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Contribution of Logistics Infrastructure to Industrial Development in China

Yaping Yu* Hojung Shin** Fakulie Alfred Jawara***

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| Abstract |

Logistics is considered the "accelerator" of economic development and a steppingstone for sustaining national or regional economic strength. This study explores the impacts of logistics infrastructure on industrial development in China from the following four dimensions: the empirical associations between logistics infrastructureand 1) economic growth, 2) household consumption expenditure, 3) distribution of human resources,and 4) labor productivity within the three strata of industries. We analyze secondary time-series data collected by the National Bureau of Statistics of China and selected variables such as value-added of the logistics industry,

* First Author: Master of Science, Dept. of Logistics, Service & Operations Management (LSOM) Korea University Business School, Korea University.
** Corresponding Author: Professor, Dept. of Logistics, Service & Operations Management (LSOM) Korea University Business School, Korea University.
*** Co-Author: Ph.D. Candidate, Dept. of Logistics, Service & Operations Management (LSOM) Korea University Business School, Korea University.

freight traffic, freight ton-kilometers, and investment in fixed asset in the logistics industry. We then conduct regression analysis to show the impact of logistics infrastructure on industrial development in China. We find that the logistics infrastructure plays a positive role in promoting the performance of the three strata of industries. However, the value-added logistics had no effect on the labor flow to the secondary and the tertiary industries although the workforce of the primary industry has declined gradually with the increase of the value-added logistics. Finally, the logistics infrastructure also greatly affected the labor productivity since logistics has improved efficiency in material flows.

▪ Key words: China, Logistics Infrastructure, Industrial Development, Industrial Structure Optimization, Industrial Structure Rationalization

I. Introduction

The globalization of manufacturing and economic trade has accelerated the flow of materials leading to the flourishing of the logistics industry around the world, including China (Shi et al. 2016). The Central Government of China places great significance on logistics, recognizing it as the “third profit source” after raw materials and labor (Chu 2012; Zhongfu 2009). As more companies started manufacturing in China, they outsource their logistics operations to 3PL firms (Wilson & Roy 2009), creating more demand for logistics services. According to the National Bureau of Statistics and the China Federation of Logistics and Purchasing’s statistics reports, China’s total value-added logistics industry reached 158.7 trillion yuan in 2005 with an average annual growth of 23% since 1984 (Hu & Wu 2009).

In 2006, the Eleventh Five-Year Plan defined China’s modern logistics

industry. With the national implementation of the Eleventh Five-Year Plan, China's economic development entered a new era — a vigorous market-oriented economy. In addition, new development opportunities for the economy have also provided broader space for the development of the logistics industry (Wang 2007). In March 2009, the State Council announced, "the logistics industry restructuring and revitalization plan," in which the logistics industry was included in the top ten industrial revitalization plan, reflecting the Chinese authorities' efforts to leverage logistics as an instrument for economic development.

The relationship between logistics and the national economy of China has drawn strong attention of both the academia and the government. However, the empirical research that attempts to quantify the contribution of logistics to China's economic growth is extremely scant. According to the theory of industrial structure, the economy of a nation is supported by its own industrial structure in which the associations of all industries are woven by the modes of connection (Dang et al. 2010). The industrial structure is not stationary, rather evolves, leveraged by such factors as sector-biased technological progress, international trade, and changing factor costs across the economic sectors. As such, an effective allocation of resources and relocation of labor would be reflected by changes in the industrial structure (Święcki 2017). Researchers in economics commonly agree that structural motivations (determinants) lead to changes in the industrial structure and that these changes are manifested through the allocation of resources and self-adjusting labor (Dang et al. 2010). Nonetheless, the fact that these changes can be facilitated, synergized, or even mitigated by the effectiveness of logistics, is often neglected in the literature. Indeed, the logistics industry can be considered as a means of connecting all industries.

The main objective of this study is to explore the empirical associations between the coordinated development of the logistics

industry and the national economy of China. Specifically, we calibrate the contribution of the Chinese logistic industry to the three economic sectors (i.e., the primary, the secondary, and the tertiary industries). The Chinese logistics industry has developed rapidly, evolving from its infant stage to the current, but the industry still faces some challenges such as political guanxi and intervention on logistics innovation (Chu et al. 2018), scarcity of qualified logistics personnel (Hensher et al. 2015), and uneven regional development (Chu 2012; Cui & Song 2017). In particular, the inquiry of whether uneven development in the Chinese economy can be explained by the relative contribution of logistics to each economic sector is a genuine empirical question, given that the extant research on the logistics industry in China is focused on enterprise logistics and regional development (e.g., Cui & Song 2017). In this context, the findings of this study will shed light on the future directions of economic development in China as well as other nations that would initiate the transition from central planning to market economy.

Ⅱ. Research Background and the Literature Review

The contribution of logistics to the Chinese economy has been realized in various aspects through 1) reduction in the costs of economic operations, 2) support to development of the national economy, and 3) the acceleration of economic growth. In fact, the level of an economy's logistics development has become a proxy for measuring the degree of modernization and comprehensive national strength.

