Research on the Relationship between Logistics Industry and Economy Based on System Dynamics

—A case study of Guizhou Province

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Abstract: The development of modern logistics is inextricably linked with the regional economy. This paper establishes a system dynamics model of the correlation between logistics industry and economic development, maintains the total retail sales of social consumer goods and the total retail sales of goods plus total stock respectively represent the logistics demand and supply capacity, then introduces the related index between logistics and economy in the model to examine the growth rate of logistics demand. This essay forecasts the growth trend of critical indicators in Guizhou Province from 2016 to 2030. Finally, some countermeasures and suggestions have been put forward to realize the rapid and coordinated development of economy and logistics in Guizhou Province.

1. Introduction

Logistics industry undertakes the activities which are non-core business of manufacturing industry and gradually grows up. Today, the logistics industry affects and is affected by the regional economy due to its close bounds with all walks of life. Guogang Li and Yuliang Cao(2012) concluded that per capita goods turnover contributes a lot to per capita GDP through a regression analysis. Lean H H (2014) found the economic growth has brought more logistics needs and promoted the development of the logistics industry. Shiu A and Lam P L (2008) held that the logistics industry and economic development supports and promotes mutually. Lan S L and Zhong R Y(2016) insist we must coordinate the development of logistics and economy to keep the two's stability. Liming He (2016) argue that improving the allocation efficiency of logistics resources and increasing the effective supply of logistics are important measures to promote quality, efficiency, transformation and upgrading of the national economy. Therefore, research on the internal mechanism between regional logistics industry and the economic development can not only help to enhance the overall economic efficiency of the region, but also stimulate the boom of the regional logistics industry so as to create convenient external environment for other industries.

2. Literature Review

Predecessors have researched the relationship between the logistics and the economy from different perspectives, for different regions and by different methods. Li Lei(2004) designed a modern logistics system framework which includes the logistics service platform, logistics supply and logistics needs. ShouPing Gui et al(2003)divided the regional logistics system into five modules: economic growth, population, consumption level, logistics needs and logistics capacity. Weilin Liu(2011) has constructed three sub-systems, namely, demand- pulling subsystem, supply-pushing subsystem and logistics-driven growth feedback subsystem in his system dynamics model. Shuang Liu(2010) used logistics demand and logistics supply ability to reflect the development level of logistics in the study of contribution of logistics industry to GDP and three kinds of industrial structure in Northeast China. Most of the relevant articles measure the degree of regional logistics development by the logistics demand and logistics supply capacity, which are a bit abstract and composed of logistics demand service scale, logistics information network construction, logistics supply material basis, the level of logistics output efficiency, logistics practitioners protection and other factors (Guohui Cui 2010). It must to select some specific statistical indicators to represent and measure these two indicators when simulating them from the perspective of system dynamics. However, there are various of shortcomings in current domestic definition and quantification of logistics demand and supply capacity: Inconsistency on the selection; ambiguous or skipped description; different units between them; difficulty of measuring and counting, some examples are shown in Table 1.

Table 1 Statistics of selected logistics indicators

Authors	Logistics Demand	Unit	Logistics Supply Capacity	Unit
Zili Xie(2009)	The total retail sales of social consumer goods	Billion yuan	The product of the turnover of goods and its unit price	Billion yuan kilometers
Hong Xiao(2013)	—	—	—	—
Meiqing Tan(2003)	—	—	Consolidated cargo turnover equivalent	Billion tone kilometers
Zhuoning Song(2011)	Turnover of goods	Billion tone kilometers	Turnover of goods	Billion tone kilometers
Wenshun Li(2004)	Freight turnover	Billion tone kilometers	—	—
Xiuli Gao(2012)	Freight turnover	Billion tone kilometers	Logistics network business mileage	kilometers

Note: "-" represents that the author does not specifically explain the selection of the indicators in the text.

This article constructs the system dynamics model of the relationship between the regional logistics industry and economic development, where the total retail sales of social consumer goods represents logistics demand and the logistics supply ability is expressed by the sum of the total retail sales volume and total inventory quantity. In this way, the substitution of the index can be agreed on the unit firstly; secondly, it's also similar to the value of the index itself so it's easy to understand; thirdly, the acquirement of the data is convenient because it can be inquired in official

databases. This essay takes Guizhou Province of China as an example, and verifies the feasibility of the model, then the growth trend of vital variables are predicted, and the improvement policy is proposed to settle the drawbacks of system development in the end.

