.

This table shows the features and dynamic trends in the importance of these producer services in China's manufacturing activities. First, the strong "mediator" characteristics in manufacturing activities imply that the producer service sector is the most important component of service sector inputs. In 2002 and 2007, for example, the inputs from the top 10 producer service sectors accounted for 94.3% and 72.2% of total manufacturing inputs, respectively. Second, the degree of the concentration of the largest producer service sectors seems to be dropping. The share of the top four, namely transport-storage and postal services, wholesale and retail trades, financial intermediation, and business services, dropped from over 75% to less than 60% between 2002 and 2007 (see table 1). This reflects a trend towards greater diversification in the producer service sector; it indicates that of the sectors that provide intermediate services to manufacturing activities, producer services are retaining their critical importance in the rapid development of the Chinese economy.

The second way of valuing the importance of these activities is by measuring the share of producer services in different factor-biased manufacturing industries. Considering the differences in factor intensiveness as well as the nature of manufacturing sectors allows us to identify those producer services that mainly provide medium inputs for manufacturing activities (see Table 2).

Table 2. Share of the Total Service Sector Input in Different Manufacturing sectors in China

（the largest ten sectors, 2007）

Labor-intensive		Capital-intensive		Technology-intensive	
Sectors	Share (%)	Sectors	Share (%)	Sectors	Share (%)
Transport, Storage and Post	22.20	Transport, Storage and Post	23.71	Wholesale and Retail Trades	23.73
Wholesale and Retail Trades	18.50	Wholesale and Retail Trades	15.85	Transport, Storage and Post	17.17
Financial Intermediation	9.49	Financial Intermediation	10.88	Financial Intermediation	10.06
Business Services	9.23	Business Services	5.01	Business Services	8.55
Catering Services	3.39	Information Transmission	4.30	Research, experiment &development	4.11
Real Estate	3.39	Catering Services	3.82	Catering Services	3.30
Technology Services	2.09	Technology Services	2.68	Technology Services	3.29
Information Transmission	1.56	Insurance	1.35	Real Estate	2.15

Catering Services	1.13	Real Estate	1.30	Information Transmission	1.96
Insurance	1.06	Research, experiment, development	1.20	Computer Services and Software	1.74

Data source：Calculated according to the related data from *Input-output Tables of Chin, 2002*，*Input-output Tables of China, 2007*. China Statistics Press, 2006, 2009.

By reclassifying manufacturing sectors according to their differences in the factor intensities of their products, the importance of producer services in manufacturing activities cannot only be clearly seen but also sectoral differences are much clearer. Specifically, three producer service sectors, namely transport, storage, and postal services, wholesale/retail trades, and financial intermediation, retain the top position in all three broadly defined sectors in terms of factor intensiveness. The only difference is in the shares of the three sectors.

As stated earlier, these producer service sectors affect manufacturing agglomeration mainly via trade costs. In the theoretical framework of NEG, trade costs include not only all the costs imposed by geographic distance, but also those caused by various institutional barriers. Anderson and Van Wincoop (2004) define trade costs as including all costs incurred in moving a good to a final user other than the marginal cost of producing the good itself. Thus, trade costs include transportation costs (both freight costs and time costs), policy barriers (tariff and non-tariff barriers), information costs, contract enforcement costs, foreign exchange costs, legal and regulatory costs, and local distribution costs (wholesale and retail).

In the real world, firms engaged in producer services, like all other firms, pursue cost minimization and provide cost-minimized inputs in the form of services for manufacturing firms in order to stimulate manufacturing agglomeration. Typical examples of this phenomenon are easy to find. For example, a specialized and professional logistics service decreases transportation costs, the development of information sectors reduces information transaction costs, and an advanced financial sector lowers financing costs. In the real world, there are both differences and connections between the concept of trade costs as defined by economists and producer services that affect trade costs. For simplification, in Table 3 we thus highlight the important producer service sectors that have the most obvious connections with changes in trade costs.

Table 3. Trade cost and related producer servises

Trade cost contents			Related producer services
Trade policy related cost	Tariff and no-tariff, quotas		--
Border-related cost	Language barrier, currency barriers, security barriers		-- --
Spatial/distance related cost	Direct	Transportation cost	Transportation sector
		Insurance premium	Insurance industry
	indirect	Storage cost	Storage business
		Information cost	Postal/information transmission
Distribution cost			Wholesale/retailing
Financial cost			Financial industry

Source：Anderson et al. (2004), Prabir (2006).

For simplicity, we choose the six producer service sectors identified in Table 3, as these have most obvious connections with trade costs as defined by economists. In a standard core/periphery NEG model, agglomeration depends on the operation of two opposite powers, namely trade costs and scale economies/spatial externalities. Considering the role of trade costs only and taking scale economies or spatial externalities as given, we can then elicit a chained mechanism that carries the effects of producer services to manufacturing sectors, resulting in the agglomeration of the latter. Trade costs occupy a critical position in this mechanism. This mechanism can be described using the simple illustration in Fig. 1.

