Chapter 38
A Study on City Logistics Design Planning Based on Logistics Requirements Potential Model

Fang Lu and Bo Lu

Abstract It is extremely important to predict the logistics requirements in a scientific and rational way for the city logistics design planning. However, in recent years, the improvement effect on the prediction method is not very significant and the traditional statistical prediction method has the defects of low precision and poor interpretation of the prediction model, which cannot guarantee the generalization ability of the prediction model theoretically, but also cannot explain the models effectively. Therefore, in combination with the theories of the spatial economics, industrial economics, and neo-classical economics, taking city of Baotou as the research object, the study identifies the leading industry that can produce a large number of cargoes, and further predicts the static logistics generation of the Baotou and its hinterlands. By integrating various factors that can affect the regional logistics requirements, this study has established a logistics requirements potential model from the aspect of spatial economic principles, and expanded the way of logistics requirements prediction from the single statistical principles to a new area of special and regional economics for the city logistics design planning.

Keywords City logistics • Design planning • Logistics requirements potential model • Prediction

F. Lu (✉)
College of Fine Arts, Dalian University, Dalian, China
e-mail: shining_112@live.cn

B. Lu
Institute of Electronic Commerce and Modern Logistics,
Dalian University, Dalian, China
e-mail: lubo_documents@hotmail.com

H. Xia and Y. Zhang (eds.), *The 2nd International Symposium on Rail Transit Comprehensive Development (ISRTCD) Proceedings*,
DOI 10.1007/978-3-642-37589-7_38,

38.1 Introduction

The regional logistics requirement which was firstly proposed in the 1990s [5], is very important for formulating city logistics design planning. After nearly 20 years of development, it has made great progress. By sorting out comprehensive overview about existing method, most researchers deal with them as a regression problem. According to the development process and the level of intelligence, it can be roughly divided into three stages:

The prediction method based on statistics in the first stage. Main methods include regression analysis [1], elasticity coefficient method, freight intensity method, clustering method, gray theory model, Markov chain, input-output model [3], space-time multi-term probability model and decision support system. The major features of this type of methods can process the sequencing and linear data, and explain the construct models effectively. The prediction method based on artificial intelligence in the second stage. Later on, to enhance the prediction accuracy, the researcher [6] adopted the artificial intelligence method, such as the artificial neural network (ANN) and its improvement model. The prediction methods based on statistical learning theory is the third stage.

Although certain achievements have been made, some urgent problems still exist in the regional logistics requirements prediction [4]. Therefore, the generalization capability of the prediction model cannot be guaranteed from theory, which makes the predictive models after training to have no stable prediction effect for the new logistics requirements data set. Third, among these methods, although the artificial intelligence methods and support vector machine method have certain advantage in the prediction of accuracy, it still cannot explain the models effectively.

In fact, regional logistics requirements is a derived requirements determined by the level of regional economic development, and the indicators that affect logistics requirements prediction such as economic, logistics industry, environmental factors will directly or indirectly affect the growth or reduction. Therefore, this study has explored the logical relationship between the regional logistics requirements and the relevant factors based on the spatial economics and new economic geography. From the perspective of logistics market potential, this study has established the logistics requirements potential model and expanded logistics requirements prediction way from the single statistical principles to new area of space economics, to enrich research method of the regional logistics requirements.

The paper is structured as follows: after introductory section of Chap. 1, there will be followed by description of logistics requirements potential model. In so doing, the research procedure is included in Chap. 2. Moreover, research scope and logistics requirements prediction are derived in Chap. 3. Finally, conclusions are drawn in Chap. 4.