Economists have studied the relationship between logistics and the economy in various aspects. Adam Smith states that the development of

a country's commerce is largely dependent upon well-developed roads, bridges, canals, harbors, and all public works (Smith 1776). He is one of the pioneers who described the relationship between economic development and logistics infrastructure in promoting commodity circulation, under the premise that logistics expenditure has a positive impact on national wealth. Furthermore, with the interconnection of local and global economies, logistics has become a necessary condition to improve the wealth of nations. Some developing countries that built high-tech logistics capabilities were able to increase their national strength (Klaus 2009). For instance, the rapid economic growth of Singapore and Hong Kong is partly due to the prior investments that they made in logistics (Carruthers et al. 2003). Efficient logistical services can improve an economy by increasing inventory turnover rates and lowering the inventory level of finished goods (Kisperska-Moron 1994).

In the 1970s, more efficient transportation modes replaced obsolete ones and logistics emerged as one of the important global economic elements (Pedersen 2001). In many developing countries, inadequate transport facilities are some of the major bottlenecks in socioeconomic development and national integration. The lack of transport facilities made it difficult to introduce other social services such as education and health care facilities. The spread of modern technology and the links among different economic sectors were hampered by the lack of transport facilities (Ahmed 1976).

The integration of high-tech and new management technologies led to new industries in which modern logistics has been widely utilized. Tavasszy (2003) proposed that it is necessary for a logistics chain to change continually to facilitate global circulation of commodities. The trend of logistics services, such as product customization and rapid order response, would influence technology development and welfare growth of different regions. Furthermore, the interactions among trade, logistics, and

regional development from the global perspective can be synergized through efficient transportation and advanced logistics (Tavasszy et al. 2003). Aschauer (1989) examined the relationship between government investment and productivity growth in the U.S. by using time-series data from 1984 to 1985 and found that the government investment in the public infrastructure, especially transport infrastructure, has a significant impact on its productivity growth.

Over the period of China's economic development during the planned economy, the logistics industry did not receive much attention. China's logistics system has undergone enormous changes since 1980s as the market economy system was gradually established and traditional structures began to be replaced (Pagano 2008). However, the rapid economic development has affected its economic and political prospects, bringing the challenges of social and macroeconomic transformation (Luger 2008). For example, China's regional development is extraordinarily uneven. This uneven development can be attributed to the imbalanced development of geographical transportation and communication networks. This further reflects the vital role of transportation and logistics for economic development (Demurger 2001).

1. Theory of industrial development

(1) Connotation of industrial structure optimization

Industrial structure optimization is an adjustment process in which the uncoordinated technical economy and the imbalanced proportion among the industries gradually become coordinated. In addition, the adjustment process of inter-industry and intra-industry structures, evolving from low levels to higher levels, promotes the coordinated development of industrial structure, resource demand structure, technology structure, and

employment structure (Xia 2010).

In different industrial sectors, the level of differences in effectiveness among the input factors — for instance, technical knowledge, labor productivity, the quality of workers and so on — can be critical. Through coordination of these input factors, the optimization of industrial structure can be fostered (Fan et al. 2014). In fact, the coordinated development pertains to the continuous development of economic structures for the entire society, while continuously coping with technological progress, social resource accumulation, and adaptability to market demand changes (Zhang & Wang 2009). This coordinated development promotes the rationalization of industrial structure and industrial structure advancement through the allocation and reallocation of resources (Dang et al. 2010).

(2) Industrial structure rationalization and advancement

Industrial structure optimization refers to the process of promoting industrial structure rationalization and advancement. The process of industrial structure optimization is to adjust the supply and demand structure, realize optimal allocation and reallocation of resources, and push forward the development of industrial structure rationalization and advancement.

Typically, rationalization and advancement are the criteria to measure the status or the change in the industrial structure (Wang et al. 2020).

Industrial structure rationalization pertains to the adjustment of the inconsistent industrial structure, mainly according to the technical and economic ratio of industry linkage. Industrial rationalization promotes a balanced development among various industries in the national economy. Accordingly, there must be a “standard model of industrial structure” that can be achieved through the effective allocation of resources, inter-industry level correlations, and dynamic balancing of sub-industries

(Chenery 1960). In contrast, industrial structure advancement refers to the dynamic process that the general status of industrial structure constantly improves toward a more advanced stage (Li 2019). Technology innovation, income demand elasticity, income gap between industries, and comparative advantage in international trade can be the driving forces behind transformation and advancement of industrial structure (Kuznets 1971). The industrial structure constantly evolves to a superior structure with knowledgeable, economic service and high value-added advancement through the efficient use of resources (Chen & Zhang 2006).

It is reasonable to state that rationalization of industrial structure takes coordination as the center while the advancement in industrial structure is centered on the ideas of evolution and transformation. Practically, a reasonable industrial structure does not necessarily aim at an absolute balance among the industries, but refers to strong coordination and complementarity among the industries (Dang et al. 2010), possibly through vertical flows of resources and labor. From the static point of view, the three economic sectors (the primary, the secondary, and the tertiary industries) and the proportion of each sector are supposed to be coordinated to meet the inherent development needs for the national economy. Moreover, from the dynamic point of view, the growth and development of inter-industries and intra-industries should be coordinated based on industrial ties to better reflect the relationship between input and output.