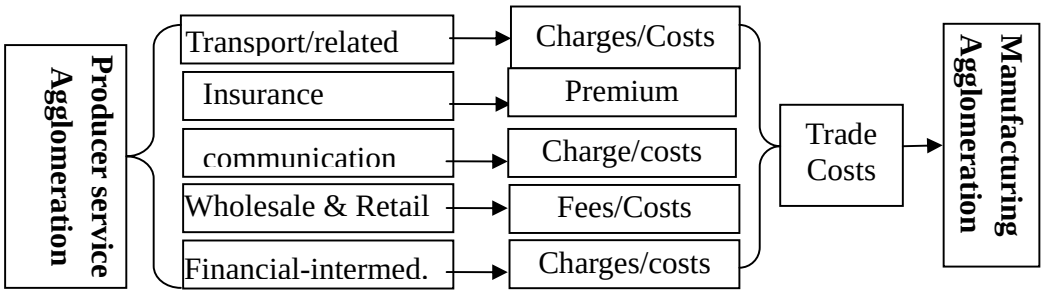


Fig. 1, a chained-mechanism of producer services on manufacturing agglomeration

In the chain mechanism in Fig. 1, trade costs are a mediator variable. In this sense, the effects producer services exert on the growing and agglomeration of manufacturing sectors are mainly via trade costs

indirectly rather than directly. In view of this, we can put the illustration above into the mediator model. As stated earlier, a mediator model depicts the relationships among three variables, namely independent, dependent, and mediator variables (see Fig. 2).

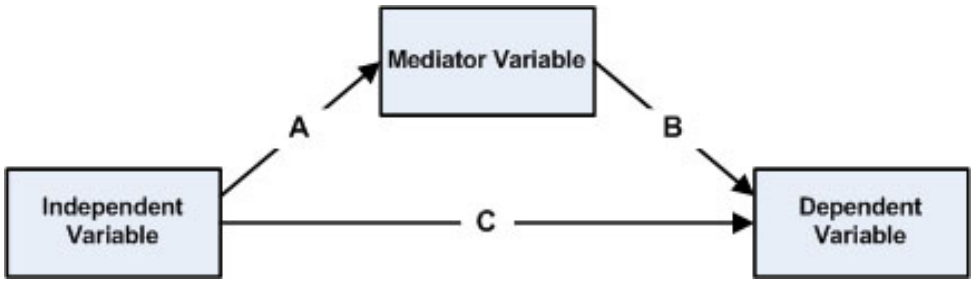


Fig. 2 a simple mediator model in statistics

Source: Wikipedia[③]

The left-hand side and right-hand side represent the independent and dependent variables, respectively. Fig 2 shows that the effects of the former do not directly affect the latter. It does that via a third variable, or another explanation variable, in between. By proposing a connection between producer services and manufacturing agglomeration in a mediator model framework, we can first follow the simple mediator model with minor changes and rearrange the variables in Fig. 3-a.

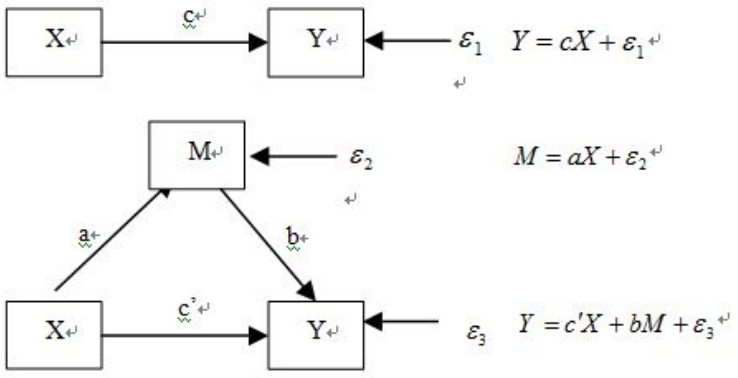


Figure 3-a. Illustration of mediator effect

Let X and Y be the proposed causes, that is the independent variables and dependent variable, respectively. Let Panel B be the simplest form of mediation, namely the type that occurs when one variable (M) mediates the effect of X on Y. The simple relationship between X and Y is often referred to as the total effect of X on Y. We denote the total effect c to distinguish it from c', the direct effect of X on Y after controlling for M. A formal heuristic analysis, which is often used to detect simple mediation effects, is straightforward and it

③ Mediated moderation model 1.from Wikipedia, the free encyclopedia: http://en.wikipedia.org/wiki/File:Mediated_moderation_model_1.png

follows directly from the definition of a mediator provided by Baron and Kenny (1986). Variable M is considered to be a mediator if (1) X significantly predicts Y ($c \neq 0$ in Fig. 3-a), (2) X significantly predicts M ($a \neq 0$ in Fig. 3-a), and (3) M significantly predicts Y controlling for X ($b \neq 0$ in Fig. 3-a).