38.2 Research Method

38.2.1 Logistics Requirement Potential Model

The concept of market potential was firstly proposed [7]

$$M_j = \sum_k Y_k g(D_{jk}). \tag{38.1}$$

where, M_j is the market potential of City j; Y_k is the income of every area; $g(D_{jk})$ is the attenuation function of distance; D_{jk} is the distance between City j and City k. However, there is no micro-structure, which only showed that the market potential is proportional to market purchasing power of various places (i.e. the market scale), and inversely proportional to the distance from this place to the market. The theoretical innovation on this issue was originated from the early 1990s when Krugman had built the New Economic Geography [2, 8, 9]. Krugman claimed that two forces determine whether the economic behavior and economic factors are convergent or diffusive in spaces in the model: centripetal force and centrifugal force. The centripetal force makes the economic activities and economic elements to reflect the industrial agglomeration in the spatial distribution in the industry level, which is why the new economic geography and spatial economics attaches great importance to industrial agglomeration.

Later, Fujita established his market potential index formula:

$$\begin{aligned} D_x(j) &= \sum_{h=1}^{l} c_x(h|j) = P_x(j)^{-(\mu+1)} \sum_{h=1}^{l} \frac{\alpha E_h T_X^{-(\mu+1)}}{\sum_{k=1}^{l} n_k \{P_x(k) T_x(k,h)\}^{-\mu}} \\ &= \left\{\Lambda^{-1} W_j^{1-\beta} \Gamma(j)^{\beta}\right\}^{-(\mu+1)} \Omega(j). \end{aligned} \tag{38.2}$$

where, $\Omega(j) = \sum_{h=1}^{l} \left[\frac{\alpha E_h T_x(j,k)^{-(\mu+1)}}{\sum_{k=1}^{l} n_k \left\{ W_k^{1-\beta} \Gamma(k)^{\beta} T_x(k,h) \right\}^{-\mu}} \right]$ is market potential of City j, where has been set the producing area; α is market distribution share; E_h is market capacity of City h; $T_x(j, h)$ is transport factor from City j to City h; n_k is differentiated products quantity of City k; W_k is wages of workers in City k; Γ is price index of City k; μ is redefinition of substitute parameter; $1 - \beta$ is investment share of labor in the process of intermediate product. The form of market potential is more clearly, and is also convenient for specific calculation. The numerator is prototype of Harris' market potential. Differing from Harris, the denominator of Fujita's market potential includes the spatial competition factors.

However, Krugman and Fujita proposed the potential model was just from the perspective of economic scale and regional economic agglomeration. On the basis of that, this paper has introduced the related logistics factors to construct the logistics requirements potential model:

$$\ln p_{rt} = \alpha_0 + \alpha_1 \ln E_{rt} + \alpha_2 \ln l_{rt} + \alpha_3 \ln e_{rt} + \alpha_4 \ln f_{rt} + \alpha_5 \ln w_{rt} + \alpha_6 \ln d_{rt} + \mu_{rt}. \tag{38.3}$$

where, r indicate the city, t indicate a particular year, μ_{rt} is random error.

For simplifying the calculation difficulty, this study has set the all power exponent of factors and random error equal 1. Therefore, according to the positive/negative correlation, the logistics requirements potential model can been re-constructed as:

$$p_i = \sum \frac{l_i E_i e_i f_i w_{1i} w_{2i}}{d_{ij} d_{ip}}. \tag{38.4}$$

where, p_i is the potential value of region i, E is the GDP, e is human capital (employee of logistics/population of the city), f is the proportion of investment in fixed assets (logistics investments/the whole investments of society), w is highway freight transport, d_{ij} is the Euclidean distance between region i and j, $d_{ip} = 2/3\sqrt{S_i/\pi}$ which is the inner region distance, where S is the region area.

38.2.2 Research Procedure

By constructing the model of the logistics requirements potential, one hand, this study need identify the cities which have high relevance with logistics of researched city to jointly constitute a logistics system. Then, based on the leading industry of researched city, this study could predict the cargo quantity of each city according to these industries by data fitting. Another hand, by applied with potential model to predict the logistics requirements, this study need calculate the parameters within the potential model. Then, the study could respectively identify the logistics requirements potential value of each city. Furthermore, the potential value of each city has been calculated independently, and the research scope of this study, which is centering on city of Baotou, has formed a system composed of 20 cities surrounding Baotou. Therefore, the study should apply the normalization processing to the independent potential values of each city: $\overline{p}_i = \frac{p_i}{\sum_i pi}$.