In contrast, the capability of transformation to advance industrial structure can be enhanced not merely by resource and labor flows, but by improvement in the technical level in order to achieve the orderly change of dominant position among the sectors. The industrial structure has gradually evolved from the primary industry to the secondary industry and then to the tertiary industry. The density of industrial production factors transforms from labor-intensive, capital-intensive, technology-

intensive to knowledge-intensive factors. Moreover, industrial technology density also evolves from low value-added to high value-added industries (Faming 2009).

2. Relationship between logistics infrastructure and industrial development

Industrial structure continues to adjust along with the development of an economy. As part of the tertiary industry, the steady development of the logistics industry will promote the sustainable development of related industries. Through the continuous integration with high-tech and innovation management, the proportion of the tertiary industry within the national economy has remarkably increased. For instance, the government of China embarked on measures to adjust its industrial structure to save energy and reduce CO2 emission (Mi et al. 2015; Jin 2012; Zhao & Niu 2013). Based on the theory and anecdotal evidence, we develop the following four propositions.

(1) Influence on development of the three strata of industries

As an integral part of the tertiary industry, the development of logistics boosts the growth of the tertiary industry output. Simultaneously, the costs of production and transaction are reduced along with the increase of circulation efficiency. Moreover, the efficiency and success of both the primary and secondary industries also depend on logistics. Modern logistics industry integrates a variety of loose transports, warehouses, and other logistics elements through high-tech means to ameliorate traditional logistics. The investment in the logistics infrastructure promotes the efficiency of material circulation, which strengthens the linkage between logistics and other industries, thus

driving the development of the primary and the secondary industries.

Proposition 1: Logistics not only augments the output of the tertiary industry, but also improves the development of the primary and the secondary industries.

(2) Influence on national consumption

Development of the logistics industry will expand consumers' purchasing opportunities because logistics serves as a bridge linking production, sales, and consumption. The reduction of transportation and storage costs owing to efficient logistics provides consumers with Pareto-efficient opportunities in which the same quality commodities and products can be acquired with lower expenditures. In addition, the value-added services extended by modern logistics can also bring more convenience to consumers. For example, third-party expert logistics systems can offer industrial customers with more competent management services as the systems eventually gain economies of scale in transportation and warehousing. Leveraged by information technology, third-party logistics providers have established online platforms where matchmaking among suppliers, manufacturers, and customers can be customized depending on the needs of the platform participants. The online platforms in the logistics industry also enable the participants to communicate efficiently and effectively. For instance, the information of product quality problems, road conditions, emergent delivery requirements, and potential supply chain disruptions can be disseminated quickly among the supply chain participants. Therefore, it is reasonable to assume that logistics contributes to stimulating and increasing consumption in the private sector.

Proposition 2: The increased access for making purchases brought about by logistics infrastructure to consumers, can lead to increase in household consumption.

(3) Influence on labor distribution

Logistics can generate a great deal of demand for high-quality talent and can contribute to the transferring of surplus labor from the primary industry to other industries, making the market structure of human resources continue to optimize and creating conditions for industrial development. As a continually emerging component of the service sector, the logistics industry has expanded its scope to include core and peripheral activities in transportation, storage, loading, packaging, distribution, and information and data processing. In addition, the current initiatives for automation and digital transformation of logistics processes have led to an increase in the number of high-quality and hi-tech practitioners in this industry. The intake of competitive human resources may have contributed to rationalizing the three strata of industries. That is, the logistics industry in China may have absorbed an increasing amount of quality labor force from the primary and the secondary industries. Those labor force transfers helped China not only to rationalize the distribution of labor, but also move forward to an advanced stage of industrial structure, a benchmark from the western industrialized societies.

Proposition 3: The demand for talent in the development of logistics promotes the labor force to flow from the primary industry to the secondary and the tertiary industries.

(4) Influence on labor productivity

The supply of quality labor has a far-reaching impact on the industrial structure advancement. High-quality labor supply to an industry can accelerate modernization of the industrial structure from labor-intensive industry to technology-intensive ones. In this context, labor productivity often serves as a significant indicator for evaluating the overall fitness of industrial structure. It has been commonly found in many regional economies that labor productivity is gradually increasing commensurate with technological advances. A plausible explanation for this phenomenon is that technical assistance from the capital-intensive machines and technology helps upgrade the given labor force, resulting in better productivity. At the level of a nation, the same phenomenon can be explained by the dynamic distribution of labor among the industries. For instance, a conjecture in this study is that a nation's labor productivity improves as less labor is concentrated in labor-intensive industries and more labor is transferred to technology-intensive and knowledge-intensive industries. Of course, the labor shifts among the industries can be synergized by the development of logistics infrastructure.

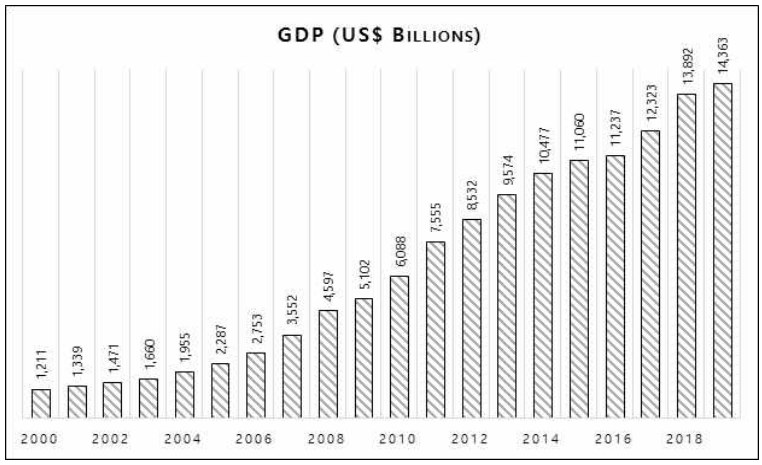
Proposition 4: The investment in logistics infrastructure and the application of science and technology can improve labor productivity in the three strata of industries.