Second, we can introduce this idea into the standard mediator model. Let us assume that trade costs are the mediator variable through which producer services affect manufacturing agglomeration (Fig. 3-b).

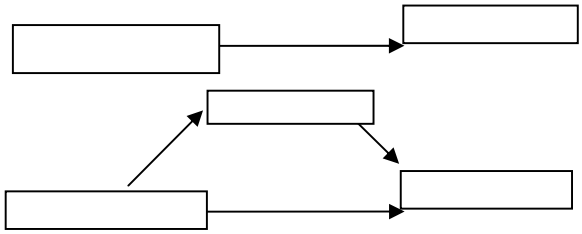


Fig. 3-b. Illustration of chain mechanism

Therefore, we use this mediator variable to test the following hypothesis: the development of producer services affects manufacturing agglomeration via decreases in trade costs.

III. Model selection and path design for the empirical work

In this section, we test the mediation effects of producer services using Chinese panel data. This sort of testing process typically consists of three specific tests, namely the F test, LM test, and Hausman test. The appropriate estimation method is a random effects model. The basic model is as follows:

$$Gini_{it} = \alpha_1 + cPS_t + \mu_{it} + \nu_i \quad (1)$$

$$TC_{it} = \alpha_2 + aPS_t + \mu_{it} + \nu_i \quad (2)$$

$$Gini_{it} = \alpha_3 + c'PS_t + bTC_{it} + \mu_{it} + \nu_i \quad (3)$$

where $Gini_{it}$ is the Gini coefficient of industry i in year t, PS_t is the development level of producer services in year t, and TC_{it} is the trade costs of industry i in year t.

Although the data derived from the official statistics agency of China are strong, they are still not enough for us to launch the test without resorting to certain forms of substitution as a way of dealing with some of the key variables (that is, trade costs). The costs of annual sales recorded in China's official statistics offer the best available proxy of trade costs. According to the official definition, sales costs are those incurred in the process of the sale of a product during the reporting period, such as transport expenses, packaging

charges, insurance premiums, and exhibition/advertisement fees.[④]

Replacing TC in equation (3) with equation (2) provides us with the following equation:

$$Gini_{it} = \alpha_4 + (c' + ab)PS_t + \mu_{it} + \nu_i \quad (4)$$

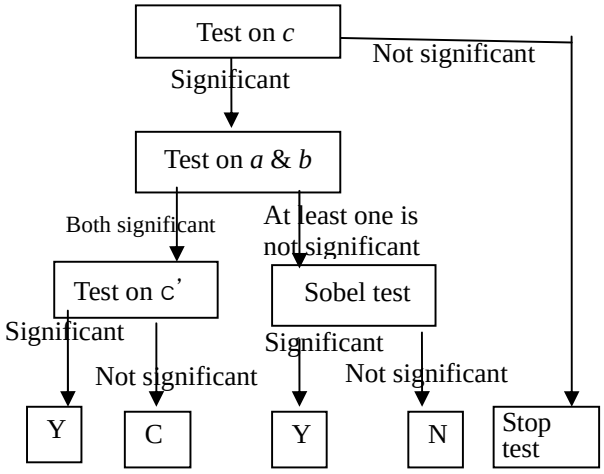
In equation (4), *ab* measures the mediator effect that trade costs cause in the mechanism of e-business as well as how they affect manufacturing agglomeration. Regarding the test of mediation effects, three specific methods are usually considered depending on the hypothesis chosen. The first one is to test the regression coefficients gradually, or test H0: c=0, a=0, b=0. If all hypotheses are rejected, the mediation effect is significant. One advantage of this method is that it is easy to carry out with a low probability of mistakes. However, it is hard to detect very low mediation effects.

The second method it is to test the existence of differences between c and c', or H0: c- c'=0. If rejected, the mediator effect is significant. Important contributions concerning this method of test have been made by Clogg et al. (1992) and Freedman and Schatzkin (1992). The former sets the standard deviation of $\hat{c} - \hat{c}'$ as approximated by $s_{\hat{c}-\hat{c}'} = r_{XM} s_{c'}$. Later, however, it was approximated as $s_{\hat{c}-\hat{c}'} = \sqrt{s_c^2 + s_{c'}^2 - 2s_c s_{c'}\sqrt{1-r_{XM}^2}}$. Here, r_{XM}, s_c, and s_c' are the correlation coefficients of the variables X and M and the standard deviation of $\hat{c}$ and $\hat{c}'$. The corresponding test-statistical values are given by $t = (\hat{c} - \hat{c}')/s_{c-c'}$.