And then, by multiplying the processed potential value by the total cargo production of each industry within the system, the logistics requirements of each industry for each city could be obtained. The formula is: $\overline{n}_i = \overline{p}_i \sum_i n_i$, where, n is the total cargo production of each industry, and $\overline{n}$ is the logistics requirements of each city (Fig. 38.1).

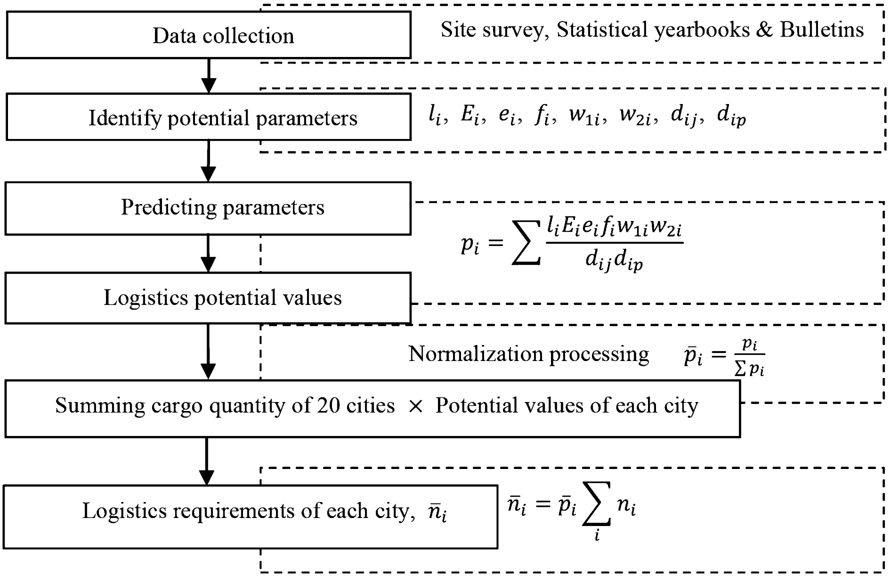

Fig. 38.1 Research procedure

38.3 Result Analysis

38.3.1 Research Scope

The study is centering on city of Baotou, scope of I, II, III area surrounding, I area is as per radius of 100 km, II area is as per radius of 100–300 km, III area is as per radius of 300–500 km. Definition of I, II, III surrounding areas is as following: central city: Baotou; I area: Erdos; II area: Hohhot, Shuozhou, Yulin, Wuhai and Bayan Nur; III area: Shijiazhuang, Taiyuan, Xi'an, Yinchuan, Erenhot, Ulan Tsab, Zhangjiakou, Datong, Xinzhou, Lvliang, Alashan, Shizuishan and Wuzhong.

38.3.2 Prediction for Static Cargo Quantity

Each city has its independent industrial type, and the production and consumption have different features. Therefore, judging the leading industry based on Baotou, this study has predicted the logistics requirements of these industries in each city.

The rapid economic development of Baotou has direct correlation with its industrial structure. The major industry in Baotou is the second industry with relatively complete category, by combining with the status of economic development, the following industries, such as: grain, vegetables, fruit, meat production,

Table 38.1 Logistics requirements potential value of each city in 2015

Items / Cities	Baotou	Hohhot	Shi J.Z.	Taiyuan	Erdos	Shuo Z.
Logistics requirement	17,232.7	6,356.53	4,758.31	2,036.71	1,601.94	388.45
Potential value	961,216	354,558	265,411	113,605	89,354.1	21,666.9
Normalization processing	52.42 %	19.34 %	14.47 %	6.20 %	4.87 %	1.18 %
Xi'an	Zhang J.K.	Ulan Tsab	Datong	Wuhai	Lvliang	Yulin
339.96	55.93	24.87	22.19	20.49	13.01	12.54
18,962.23	3,119.80	1,387.40	1,237.71	1,143.09	725.56	699.24
1.03 %	0.17 %	0.08 %	0.07 %	0.06 %	0.04 %	0.04 %
Xinzhou	Yin C.	Alashan	Bayan Nur	Erenhot	Shi Z.S.	Wu Z.
7.38	2.07	1.06	0.96	0.11	0.08	0.004
411.56	115.45	59.12	53.54	5.82	4.16	0.246
0.02 %	0.01 %	0.00 %	0.00 %	0.00 %	0.00 %	0.00 %
Unit: Hundred thousand tons						