Ⅲ. China's Economic Development Status

Manufacturing and logistics operate symbiotically. The Growth of the manufacturing industry necessitates suppliers' or 3PL's responsive deliveries of raw materials and components as well as physical

distribution systems by which outbound logistics activities connect to end users. Likewise, the logistics industry's flourishing depends on the progress of manufacturing industry. The manufacturing industry not only creates machines and equipment to be used in the logistics industry, but also triggers a great deal of material flows in the supply chain which form the sources of revenue for logistics firms. Therefore, it is natural to observe the simultaneous growth of both industries. However, the synchronized development of production and logistics systems was not prevalent in China because economic planning was focused on improving agrarian yields. Later on, when pursuing economic reforms during the opening-up period of China, the Chinese government leveraged the logistics industry for rapid and balanced development of the economy.

<Figure 1> Gross Domestic Product of China (2000-2019)[1)]

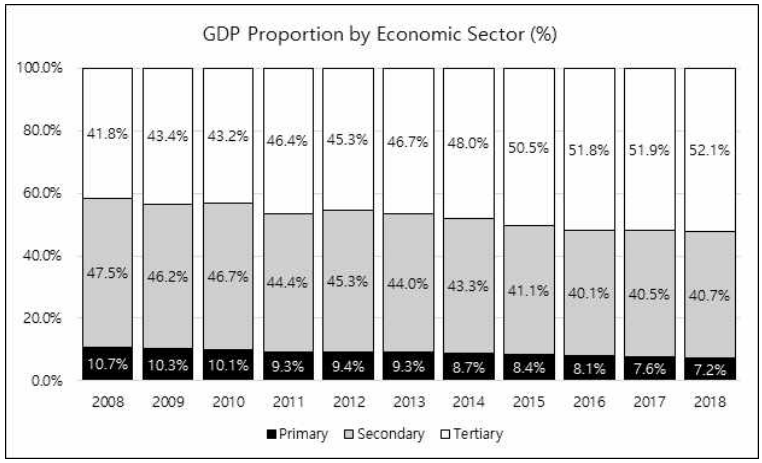


As can be seen in Figure 1, China's total economy measured as Gross Domestic Product (GDP) had an annual growth of approximately six percent albeit a slight decline brought on by the 2008 global financial

1) National Bureau of Statistics of China, http://www.stats.gov.cn/english/. (accessed on January 28, 2020)

crisis. In recent years, China's industrial development has capitalized on the comprehensive adjustment of industrial structure. The structure of the three strata of industries has improved and upgraded in China, moving toward a service and technology driven economy as can be seen in Figure 2.

<Figure 2> The industrial structure of China from 2008 to 2018[2)]

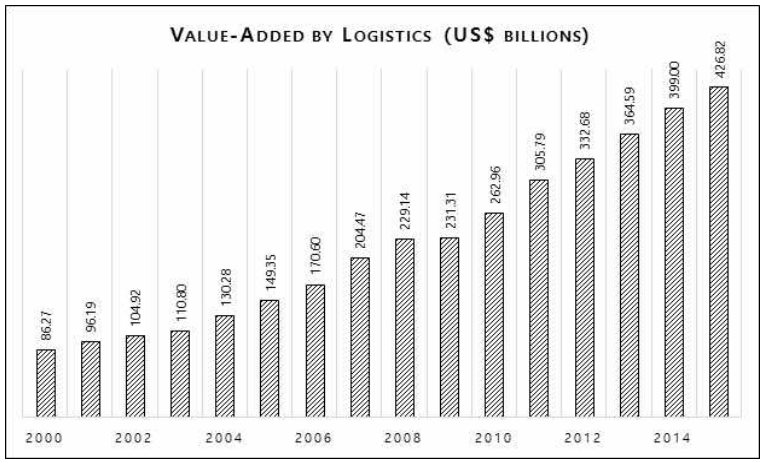


While the value-added in each of the three strata of industries has continually increased, the dynamics of the industries proportions in GPD evolved. In 2011, for the first time, the value-added of the tertiary industry exceeded that of the secondary industry as shown in Figure 2. The proportion of the value-added of the tertiary industry in GDP soared, reaching a 50% mark in 2015. The proportion of the value-added of the secondary industry continued to decline from 47.5% in 2008 to 40.7% in 2018. The value-added of the primary industry in GDP is the smallest, accounting for a meager 7.2% in 2018. These statistics indicate that China's economic development mainly depends on the secondary and the tertiary industries and that China has successfully been transforming to a

2) Ibid.

service-oriented industrial structure.

<Figure 3> The value-added by the logistics industry in China (2000 to 2015)[3)]



1. China's logistics development status

China adopted clear macro-level control objectives for the logistic industry by which the level of logistics services and coordination have significantly improved. The value-added of China's logistics industry has continued to increase from US$ 86.27 billion in 2000 to 426.82 billion, albeit a decline in the annual growth rate as illustrated in Figure 3. As of 2015, the value-added by the logistics industry in China captured about 2.97% of the entire GDP.