The third method is to test the combination of regression coefficients, or H0: ab=0: if rejected, the mediator effect is significant. A complex estimation here involves the standard deviation of $\hat{a}\hat{b}$. Sobel (1982, 1987) simplifies this estimation by deriving an approximate equation using the first-order Taylor expansion as $S_{ab} = \sqrt{\hat{a}^2 S_b^2 + \hat{b}^2 S_a^2}$ and then sets $Z = \hat{a}\hat{b}/S_{ab}$ as the test statistics. Here, s_a and s_b represent the standard deviation of $\hat{a}$ and $\hat{b}$. MacKinnon et al. (1998) adjust the threshold of the z statistics in order to improve this test further.

By simplifying and reducing the probability of errors when testing the mediation effects, academic research in psychology proposes other changes. Wen et al. (2004) suggest a stepwise procedure that combines the three methods of mediation tests together in a chained form. Following this procedure, the mediation effect test can be carried out both at higher efficiency and with fewer mistakes compared with single tests. The procedure has strong reference to our empirical work. We can easily use this procedure for our test, although with some changes to the definitions of certain variables. The procedure and each of the steps and elements involved in the whole test of mediation effects are summarized in Fig. 4.

[④] This definition is given by the State Statistics Bureau of China in its annual publication, the *Industrial Economy Statistical Yearbook of China*.



Note: The names of the columns are abbreviated in this table as follows:

Y, mediator effect significant;

C: complete mediator effect;

N: mediator effect is not significant.

Fig. 4. Illustration of mediator effect: a procedure of tests

The procedure for testing the mediation effects is a strong stepwise approach. Following this procedure, our empirical work follows three possible steps in a stepwise manner:

- If the coefficient c is significantly positive, the development of producer service sectors would benefit manufacturing agglomeration. Then, we can assess the coefficients *a* and *b*.

- If both of these are significant, it means that the mediator effect is significant.

- If neither of them is significant, then a Sobel test is required.

IV. Producer service sector and manufacturing agglomeration: mediator effects test

Here, we examine the effects of coagglomeration between producer services and manufacturing. However, instead of assessing the effects directly, we rather assess changes in trade costs along with the development of producer service sectors. We do this at two levels: a general one and a sectoral one.

4.1. Sample and data description

We start by sorting and describing the data. We choose 28 manufacturing sectors covering the codes from C13 to C41 in the *Industrial Classification of the National Economy of China* (GB/T4754-2002)[⑤]. The data cover a period from 2001 to 2008.

[⑤] It was composed and published by the National Bureau of Statistics of China and other two related governmental agencies. The latest version is published in 2011. (see the official web of the SSBC: http://www.stats.gov.cn/english/)

To assess the degree of geographical concentration for all industries we choose sample regions and calculate the spatial distributions of industries at the two-digit level. By considering both the availability of statistical data and the spatial implication of trade costs, we choose China's provincial regions as the sample units. Second, the spatial Gini coefficient is selected to calculate the spatial distributions of specific industries. This coefficient was originally suggested by Krugman (1991) following Gini (1912) and it can be replaced by the E-G index (Ellison and Glaeser, 1997) among other methods. However, the spatial Gini coefficient is more appropriate for identifying dynamic trends in the regional distributions of specific industries. A Gini coefficient for each industry is thus calculated using the following equation:

$$G_i = \sum_i (s_{ij} - x_j)^2$$

where *Gi* is the Gini coefficient of industry *i*, s_{ij} is the share of employees of industry *i* in province *j* divided by the share of employees of industry *i* in the whole of China, and x_j is the share of employees in province j relative to China. If an industry is equally distributed across all provinces, the index equals zero. An index value close to 1 suggests that an industry is entirely concentrated in that region (see Table 4).

Because there is no generally accepted definition of producer services, and considering both the availability of statistical data and their connection with manufacturing sectors, we only choose typical producer services as sample ones that cover three of the largest categories: transport, storage, and postal, wholesale and retail trades, and financial intermediation. Their inputs account for almost 40% of general manufacturing inputs and more than half in those in capital- and technology-intensive industries (see Tables 1 and 2). Further, we use annual real growth rates to evaluate their levels of development.

We use the statistical series listed as "business operation expenses" in China's official statistics as a proxy for trade costs. According to the official definition, this series of statistics includes the various costs/fees paid in the whole product delivery process, including payment, fees, transportation charges (either visible or invisible), cargo loading and unloading, insurance, wholesale and retailing, marketing, and advertising. Data are collected at the firm level. This series of data also correspond to producer services. The data are derived from the *China Statistical Yearbook* and China Statistical Database. Nominal data were converted into real terms through annual CPI (consumer price index) deflation. All data were re-inputted as deviations from the mean.

4.2. Testing the mediator effects of trade costs: a general view

Using related statistical data on China as described earlier in panel form, we carry out the test in three steps. First, we regress model (1). If the regression coefficient is positive, this means that the development of producer services is beneficial to the agglomeration of manufacturing industries. Second, the mediation effects can be tested by regressing models (2) and (3). If both coefficients are significant, this means that the

mediation effects are significant. However, if one is not significant, then a Sobel test is required, as described in Section 3.

