Informatization, Production Network Externalities and Regional Logistics*

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***Abstract* -This paper has established a Logistics Information demand model based on information technology network externalities to explain that information technology network externalities has made the logistics firms join the momentum of the information network. And based on the panel data from 1995to 2006 across 30 China provinces, the paper use panel root test and panel cointegration technology to demonstrate that the production network externalities exist reasonably in the regional logistics.**

Keywords- Regional logistics; Informationization; Production Network Externalities; Panel cointegration.

I. INTRODUCTION

In the new century, China has established the policy of industrialization and informationization. What is the motivity of informationization in terms of regional logistics. So far, there is an explaination from the standpoint of management that logistics digitalization boosts logistics output by improving logistics management and service efficiency and by reducing energy consumption with information technology. This paper think this kind of explaination doesn't reflect production network externality taken by logistics informationization.

Logistics industry requiring good cooperation and information sharing is different from other industry, which includes transportation, storage, loading and unloading, transit, packaging, circulation and machining, distribution and information disposal. Informationization promote regional logistics from two aspects: it reduces the costs of transportation, distribution, storage and labor; it also brings network externality by providing good condition for cooperation in the industry and integrating resource and market with information integration. Network externality means that the income of each logistics manufacturer entering information network brought by informationization with the popularization of logistics digitalization. But so far there are few literatures to analyze this problem with proper models. This paper tries to establish a theoretical model to cover the shortage.

The rest of this article is laid out as follows: a brief account of existed literatures and the research foundation of this paper is given in part two; in part three, we set up a theoretical model and analyze the conclusion; we have a empirical analysis in part four; the final part provides a brief conclusion.

II. LOGISTICS INFORMATION DEMAND MODEL BASED ON INFORMATION TECHNOLOGY NETWORK EXTERNALIES

Let there are M logistics factories. To the factory i=1,2,…,M,

$$x_i = \begin{cases} 0 & \text{if factory i isn't inf ormtionizated} \\ 1 & \text{if factory i is inf ormationizated} \end{cases}$$

Suppose that logistics factory i plan to produce Y_i with input of capital K_i, labor L_i, information I_i. In order to simulate network externality of logistics informationization, this paper establishes two Cobb-Douglas production function:

$$Y_i = AI_i^{\gamma} K_i^{\alpha} L_i^{\beta} \tag{1}$$

where $I_i = (\sum_{j \neq i} I_{ij}) x_i + 1$, it indicates available information that the factory can get from information integration. I_{ij} denotes the information that factory i get from factory j after entering information network. Suppose that the quantity of information obtained by other ways is 1.

When $x_i = 0$, the output of factory i who isn't informationizated is

$$Y_i^0 = AK_i^{\alpha} L_i^{\beta} \tag{2}$$

When $x_i = 1$, the output of factory i who is informationizated is

$$Y_i^1 = A(\sum_{j \neq i} I_{ij} + 1)^{\gamma} K_i^{\alpha} L_i^{\beta} \tag{3}$$

It can be seen from the definition formula that the output depends on capital, labor, information and whether other factories are informationization or not. In addition, suppose

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that both production function has monotony: $\partial Y_i / \partial K_i \geq 0$, $\partial Y_i / \partial L_i \geq 0$, $Y_i^0 \leq Y_i^1$.

In order to underline network externality, suppose as to all $i \neq j$, $\partial Y_i / \partial x_j \geq 0$, that is, with new factories entering, the output of existed factories who have been informationizated will not be reduced.

Suppose factory i aims at maximum profit. The prices of logistics service, capital(K) and labor(L) are respectively P, r and w which are assumed to be constant. The price of information is a variable p depending on the amount of the factories in the information network. That is

$$p = a - b\sum_{j \neq i} x_j \tag{4}$$

$$\pi_i = PY_i - (px_i + rK_i + wL_i) \tag{5}$$

Substituting (1) into (2), we obtain

$$\begin{aligned} \pi_i &= PA[(\sum_{j \neq i}^{n} I_{ij})x_i + 1]^{\gamma} K_i^{\alpha} L_i^{\beta} - [px_i + rK_i + wL_i] \\ &= \begin{cases} PAK_i^{\alpha} L_i^{\beta} - (rK_i + wL_i) & x_i = 0 \\ PAK_i^{\alpha} L_i^{\beta} (\sum_{j=1}^{n} I_{ij} + 1)^{\gamma} - [p + rK_i + wL_i] & x_i = 1 \end{cases} \end{aligned} \tag{6}$$

Under the restriction of manufacturer's cost, we suppose that $\hat{\pi}_i$ denotes the estimated maximum. Let $\hat{\pi}_i(x = 0) = \hat{\pi}_i^0$, $\hat{\pi}_i(x = 1) = \hat{\pi}_i^1$.