3. Establishment of the System Dynamics Model

3.1 Establishment of system causal diagram and flow chart

There are three subsystems, of which the GDP represents the economic development; population subsystems mainly consider the number of urban employment population; logistics development is reflected from the logistics demand and logistics supply capacity. Figure 1 is the systematic causal graph and figure 2 is the corresponding system flow diagram.
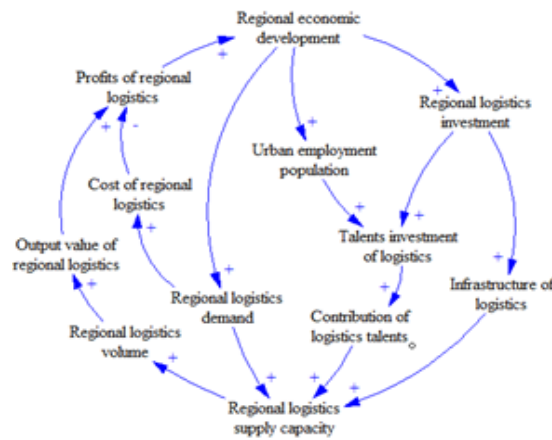

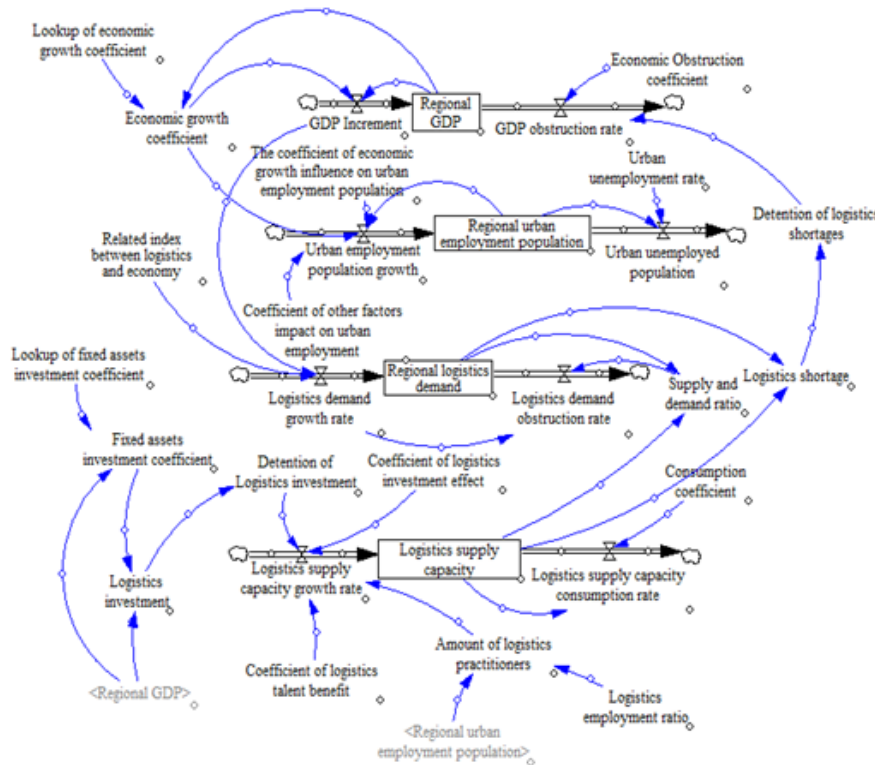Figure 1 Causal map of regional logistics industry and regional economic development system

Figure 2 Flow chart of regional logistics industry and economic development

3.2 Establishment and Explanation of System Model Equation

Based on the relevant data of Guizhou Province since 2008 to 2015 from National Bureau of Statistics of the People's Republic of China, the initial value of the integral variables and the constants' value are determined. The simulation time ranges from 2008 to 2030 and the time step is 0.5.The calculating functions of the variables and the values of the constants are elaborated in detail as the following:

(1) Regional GDP = INTEG(GDP increment — GDP obstruction rate, 3561.56); Units: One hundred million yuan.

(2) GDP Increment = Regional GDP* Economic growth coefficient; Units: One hundred million yuan.

(3) Lookup of economic growth coefficient = [(3000,0)(12503,0.4)],(3561.56,0.23),(3912.68,0.1),(4602.16,0.18),(5701.84,0.24),(6852.2,0.2),(8086.86,0.18),(9266.39,0.15),(10502.6,0.13); Units: Dmnl. The independent variable represents the regional GDP and the dependent variable represents the economic growth coefficient.

(4) GDP obstruction rate = IF THEN ELSE (Detention of logistics shortages >0, Economic Obstruction coefficient* Detention of logistics shortages,0); Units: One hundred million yuan.

(5) Economic Obstruction coefficient = 0.04; Units: Dmnl.

(6) Detention of logistics shortages = DELAY FIXED(Logistics shortage, 0.8 , 175); Units: One hundred million yuan.

(7) Logistics shortage = Logistics demand—Logistics supply capacity; Units: One hundred million yuan.

(8) Regional logistics demand = INTEG(Logistics demand growth rate—Logistics demand obstruction rate,1075.20); Units: One hundred million yuan.

(9) Logistics demand growth rate = GDP increment * Related index between logistics and economy; Units: One hundred million yuan.

(10) Related index between logistics and economy = 0.34; Units: Dmnl. This index indicates that the logistics demand growth that brought by the economic growth.

(11) Logistics demand obstruction rate =IF THEN ELSE(Supply and demand ratio <1, Logistics demand growth rate * (1- Supply and demand ratio),0); Units: One hundred million yuan.

(12) Supply and demand ratio = Logistics supply capacity / Logistics demand; Units: Dmnl.