The test results are listed in Table 4. We first find that the regression is significant at the 1% level of significance. As we continue the test, a negative coefficient in the second step shows that the development of the producer service sector can reduce trade costs. In the third step, trade costs are introduced. The coefficients of producer services are now found to be significantly positive, indicating that producer services affect agglomeration through trade costs. Further, trade costs have mediating effects. Specifically, the positive relationship between the development of the producer service sector and manufacturing agglomeration indicates that the former would benefit the promotion of manufacturing agglomeration. The most significant promotion effect occurs in the transport, storage, and postal sector (with a regression coefficient of 0.0828). This result also suggests that this kind of promotion occurs through a reduction in trade costs. For the sectors of transport, storage, and postal, wholesale and retail trades, and financial intermediation, the reduction in trade costs can explain 40.37%, 57.96%, and 36.23%, respectively.

Table 4 results of mediator effects tests

Steps	**DV**	**IV**	**Coefficients**		**Condition**	**ME**	**ME/TE**
I	JT	GINI	c_1	0.0828*** (0.0162)	Coefficient *c* significant	--	--
	PL	GINI	c_2	0.0685*** (0.0137)		--	--
	JR	GINI	c_3	0.0257*** (0.0256)		--	--
II	JT	TC	a_1	-0.0507***(0.0075)	Coefficient *a* significant	--	--
	PL	TC	a_2	-0.0596***(0.0057)		--	--
	JR	TC	a_3	-0.0187***(0.0016)		--	--
III	JT	GINI	c'_1	0.0494***(0.0170)	Coefficient *b & c'* significant	0.0334	0.4037
	TC		b_1	-0.6588***(0.1386)			
	PL	GINI	c'_2	0.0288* (0.0162)		0.0397	0.5796
	TC		b_2	-0.6658***(0.1560)			
	JR	GINI	c'_3	0.0164***(0.0048)		0.0093	0.3623
	TC		b_3	-0.4973*** (0.1586)			

Note:

i) Meaning of each of the abbreviated letters:

DV is “dependent variable”; IV, independent variable; GINI, the Gini coefficients;

JT is Transport/Storage and Postal sector; PL, Wholesale/Retail Trades; JR, Financial Intermediation; TC, trade costs;

ME is mediator effect; TE, total effect.

ii) The numbers in brackets are standard errors. c. *, **, and *** indicate significance higher than 0.10, 0.05 and 0.01 levels, respectively. d. All results are produced with stata 11.0 programmer.

In order to validate the robustness of these results we add control variables into models (1)–(3) and rerun the mediator effects test. Considering the causality between variables, an ideal control variable would be a reasonable explanatory variable of manufacturing agglomeration that is also related to trade costs. However, this should not be related to the development of the producer service sector. Thus, we introduce trade protection as a control variable, as measured by the share of GDP contributed by state-owned enterprise in this industry. The regression results that contain the control variable are shown in Table 5.

Table 5 Further Test on Mediator Effects

Steps	**DV**	**IV**	**Coefficients**		**Condition**	**ME**	**ME/TE**
I	JT	GINI	c_1	0.0526*** (0.0177)	Coefficient *c* significant Coefficient *a* significant	--	--
	TP			-0.0531*** (0.0143)		--	--
	PL	GINI	c_2	0.0396** (0.0157)		--	--
	TP			-0.0529*** (0.0150)		--	--
	JR	GINI	c_3	0.0191*** (0.0048)		--	--
	TP			-0.0352** (0.0157)		--	--
II	JT	TC	a_1	-0.0237***(0.0074)	Coefficient *b & c'* significant	--	--
	TP			0.0476*** (0.0060)		--	--
	PL	TC	a_2	-0.0396***(0.0061)		--	--
	TP			0.0366*** (0.0059)		--	--
	JR	TC	a_3	-0.0129***(0.0019)		--	--
	TP			0.0311*** (0.0062)		--	--
III	JT	GINI	c'_1	0.0400**	Coefficient	0.0126	0.239

				(0.0177)	*c* significant		
	TP			-0.0279 (0.0158)			
	TC		b_1	-0.5304***(0.1561)			
	PL	GINI	c'_2	0.0186* (0.0168)		0.02101	0.5301
	TP			-0.0334* (0.0159)			
	TC		b_2	-0.5302***(0.1677)			
	JR	GINI	c'_3	0.0136** (0.0052)		0.0055	0.2884
	TP			-0.0219 (0.0164)			
	TC		b_3	-0.4268** (0.1668)			

Note: as for table 3.

As shown in Table 5, even with the inclusion of a control variable for the effects of trade protection, the overall results change little. This means that the mediator effects of trade costs exerted by producer services remain significant. E-business can thus benefit agglomeration through trade costs. Moreover, trade protection is negatively related to agglomeration. The only difference between the results is that the mediator effects decline slightly. This proves that the result above is robust.