Formula (6) can be expanded with the application of Maclaurin formula. We obtain

$$\left(\sum_{j \neq i} I_{ij} + 1\right)^{\gamma} \approx 1 + \gamma \sum_{j \neq i} I_{ij} + \gamma(\gamma - 1)\left(\sum_{j \neq i} I_{ij}\right)^2 / 2! \tag{7}$$

Then

$$\begin{aligned} \hat{\pi}_i^1 &= \hat{\pi}_i^0 - (a - b\sum_{j \neq i} x_j) \\ &\quad + PAK_i^{\alpha} L_i^{\beta} \left[\gamma \sum_{j \neq i} I_{ij} + \gamma(\gamma - 1)(\sum_{j \neq i} I_{ij})^2 / 2!\right] \end{aligned} \tag{8}$$

Due to factory i aiming at maximum profit, factory i chooses to be informationizated when $\hat{\pi}_i^1 \geq \hat{\pi}_i^0$ and refuses it when $\hat{\pi}_i^1 < \hat{\pi}_i^0$. Suppose any factory gets same amount information I_{ij} from other factory, then $\sum_{i \neq j} I_{ij} = NI_{ij}$, $\sum_{j \neq i} x_j = N$, where N denotes existing information network size. Factory i 's informationization demand can be denoted by

$$x_i = \begin{cases} 0 & if \ f(N, I_{ij}) < a \\ 1 & if \ f(N, I_{ij}) > a \end{cases} \tag{9}$$

To simplify the formula, let

$$f(N, I_{ij}) = PAK_i^{\alpha} L_i^{\beta} \left(\gamma NI_{ij} + \gamma(\gamma - 1)(NI_{ij})^2 / 2!\right) + bN.$$

Then formula (8) indicates two meanings: first of all, for logistics factory i aiming at maximum profit under the restriction of cost, its desire to be informationizated will rise with the amount of information consumers, which just reflects the concept of network externality; each of network users take the advantage of entering network into account and ignore the externality due to their entry. Thanks to their entry, the scale of the network becames bigger and then the efficiency of information network is improved. Secondly, the model doesn't always arrive at the equilibrium that informationization will be realized in regional logistics. On one hand, if the initial condition is that information network size N is big enough so that it not only satisfies those existing users, but also makes potential users join in it. And N will increase until $f(N, I_{ij}) = a$. On the other hand, if the initial condition N is very small, then $f(N, I_{ij})$ will dwindle with N, which will make N decrease until $N = 0$. Rohlfs(1997) refered to the ratio N/M of the logistics factories in information network and all of them in the region as network service critical ratio when it comes to equilibrium. Namely, only when the scale of information network exceeds critical ratio, network service can be self-strengthened. However critical ratio increases with the price so that it is very difficult that the network arrives the state of being strengthened.

III. Empirical Tests

A. *Econometrical Model*

According to the above theoretical model, we obtain the following econometrical model of production function that includes three elements of production.

$$\log Y_{it} = \alpha + \beta_K \log K_{it} + \beta_L \log L_{it} + \beta_I \log I_{it} + \gamma_N \log N_{it} + \varepsilon_{it} \tag{10}$$

Where Y_{it}, L_{it}, K_{it}, I_{it} and N_{it} are respectively output, labor, capital, information service and information network size. The unknown parameters to be estimated, α, β and γ, are respectively output elasticity of labor, capital and information service.

To draw a more robust conclusion, this paper uses the new method of panel root test and panel cointegration based on the panel data.

B. *Data*

We collect yearly data from China statistical yearbook, which include gross regional product(logistics output Y), staff and workers (labor L) and total investment in fixed

assets (capital K) in the industry of transport, storage, post and telecommunication services, represent information service with business volume of post and telecommunications.

Due to no index and data of logistics information network scale, we take internet online population for the potential logistics information network size N. In light of the fact that China began to develop information technology from the mid 90s in last century, the sample period is 1995-2006 and the panel data cover the provinces / municipalities / autonomous regions of Beijing, Tianjin, Hebei, Shaanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Sichuan, Guizhou, Yunnan, Shanxi, Gansu, Qinghai, Ningxia and Xinjiang. We have excluded those whose statistical data do not at present meet our needs.

C. Empirical Results.

Before cointegration test, we should test whether the variables are stationary and do unit root tests. If the variables are nonstationary, which means unit root, we can go ahead to take cointegration test. The commonly used unit root tests based on a single time series lack power in distinguishing the unit root null from stationary alternatives, and using panel data unit root tests is one way of increasing the power of the former. To guarantee the robustness of the conclusion, this paper uses LLC test, Breitung test, IPS test, Fisher-ADF test and Fisher-PP test. The results are shown in Table I.