milk, metallurgical industry, non-metallic mineral products, coal mining and washing, textile, beverage manufacturing, chemical materials and chemical products, food processing and the flow of commerce will bring a large quantity of logistics requirements, have been set as the research centre.

38.3.3 *Prediction for Dynamic Logistics Requirements*

The predicting results of logistics requirement for each city in 2015 have been summarized in Table 38.1, and the following observations can be made. The column and row totals represent, respectively, the logistics requirements and potential values of each city in 2015. It is clear that, Baotou has the best performance among the twenty cities. Hohhot and Shijiazhuang ranked as the second and third best in this model, respectively. The values were more than 10 %, with these potential values far exceeding that of other cities. According to potential values, although Baotou, Hohhot and Erdos have more potentiality than others, there is a big distance, however, among them. With the similar economic scale and location, the huge gap of logistics requirements and potential values which are depended on the logistics potential parameters among three cities, can be explained that Baotou has most convenient logistics infrastructures, therefore it is possible to become the biggest logistics centre and the most important node in Inner Mongolia, firstly.

In the contrary, logistics potential values of most others are less than 1 %, thus indicating that they would need to improve their investment of resources to enhance the logistics competitive power. Among them, Wuzhong has the least potential value.

38.4 Conclusions

Implementation of West Development Strategy has laid a policy advantage for development of city logistics industry in Inner Mongolia. The state has intensified support for logistics infrastructures, such as logistics parks. However, the vacancy rate of logistic park is as high as 60 %, resulting in huge wasting of resources. Therefore, construction of logistics parks should follow a uniform design planning and should not be repeated. Because of that, a scientific prediction is a basic work for proper planning. Prediction of regional logistics requirements can provide a basis in theory for national and regional economic administrations. Moreover, according to predicting results, the government could evaluate the contribution of the logistics industry to local economic development which is useful in helping the government to formulate for the logistics industry and guide optimum configuration of resources in the logistics market. From a micro perspective, logistics enterprises should properly configure limited resources according to the prediction of logistics requirements in order to minimize investment risks and maximize benefits.

There are also some limitations in this study. In the construction of model, this study has set the all power exponent of factors and random error equal 1. However, the weight of each factor is inequality, obviously. Moreover, rationality of research scope also needs further explaining. Therefore, in the future research, the research will concentrate on the two aspects.

References

1. Chu LY, Tian ZG, Xie XL (2010) Application of an combination forecasting modal in logistics demand. J Dalian Marit Univ 30(4):43–46
2. Fujita M, Thisse JF (2002) Economics of agglomeration: cities, industrial location and regional growth. Cambridge University Press, Cambridge, MA
3. Guo XC, Xie SH, Hu B (2009) Regional logistics demand analysis model and solution. J Southeast Univ 31(3):24–31
4. Luo SG, Ye S, Hu R (2010) A research of forecasting the logistics amount based on multi-output support vector regression. J East China Jiao tong Univ 27(5):67–71
5. Xia GE (2010) A study on the development of regional logistics requirements prediction. China Logist Purch 4:68–69
6. Yin YL (2010) Logistics demand forecast based on adaptive neural network. J Henan Polytech Univ 29(5):700–704
7. Harris CD (1954) The market as a factor in the localization of industry in the United States. Ann Assoc Am Geogr 44:315–348
8. Krugman P (1991) Increasing returns and economic geography. J Poetical Econ 99:483–499
9. Acs Z, Anselin L, Varga A (2002) Patents and innovation counts as measures of regional production of new knowledge. Res Policy 31(7):1069–1085