4.3. Testing the mediator effects of trade costs: an industrial heterogeneity view

The above analysis does not consider industrial heterogeneity. Indeed, if we were to take factor intensity into consideration, different types of industries may have different trade costs owing to different industry characteristics. Thus, agglomeration effects would differ by industry. This empirical fact has already been noted by the empirical study of European manufacturers presented by Forslid et al. (2002).

At the same time, the link between manufacturers and producers also differs by industry. The former input-output data show that technology-intensive manufacturers are mostly closely linked to producer services followed by capital-intensive industries. Labor-intensive industries have the weakest connections. Chen (2010) attributes this result to different production chain lengths. Technology-intensive industries have the longest production chains, labor-intensive industries have the shortest chains, and capital-intensive industries are in the middle. Thus, it is necessary to consider industrial heterogeneity.

In response to this finding, we divided the manufacturing industries into three categories, namely “technology-intensive manufacturers,” which refers to industries that have the codes C35–C37 and

C39–C41, “capital-intensive manufacturers” (C25–C34), and “labor-intensive manufacturers” (C13–C24)[⑥]. Using the same procedure as before, the results are shown in Table 5. Because the coefficient in step three is not significant in the test of labor- and capital-intensive manufacturers, a Sobel test is needed. The difficulty of the Sobel test is acquiring the standard errors of ab. Thus, an approximate value of S_{ab} is given as:

$$S_{ab} = \sqrt{a^2 S_b^2 + b^2 S_a^2},$$

where a and b are the regression coefficients in steps one and two, while S_a and S_b are the corresponding standard errors. Further, in order to conduct the test *ab* is divided by S_{ab} to yield a critical ratio $Z = ab / S_{ab}$ to compare with the critical value. If the sample is relatively small, the critical ratio is 0.97 at a significance level of 5%. The results after considering industrial heterogeneity are presented in Table 6.

Table 6. Mediator Effects of different Industries

	Variables			Coefficient	Mediator Effects			Direct Effects	Result	
	Y	X	M	C	a	B	Z	C’	Mediator Effects	Direct Effects
LI	Gini	JT	TC	0.0651*** (0.0216)	-0.0424*** (0.011)	-0.2095 (0.2046)	0.9902	0.0562** (0.0232)	Y	Y
		PL		0.0527*** (0.0183)	-0.0589***(0.007)	-0.0927 (0.2424)	0.3817	0.0472** (0.0233)	N	Y
		JR		0.0197*** (0.0053)	-0.0174***(0.0023)	0.0573 (0.2366)	-0.242	0.0207*** (0.0067)	N	Y
CI	Gini	JT	TC	0.0527** (0.0223)	-0.0633***(0.0143)	-0.3266* (0.1739)	-	0.0320 (0.0245)	C	N
		PL		0.0639*** (0.0181)	-0.0675***(0.0119)	-0.1850 (0.1841)	0.9898	0.0514** (0.0219)	Y	Y

[⑥] According to the international standard industry classification (ISIC3.0) adopted by OECD.

		JR		0.0196*** (0.0053)	-0.0219*** (0.0031)	-0.1311 (0.1934)	0.6746	0.0168** (0.0068)	N	Y
TI	Gini	JT	TC	0.1683*** (0.0493)	-0.0465*** (0.0142)	-2.8040*** (0.3083)	-	0.03802 (0.0329)	C	N
		PL		0.1078** (0.0439)	-0.0479*** (0.0113)	-3.2375*** (0.3230)	-	-0.0473 (0.0291)	C	N
		JR		0.0477*** (0.0118)	-0.0159*** (0.0031)	-2.9407*** (0.3519)	-	0.0008 (0.0093)	C	N

Note: as for table 3.

As shown in Table 6, these types of industries differ in their mediator effects. First, for technology-intensive manufacturing industries, trade costs show complete effects in the relation between the producer service sector and agglomeration, which means that the effects of producer services on manufacturing agglomeration is entirely through a reduction in trade costs. This result is in line with the prevailing industrial characteristics. Technology-intensive industries have the longest production chains and thus they are most heavily dependent on the producer service sector. Therefore, the development of the producer service sector could decrease trade costs, thereby promoting manufacturing agglomeration more effectively.

Second, for capital-intensive industries, the mediating effects of trade costs are significant in terms of the transport, storage, and postal and wholesale and retail trades sectors affecting manufacturing agglomeration. Moreover, although the finance sector is positively related to manufacturing agglomeration, the mediating effect is not significant. Thus, the enhancement of the financial sector positively and directly affects manufacturing agglomeration, but not via a change in trade costs. This can again be explained by the prevailing industry characteristics. Capital-intensive industries are heavily dependent on the finance sector. However, this kind of dependence is more concentrated on the production process (that is, large and expensive equipment, investment requirements) instead of the downstream production chain. Thus, a positive direct effect exists instead of a mediating effect.