China's freight traffic is also continuously increasing from 17.10 billion tons in 1996 to 43.68 billion tons in 2015, with an average annual growth rate of 6.34%. Of these, ground transportation is the core mode of transport in China, followed by railways and waterways. The freight traffic of waterways (including ocean transportation) exceeded the freight

3) Ibid.

traffic of railways in 2010, indicating that China's logistics development has marched with international trades in which maritime logistics is a dominant form of transportation.

Ⅳ. Methodology and the Empirical Models

This study explores the impact of logistics infrastructure on China's industrial development for the following four dimensions — the output of the three strata of industries, the national consumption, the labor distribution, and the labor productivity. For the statistical analysis, we analyze publicly available secondary data, collected by the National Bureau of Statistics of China.[4] The data are available in various time units such as monthly, quarterly, and annual data. The data matching among the alternative variables was only possible at the annual data level. The data that guarantee the complete coverage of all the variables of interest span 1996 to 2005. Annual data often cause problems with limited degrees of freedom and data persistency (Wooldridge 2010). A preliminary analysis also confirmed that the data are indeed time-persistent and that almost 90% of the variation in the dependent variable is accounted for by time index (i.e., year as an independent variable). Such data characteristics make it too difficult to include many independent variables to a regression model because doing so may raise a potential problem of multi-collinearity and/or inflated beta coefficients. Thus, we have decided to focus on the net impact of independent variable, only calibrating the incremental R-square for each independent variable of interest.

4) Ibid.

1. Variable and operational definition

Taking the availability and complexity of the data into account, we selected the following four indicators to measure the development of the logistics infrastructure. First, the value-added of logistics (VAL) is measured by the output value of transport, storage, and post. This indicator was used by most researchers in the past to measure the development of the logistics industry. Then, freight traffic (FT) was selected as the second independent variable because freight traffics holistically reflect the amount of services created by the transportation industry. FT is an important indicator used to formulate the national transportation plans, and the statistical data of transportation well reflects the development of logistics industry to a certain degree (Zhong 2010). However, a fundamental limitation of FT is that it only estimates the actual weight of the goods transported and does not take the type of freight and the distance of travel into account. Therefore, we introduced Freight Ton-Kilometers (FTK) as an alternative. FTK is computed as the volume of transported cargo multiplied by the transport distance. The last indicator is the investment in the fixed assets for transportation, storage, and post (IL), which may reflect the relative investment intensity for the logistics industry. Table 1 summarizes all the variables and provide explanations on their operational definitions.

We select the outputs of the three strata of industries (GDP1, GDP2, GDP3), total number of the employed persons by the three strata of industries (EP1, EP2, EP3), labor productivity (LP1, LP2, LP3) and household consumption expenditure (HCE) as the measure of industrial development indicators. Besides, Investment in Fixed Assets (IL) is a proxy for the investment into the logistics industry. In general, the value of IL should be greater than the actual amount of investment purely allocated to the logistics industry.

<Table 1> Summary of variables

Dependent Variable	Abbreviation	Operational Definition	Unit of Analysis
Gross Domestic Product	GDP1, GDP2, & GDP3	The final products at market prices produced by all resident units engaged in the primary, the secondary, or the tertiary industry during a certain period.	Yuan
Household Consumption Expenditure	HCE	The average consumer expenditure calculated based on permanent residents.	Yuan
Employed Persons	EP1, EP2, & EP3	The number of employed people aged 16 and over who are engaged in gainful employment and thus receive remuneration payment or earn business income.	No. of people
Labor Productivity	LP1, LP2, & LP3	Labor productivity is calculated, dividing the value-added of each sector by the number of the employed persons in the sector.	GDPi/No. of people
Explanatory Variable	Abbreviation	Operational Definition	Unit of analysis
Value-added of Logistics	VAL	The final products at market prices produced by all resident units engaged in the transport, storage, and post industry during a certain period.	Yuan
Freight Traffic	FT	The weight of freight transported with various means within a specific period.	Ton
Freight Ton-Kilometers	FTK	The sum of the product of the volume of transported cargo multiplied by the transport distance.	Ton*Km
Investment in Fixed Assets	IL	The monetary value invested in civil engineering, construction, and real estate development projects made by a variety of urban and rural enterprises, institutions, administrative units.	Yuan

2. The Model

The main tool for statistical analysis is a time series regression model with one-year lagged variable included. Since such strong correlations are present among the independent variables, we are not able to include all the indicators in the model at the same time (see Table 2 for example). In addition, taking hysteresis of economic development — the propensity that the development of logistics infrastructure in the previous years may impact industrial development of the current year — into account, we also introduced a one-year lagged indicators of logistics into the model. For a robustness check, we compared the proposed model and the alternative model which does not include the lagged variable and found that the results (the values of beta coefficients in particular) were consistent, indicating that the empirical results are pretty stable despite the models' limited sample size.

Specifically, the proposed model in this study can be written as follows;

$$Y_{it} = \beta_0 + \beta_1 t + \beta_2 x_t + \beta_3 x_{(t-1)},$$

where Y_{it} is the industrial development indicator of the industry i (the primary, the secondary, or the tertiary, given i = 1, 2, or 3) in year t, and x_t and $x_{(t-1)}$ represent the logistics indicators in year t and $t-1$ respectively.