TABLE I Panel Unit Root Tests

Variable		Levin, Lin & Chu t*	Breitung t-stat	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP – Fisher Chi-square
lnY	Level	-4.6915 (0.0000)	-1.0588 (0.1448)	0.8395 (0.7994)	71.5797 (0.1455)	169.033 (0.0000)
	Difference	-1.8634 (0.0312)	-3.4273 (0.0003)	-0.6366 (0.2622)	80.5409 (0.0396)	210.015 (0.0000)
lnK	Level	-2.3044 (0.0106)	-1.7100 (0.0436)	3.2933 (0.9995)	27.7747 (0.9999)	60.3398 (0.4634)
	Difference	-9.9177 (0.0000)	-5.718 (0.0000)	-5.1180 (0.0000)	127.043 (0.0000)	262.692 (0.0000)
lnL	Level	-6.9608 (0.0000)	0.4362 (0.6687)	-1.7617 (0.0391)	71.1763 (0.1531)	67.7119 (0.2308)
	Difference	-11.8102 (0.0000)	-5.69 (0.0000)	-5.16824 (0.0000)	132.188 (0.0000)	232.114 (0.0000)
lnI	Level	-7.4027 (0.0000)	-0.1101 (0.4562)	1.5420 (0.9385)	41.7602 (0.9648)	68.4136 (0.2133)
	Difference	-1.1839 (0.1182)	-4.6240 (0.0000)	-1.3131 (0.0946)	66.6159 (0.26)	218.932 (0.0000)
lnN	Level	0.1112 (0.5443)	-0.7889 (0.2151)		24.2158 (1.0000)	2.49293 (1.0000)
	Difference	-10.0068 (0.0000)	-3.10355 (0.001)		148.376 (0.0000)	120.89 (0.0000)

Notes: The regressions of lnY, lnK, lnL and lnI all include an intercept term. The regression of lnN includes no intercept and linear time trend. P-values are in parentheses.

Table I reports the results of the unit root tests for individual regions. The results show that we can't reject the null hypothesis of unit roots when the tested objects are in level. When the tested panel data are differenced, we can reject the null hypothesis significantly. Therefore lnY, lnK, lnL, lnI and lnN are integrated of order one. Because these panel data are nonstationary, using OLS estimation will lead to spurious regression. So we should analyze cointegration between these variables, before going ahead to study their long-run relationship.

This paper tests for cointegration based on panel unit root tests to judge whether there is long-run relationship between these nonstationary series. In this paper, we use the residual-based tests for the null of no cointegration developed by Pedroni (1999, 2004) who constructed seven statistics. Table II reports the results of the cointegration tests.

TABLE II PANEL COINTEGRATION TESTS

Panel v-stat	Panel rho-stat	Panel pp-stat	Panel adf-stat	Group rho-stat	Group pp-stat	Group adf-stat
-1.19220	2.62483	-6.65619	-3.40945	5.09446	-7.54184	-8.11011

According to Pedroni(1999), the small sample test power of panel adf-stat, group adf-stat is highest, while the test power of panel v-stat and group rho-stat is lowest. The rest are in the middle position. Under the alternative hypothesis, the panel variance statistic diverges to positive infinity, and consequently the right tail of the normal distribution is used to reject the null hypothesis. For each of the other six test statistics, these diverge to negative infinity under the alternative hypothesis and consequently the left tail of the normal distribution is used to reject the null hypothesis. The critical value under 10%, 5% and 1% significant level are respectively 1.625, 1.96 and 2.58. From Table 2, we obtain that panel adf-stat, group adf-stat, panel pp-stat, group pp-stat all reject the null hypothesis under the significant level of one percent. Therefore it can be deduced that there exists panel cointegration. How do the variables effect each other? This paper use the new method of between-dimension FMOLS suggested by Pedroni(2000,2001) which has advantages over the other estimators in the presence of heterogeneity of the residual dynamics around the cointegrating vector. Table III reports the results of panel FMOLS estimation.

TABLE III Panel FMOLS Estimation

lnK	lnL	lnI	lnN
0.02(-58.35)	0.24(-28.36)	0.33(-43.04)	0.04(-265.21)

Notes: t-statistics are in parentheses.

From Table III, We can see:

Firstly, the estimated coefficients of capital, labor, information service are significantly positive which are consistent with theoretical anticipation. Therefore this paper's analysis is meaningful. The estimated coefficients are respectively 0.02, 0.24, 0.33, which proves that the product function of regional logistics is diminishing returns to scale, and that regional logistics is labor-intentive.

Secondly, it is found in this paper that the coefficient of network size is positive, which proves there exists technology network externalities. It also follows that the main impetus of using information network technology for the logistics factory is that it can get benefit from other factories' entry into the network.

IV. CONCLUSION

In this paper, both the theoretical model and econometrical tests prove that there are technology network externalities in the production function of regional logistics. That is, when some factories adopt information technology, they will obtain profit from other's entry.

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