Third, for labor-intensive industries, the mediating effects of trade costs are significant only in terms of the transport, storage, and postal sector affecting manufacturing agglomeration. This result might be because the added value of this kind of industry is relatively low and thus it is more sensitive to changes in transport costs. Meanwhile, a labor-intensive industry with the shortest chain benefits less owing to a weaker

connection with producer services; thus, its mediating effect is not significant compared with the other two producer services.

V. Concluding remarks

In conclusion, four of the findings presented herein should be stressed. Firstly, producer services play a crucial role not only in the daily running of manufacturing activities but also in the geographical concentration of manufacturing firms or manufacturing agglomeration. From the viewpoint of NEG, producer services do not directly affect manufacturing agglomeration but rather do it indirectly via trade costs. Logically, as the sorts of services that rely on manufacturing activities, the development and agglomeration of producer services that can change in the first step are trade costs that manufacturing activities involve. In the second step, their effects could then be channeled to manufacturing by changing trade costs. From this objective, trade costs act as a mediator variable between the two sectors, especially in the process of manufacturing agglomeration.

Secondly, a simple model can be built following the mediation modeling carried out by experts in the statistics field. With such a model, a chained linkage among the three sets of key variables, namely improvement in producer services, trade costs, and manufacturing agglomeration, could be traced, and the mechanism of the formation and transmission of the related effects from producer services to manufacturing agglomeration could be depicted. This finding conforms to the tradition of the NEG, which stresses the important role of trade costs in the agglomeration of economic activities. In this sense, this finding and the related mechanism analysis stresses the analytical importance of exogenous variable in the framework of the NEG model.

Thirdly, the empirical testing of the mediator effects of trade costs on the causation from producer services to manufacturing agglomeration can borrow ideas from psychology research and follow a “stepwise procedure.” Three steps are involved in the test, and each plays a kind of “backup” role to the others in the procedure. This increases the probability of the accuracy of the tests.

Fourthly, the empirical tests using the data from China strongly support the chained mechanism reasoning and prove the existence of mediator effects. A positive connection can be seen from producer services’ improvements to manufacturing agglomeration via the tests of the mediator effects. The test results also show that the mediator effects of trade costs from such services as the transport, storage, and postal sector are more significant than that from other producer service sectors in China. Further tests that consider the difference in sector factor intensiveness might also support the hypothesis. Moreover, the mediator effects of trade costs are more significant in technology-intensive industries than they are in capital- and labor-intensive ones. This shows that outsourcing producer services can effectively reduce trade costs and positively affect manufacturing agglomeration.

For local governmental intervention with regional industrial development in China, these conclusions lead to at least two important implications. Firstly, policy that targets the promotion of clusters of manufacturing firms should pay more attention to the development of producer services. Secondly, an effective way to promote manufacturing upgrading, especially technology upgrading, is to encourage the development of the producer service sector. Our result shows that compared with capital- and labor-intensive manufacturing industries, the mediator effects of trade costs are larger in technology-intensive manufacturing sectors. This means that the development of the producer service sector would benefit the development of technology-intensive industries and enhance industrial upgrading through the agglomeration economy. This might be a better approach than traditional ways such as enhancing technology investment and R&D inputs.

However, the preliminary empirical work in this paper is far from complete, which leaves a number of imperfections for further study. One such imperfection is the lack of reciprocal testing between the two sorts of industries. We only assessed the mediator effects that trade costs carry from the producer service sector to manufacturing and not the effects from the manufacturing sector to producer services. This and other similar defects in our work are open to suggestions from readers.

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Attachment:

A. table 1 Gini coefficient of three major producer services sectors（1995-2000）

Year	transportation Gini coefficient	financial Gini coefficient	manufacturing Gini coefficient
1995	0.006004	0.003457	0.007162
1996	0.005935	0.003546	0.007176
1997	0.007081	0.004317	0.007568
1998	0.006602	0.004476	0.006686
1999	0.006758	0.004435	0.006884
2000	0.006761	0.004439	0.00733
平均	0.006524	0.004262	0.007134

Source: calculated according to the data from the State Statistics Bureau of China, *China Statistical Yearbook*, related years.