Ⅴ. Statistical Results and Discussion

1. Contribution of logistics indicators to economic growth and household consumption

Due to the heterogeneous units of analysis, we have standardized every

variable to secure consistency in measurements before delving into the actual analysis. As a result, the beta coefficients reported in Tables 2, 3, and 4 are also standardized automatically. Note that in each table, the coefficients for time index (year t) are all omitted for brevity and clarity of presentation. As discussed, the time index is statistically significant in every model with the value of net R^2 ranging from 85.7 to 97.8%. Such a high R^2 value implies that a strong linear trend is embedded in the data and that the actual measurements of each variable could be considerably autocorrelated. At the same time, the results indicate that all the economic indicators in China such as GDP, labor productivity, freight kilometers have continually improved, regardless of industries and economic sectors.

The primary interest is placed on the interpretation of incremental R^2s for both the current and the lagged effects of independent variables (x_t and $x_{(t-1)}$). The incremental R^2 (ΔR^2) represents the explanatory power of the corresponding indicator in explanation of a dependent variable. The results associated with the effects of logistics indicators on GDP and HCE are summarized in Table 2.

In Model 1, the current (t) value-added by the logistics industry (VALt) positively correlate with all GDPs and HCE, providing limited evidence that the development of the logistics industry might have contributed to the growth in all GPDs and HCE. This result is not decisive evidence due to a possible endogeneity problem between VALt and GDPt. That is, it is also possible that the current GDPt's could have affected VALt rather than VALt affecting GDPt's. Stronger evidence is found in the associations between VAL_{t-1} and GDP3 (β = 0.60, $p<0.01$) and between VAL_{t-1} and HCE (β = 0.46, $p<0.05$). The linkage between a lagged independent variable and a current dependent variable is less susceptible to endogeneity issues, for they create a clear sequence in terms of time progression. The value-added by the logistics industry in

the prior year leads to an improvement in GDP3 and HCE although the incremental effect sizes are relatively small (ΔR^2 of 1.2 and 1.0% respectively). With respect to FT and FTK (Models 2 and 3), all the lagged effects are significantly positive on GDPs and HCE, confirming that an increase in national freight traffics has contributed to the growth of Chinese economy and household consumption. In Model 4, the statistical analysis for the effect of IL (investment in the fixed assets) generates the results that are similar to that of Model 1. In other words, the associations between IL_{t-1} and GDP3 (β = 0.43, $p<0.05$) and between IL_{t-1} and HCE (β = 0.53, $p<0.05$) are found to be statistically significant, but their effect sizes are quite small.

<Table 2> Contribution of logistics indicators to the growth of the three strata of industries

Model No.		GDP1		GDP2		GDP3		HCE	
	IV	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2
1	VAL_t	1.25**	0.083	1.29**	0.053	0.78**	0.092	0.91**	0.090
	VAL_{t-1}	0.10	0.000	-0.21	0.000	0.60**	0.012	0.46*	0.010
2	FT_t	0.10	0.075	0.52**	0.059	0.52+	0.060	0.42+	0.063
	FT_{t-1}	0.81**	0.011	0.32**	0.002	1.28**	0.026	1.20**	0.023
3	FTK_t	0.05	0.059	0.37**	0.041	-0.47	0.074	-0.38	0.044
	FTK_{t-1}	1.09**	0.021	0.70**	0.008	1.42**	0.015	0.85**	0.032
4	IL_t	0.25	0.700	0.11	0.043	0.37*	0.087	0.24	0.082
	IL_{t-1}	0.47	0.004	0.45	0.003	0.43*	0.003	0.53*	0.004

▪ ** $p<0.01$, * $p<0.05$, + $p<0.1$; N=19

The empirical finding provide support to Propositions 1 and 2. In other words, logistics infrastructure development in China has positively affected the growth of GDP (the tertiary industry in particular) as well as the household consumption. The enhanced material flows leveraged by the effective logistics network can offer consumers a convenient way of possessing high-quality products and services. The improved accessibility to products and services will not only stimulate household

consumption, but also create opportunity for suppliers to expand their market territory.

2. Effects of logistics indicators on labor force distribution

We proposed that the surplus of labor force will move from the primary industry to the secondary or the tertiary industry to rationalize the industrial structure. Furthermore, the movement could speed up through the development of logistics infrastructure. Thus, the coefficients for the primary industry are supposed to be negative while being positive for the secondary and the tertiary industries. Overall, the empirical results are rather mixed, which need a careful interpretation. As can be seen in Table 3, negative associations are present between the logistics indicators and EP1 in general. Specifically, the effects of VALt (β = −1.40, $p<0.05$) and FTK_{t-1} (β = −0.91, $p<0.01$) are rather strong with incremental effect sizes (ΔR^2) of 8.4 and 1.5% respectively. In other words, due to the increases in the value-added by the logistics industry and the freight traffic, the workforce of the primary industry has decreased over time in China, partially supporting Proposition 3.

If a decrease in the labor force were detected in the primary industry, there must be an increase in labor force detected in the other industries. The current freight traffic (FTt) has a significant positive effect (β = 1.91, $p<0.01$) on EP2 while showing a negative effect (β = −1.07, $p<0.05$) on EP3 in Model 2. In contrast, the lagged effect of freight traffic (FT_{t-1}) on EP2 is negative (but insignificant) while being positive (β = 1.12, $p<0.01$) on EP3. If the two results are combined, we can conclude that in a short term (less than a year), the improved logistics infrastructure (measured by FT) may initiate labor force transfer from the primary and the tertiary industries to the secondary industry, strengthening the manufacturing sector. In the long run (more than a year), however, a

shift of labor force might take place, moving away from the secondary to the tertiary industry. This pattern was also evidenced in Model 3 by the current and lagged effects of freight ton-kilometers (FTKt and FTK_{t-1}) on EP2 and EP3. These results confirm that the logistics infrastructure more or less induces labor force transfers, cannibalizing the labor force of the secondary industry and ultimately building a bigger labor force in the tertiary industries. This pattern in the migration of workers could damage the growth of manufacturing sector in China. In fact, the dynamics of labor force transfer is not straightforward, rather they cascade sequentially through the industrial hierarchy due to hidden factors that are not investigated in this study.

<Table 3> Effect of logistics indicators on labor force distribution in the three strata of industries

Model No.	IV	EP1		EP2		EP3	
		β	ΔR^2	β	ΔR^2	β	ΔR^2
1	VAL_t	-1.40*	0.084	1.84	0.027	0.11	0.015
	VAL_{t-1}	0.040	0.000	-1.02	0.005	0.45	0.001
2	FT_t	-0.25	0.071	1.91**	0.063	-1.07**	0.012
	FT_{t-1}	-0.65	0.006	-0.92+	0.013	1.12**	0.019
3	FTK_t	-0.36	0.074	1.52**	0.087	-0.66+	0.007
	FTK_{t-1}	-0.91**	0.015	-0.13	0.000	0.78*	0.011
4	IL_t	-0.89+	0.072	0.55	0.016	0.43	0.016
	IL_{t-1}	0.17	0.000	-0.21	0.000	-0.08	0.000

▪ ** p<0.01, * p<0.05, + p<0.1; N=19

3. Influence of indicators on industrial labor productivity

Table 4 presents the results of regression analysis using labor productivity as the dependent variable. As shown in Table 4, the current (t) value-added by the logistics industry (VAL_t) can directly improve the

labor productivity of the three strata of industries, as shown for Model 1. With respect to FT and FTK (Models 2 and 3), all the lagged effects are significantly positive on the labor productivity of all three industries. Especially, the effect sizes (ΔR^2) for the associations lagged between FT_{t-1} and LP1 (3.9%) and FTK_{t-1} and LP1(4.9%) are greater than others. The primary industry seems to be the principal beneficiary of logistic infrastructure development in China with respect to labor productivity. The lagged effects also highlight that an increase in national freight traffics has contributed eventually to the improvement in productivity of the Chinese labor force, providing support to Proposition 4. In Model 4, the effect of fixed asset investment on labor productivity is tested. However, the lagged effects of investment (IL_{t-1}) on labor productivity is minor, only significant at the 10% significance level.

<Table 4> Effect of logistics indicators on labor force productivity in the three strata of industries

Model No.		LP1		LP2		LP3	
	IV	β	ΔR^2	β	ΔR^2	β	ΔR^2
1	VAL_t	1.16**	0.136	1.01**	0.032	0.88*	0.055
	VAL_{t-1}	0.53*	0.001	-0.17	0.000	0.21	0.001
2	FT_t	-0.65*	0.090	0.33*	0.033	0.26+	0.054
	FT_{t-1}	1.58**	0.039	0.30*	0.003	0.52**	0.005
3	FTK_t	-0.49	0.063	0.24+	0.028	0.07	0.043
	FTK_{t-1}	1.67**	0.049	0.55**	0.006	0.90**	0.014
4	IL_t	-0.43	0.123	0.05	0.026	0.18	0.049
	IL_{t-1}	0.51+	0.004	0.39+	0.002	0.42+	0.003

▪ ** p<0.01, * p<0.05, + p<0.1; N=19

4. Discussion

The theory of industrial structure optimization emphasizes the

rationalization and advancement in the industrial structure through coordination, evolution, and transformation of the industries in a nation's economy. The measurable outcomes of the industrial structure optimization are reallocation of resources (such as the value-added or the amount of investment injected to an industry) and changes in labor composition among the industries. On the one hand, the extant macro-level studies in economics articulate the phenomena of shifting resources and labor. Yet, they do not pay much attention to the fact that reallocation of resources and relocation of labor can be facilitated and accelerated tangibly by logistics. On the other hand, micro-level studies on logistics have focused on identifying logistics as an important driver of regional development (Lean 2014). In fact, the research on how specifically logistics performance affects the national economy is piecemeal. In this context, this study fills the gap by attempting to quantify the net effect of logistics contribution to the national economic growth of China.

The major theoretical implication of this research is that in order to advance national economic development through Growth of GDP, household consumption, or industrial labor productivity, it matters to coordinate the logistics industry through 1) increases in the value-added by the logistics industry, 2) the freight traffic, and 3) investment in logistic infrastructure development. To the best of our knowledge, there are no prior studies investigating the role of logistics industry in improving the nation's industrial productivity in this manner.