A. table 2 Gini coefficient of 28 manufacturing sectors in China (2001-2009）

year sectors*	2001	2002	2003	2004	2005	2006	2007	2008	2009
13 Agro-food processing	0.0244	0.0473	0.0362	0.0428	0.0495	0.0495	0.0457	0.0436	0.0421
14 food	0.0158	0.0164	0.0137	0.0127	0.0140	0.0165	0.0164	0.0143	0.0132
15 beverage	0.0084	0.0097	0.0091	0.0090	0.0086	0.0076	0.0056	0.0056	0.0064
16 tobacco	0.0181	0.0177	0.0178	0.0208	0.0208	0.0212	0.0239	0.0276	0.0251
17 textile	0.0346	0.0386	0.0444	0.0479	0.0548	0.0571	0.0586	0.0609	0.0577
18garments, Footwear and Headgear	0.0907	0.0891	0.0905	0.0858	0.0867	0.0865	0.0829	0.0827	0.0769
19 leather, fur, feathers	0.1155	0.1338	0.1383	0.1327	0.1429	0.1414	0.1366	0.1396	0.1316
20 wood, bamboo, grass products	0.0219	0.0244	0.0337	0.0272	0.0272	0.0274	0.0249	0.0305	0.0243
21 Furniture Manufacturing	0.0568	0.0717	0.0818	0.0993	0.1115	0.1070	0.1103	0.1062	0.0924
22 Paper and Paper Products	0.0186	0.0216	0.0234	0.0270	0.0314	0.0294	0.0302	0.0316	0.0275
23 printing, recording medias	0.0204	0.0251	0.0373	0.0492	0.0532	0.0641	0.0688	0.0708	0.0612
24 Educational and Sports Goods	0.2210	0.2088	0.2037	0.2049	0.2188	0.2078	0.2011	0.2211	0.2098
25 petroleum processing, coking and nuclear fuel	0.0440	0.0457	0.0525	0.0544	0.0602	0.0671	0.0630	0.0536	0.0564

processing									
26Chemical materials and chemical products	0.0100	0.0112	0.0116	0.0119	0.0124	0.0135	0.0135	0.0147	0.0145
27 pharmaceutical	0.0080	0.0088	0.0092	0.0084	0.0081	0.0082	0.0077	0.0081	0.0083
28 chemical fiber manufacturing	0.0381	0.0470	0.0572	0.0624	0.0756	0.0832	0.0790	0.1001	0.1059
29 Rubber Products	0.0278	0.0341	0.0362	0.0370	0.0415	0.0418	0.0401	0.0403	0.0378
30 plastic products	0.0650	0.0717	0.0819	0.0801	0.0908	0.0880	0.0967	0.1043	0.0954
31 non-metallic mineral products	0.0058	0.0060	0.0073	0.0084	0.0091	0.0102	0.0182	0.0098	0.0087
32 ferrous metal smelting and rolling processing	0.0269	0.0261	0.0251	0.0245	0.0243	0.0256	0.0263	0.0262	0.0267
33 non-ferrous metal and rolling processing	0.0138	0.0142	0.0133	0.0116	0.0107	0.0099	0.0082	0.0087	0.0082
34 metal products	0.0460	0.0533	0.0592	0.0640	0.0723	0.0766	0.0809	0.0726	0.0635
35 general equipments	0.0284	0.0312	0.0350	0.0404	0.0422	0.0438	0.0437	0.0428	0.0395
36 special equipments	0.0195	0.0199	0.0131	0.0159	0.0184	0.0195	0.0203	0.0225	0.0195
37 transport equipments	0.0180	0.0179	0.0177	0.0198	0.0206	0.0205	0.0203	0.0219	0.0196
39 electrical machinery and equipment manufacturing	0.0548	0.0622	0.0823	0.0909	0.1104	0.1203	0.1164	0.1065	0.0944
40 communications, computers and other electronic equipment	0.1245	0.1448	0.1536	0.1622	0.1932	0.1859	0.1779	0.1813	0.1797
41 Instrumentation and culture, office machinery	0.0437	0.0518	0.0894	0.0953	0.0975	0.0985	0.0980	0.0915	0.0841

Note: * official classification of industries.

Source: *China Industrial Economic Yearbook*, related years.

A. Table 3 **output shares of manufacturing sector and producer service in provincial regions, 2009**

	Manufacturing industry		Producer service	
	%	Regional sequence	%	Regional sequence
Guangdong	13.01	1	8.67	2
Shandong	9.89	2	5.69	3
Zhejiang	9.52	3	5.11	5
Jiangsu	8.71	4	4.64	7
Fujian	6.63	5	2.66	16
Henan	4.50	6	5.18	4

Liaoning	4.12	7	4.14	8
Sichuan	3.58	8	3.69	11
Shanghai	3.43	9	4.84	6
Hubei	3.42	10	3.86	9
Hebei	3.36	11	3.72	10
Hunan	2.84	12	3.12	13
Beijing	2.84	13	11.74	**1**
Shaanxi	2.36	14	2.92	15
Heilongjiang	2.22	15	3.46	12
Shanxi	2.03	16	3.11	14
Anhui	2.03	17	2.32	19
Tianjin	2.02	18	1.87	24
Jiangxi	1.97	19	1.93	23
Jilin	1.72	20	2.22	20
Yunnan	1.69	21	2.39	18
Guangxi	1.65	22	2.46	17
Chongqing	1.63	23	1.95	22
Gansu	1.13	24	1.44	27
Inner Mongolia	1.10	25	2.00	21
Guizhou	1.06	26	1.61	25
Xinjiang	0.72	27	1.56	26
Ningxia	0.31	28	0.44	30
Qinghai	0.25	29	0.48	29
Hainan	0.22	30	0.64	28
Tibet	0.02	31	0.14	31

Source: State Statistics Bauru, *China Statistical Yearbook*, 2009.