Another important finding is that logistics infrastructure not only drive the output of the tertiary industry but also boost the advancement of the primary and the secondary industries. Moreover, the improvement of logistics infrastructure provides convenience and high-quality services for consumers, which in turn stimulates national consumption. This result is similar to that of Lean et al. (2014). That is, good land transport has

significant impact on economic development with a duplicate effect of transport infrastructure construction: the improvement of the transport network boosts economic growth through saving travel time, cost and other channels, while economic growth causes the development of transport infrastructure. Finally, the continuous high-tech logistics infrastructure makes full use of production factors, thereby enhancing the labor productivity of the three strata of industries.

The effect of logistics infrastructure on labor distribution is somewhat complicated, revealing that there exists a sequential domino effect among the industries. The relative ambiguity in the empirical findings could be explained based on the current development of logistics in China. With the rapid economic growth, the demand for talents has become a prevalent problem in China. The absolute shortage of labor force may have caused a comparatively slow movement of labor circulation among the industries (Li & Zhao 2017). According to Pak (2018), China continues to suffer from labor shortage despite a great number of workers available nationwide. This problem is driven by the development of urban areas combined with the "single child policy." Under the aging population and skyrocketing living expenses, the average Chinese worker is not willing to migrate to industrial cities, aggravating the labor shortage problems. In other words, the movement of labor forces does not simply correspond to the development in transportation and logistics. Mahoney (2013) also reports that "an increasing number of workers previously employed on the coast are now actively seeking work in interior provinces closer to their birth counties" due to the structural constraints created by the government policies and socioeconomic changes. These findings provide meaningful insights to economic policy makers that sociopolitical decisions and economic policy decisions inherently conflict with one another, impeding the successful implementation of economic policies.

Ⅵ. Conclusion

In this study, we have explored the impacts of logistics infrastructure on industrial development in China from the following four dimensions: 1) economic growth, 2) household consumption expenditure, 3) distribution of human resources, and 4) labor productivity within the three strata of industries. Based on the theory of industrial structure optimization, we developed four Propositions that may discover the contribution of logistics to industrial development in China. We analyzed secondary time-series data collected by the National Bureau of Statistics of China and conducted regression analysis to find empirical evidence to support the propositions.

The empirical findings of this study support that the logistics infrastructure has promoted China's industrial development and labor productivity and suggest that China strengthen investment in human capital, continue to invest in the logistics infrastructure, and synchronize logistics activities to improve the nation's economic welfare (Bowersox et al. 2000). However, excessive investments in transportation and logistics cannot be a panacea, perhaps due to the diminishing returns of economic rent (Rong 2001). This issue needs a further study in the future.

No empirical study is impeccable, and this study is also bounded by limitations, which may provide guidelines for future research. A fundamental limitation of this study is that we have established Propositions mainly based on anecdotal evidence and/or macro-economic theoretical framework in economic studies. If similar findings can be established at the firm-level based on a large sample size and detailed research hypotheses, more meaningful results could be attained. Moreover, subsequent statistical analysis was done, using the annual data aggregated for the three economic sectors. If a panel data analysis which allows for greater degrees of freedom can be conducted in the future, more precise findings can be excavated.

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| 국문초록 |

중국의 산업 개발에 기여한 물류 기반시설의 영향력에 관한 실증적 연구

여아평·신호정·자와라 파쿠리에 알프레드
(고려대학교 경영학과)

물류산업은 경제발전의 가속기로서 국가 또는 지역의 경제력을 유지하기 위한 디딤돌이다. 또한, 물류산업의 성장은 재화와 인구의 산업 간 이동을 원활하게 하는 동시에, 서비스산업 발전의 촉매제 역할을 수행한다. 본 연구에서는 산업구조 최적화 이론과 합리화 이론을 기반으로 중국의 물류 기반시설이 중국의 1) 경제성장, 2) 가계지출, 3) 인적자원 분배, 4) 노동생산성의 네 가지 거시경제지표에 미친 영향력을 실증분석하였다. 중국통계청에서 수집한 시계열 자료에서 선별한 물류산업의 부가가치, 화물 운송량, 운송거리 가중치 및 물류산업에 대한 자산투자와 같은 독립변수를 활용하여 시계열 회귀분석을 수행하였다. 분석과정에서 시간변수를 포괄적으로 통제함으로써, 물류산업의 성장과 직접 연관된 독립변수들이 종속변수에 미치는 순수한 효과만을 보수적으로 계량화하였다. 분석결과, 중국의 물류 기반시설은 전반적으로 모든 산업 분야의 발전에 긍정적인 역할을 해온 것이 입증되었다. 또한, 물류 기반시설에 대한 투자는 유통의 효율성을 높여 산업의 노동생산성 증진에 기여한 것으로 나타났다. 반면에 물류산업이 창출한 부가가치가 일차산업의 인력비중을 줄이는 데는 이바지하였으나, 이차 및 삼차 산업의 인력배분에는 유의한 영향을 미치지 못한 것으로 나타났다. 이 결과는 중국의 빠른 경제성장을 지속적으로 뒷받침하는 전문인력의 육성이 원활하게 이루어지지 못하고 있음을 시사한다.

▪ 주제어: 중국, 물류기반시설, 산업개발, 산업구조 최적화, 산업구조 합리화