(13) Logistics supply capacity =INTEG(Logistics supply capacity growth rate—Logistics supply capacity consumption rate,900.20); Units: One hundred million yuan.

(14) Logistics supply capacity growth rate = Detention of logistics investment * Coefficient of logistics investment effect + Coefficient of logistics talent benefit * Logistics talent factor; Units: One hundred million yuan.

(15) Detention of Logistics investment = DELAY FIXED(Logistics investment, 0.5 , 258.24); Units: One hundred million yuan.

(16)Logistics investment = Regional GDP *
Lookup of fixed assets investment coefficient; Units: One hundred million yuan.

(17) Coefficient of logistics investment effect = 0.65; Units: Dmnl.

(18) Lookup of fixed assets investment coefficient =[(3000,0)-(10503,0.2)],(3561.56,0.07),(3912.68, 0.1),(4602.16,0.11),(5701.84,0.1),(6852.2,0.11),(8086.86,0.13),(9266.39,0.14),(10502.6,0.15);Units: Dmnl. The dependent variable is the regional GDP, the dependent variable is the investment coefficient of the fixed assets of the logistics.

(19) Coefficient of logistics talent benefit = 0.38; Units: One hundred million yuan / One hundred thousand persons. It represents the contribution of the logistics practitioners make to the

regional logistics supply capacity.

(20) Amount of logistics practitioners = Regional urban employment population * Logistics employment ratio; Units: ten thousand persons.

(21) Logistics employment ratio = 0.042;Units: Dmnl.

(22) Logistics supply capacity consumption rate = Logistics supply capacity * Consumption coefficient; Units: One hundred million yuan。

(23) Consumption coefficient = 0.03; Units: Dmnl. It means the depreciation rate of logistics fixed transportation facilities.

(24) Regional urban employment population = INTEG (Urban employment population growth—Urban unemployed population); Units: ten thousand persons.

(25) Urban employment population growth = Economic growth coefficient*The coefficient of economic growth influence on urban employment population * Regional urban employment population; Units: ten thousand persons.

(26) Urban unemployed population = Regional urban employment population * Urban unemployment rate; Units: ten thousand persons.

(27) The coefficient of economic growth influence on urban employment population = 0.33; Units: Dmnl.

(28) Coefficient of other factors impact on urban employment = 0.02; Units: Dmnl.

(29) Urban unemployment rate = 0.033; Units: Dmnl.

4. Model test

The system dynamics model established in this paper has been tested and proved the validity of the model design, and the feasibility of selection representative index in the model.

4.1 Operation test

Simulations under 3 different interval settings: 1, 0.5,0.25 are executed to checking the stability of the model and inspecting whether there will be abnormal results when running it. It can be seen from figure 3 that the simulation results of the four integral variables have a very slight difference at three different situations.
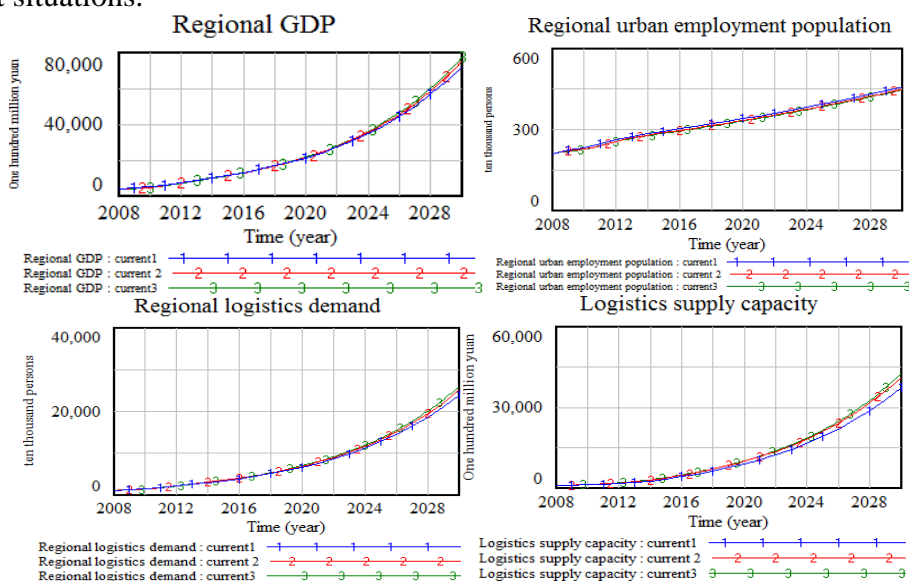

Figure 3 The simulation curves for at different intervals

4.2 Historical test

The simulated data in the second case (time interval is 0.5) is compared with the historical data of the integral variables and the average deviation in the past 8 years are within the range of ± 10%, as presented in table 2.

Table 2 Deviation from Model History Test

Variables	GDP	Urban Employment	Logistics Demand	Logistics Supply Capacity
Average deviation	8.20%	-2.62%	-1.15%	-4.34%

4.3 Sensitivity test

During the sensitivity test of the model, constants are all changed within a range of ± 3%, and there aren't great differential between the new simulation results and the formers.

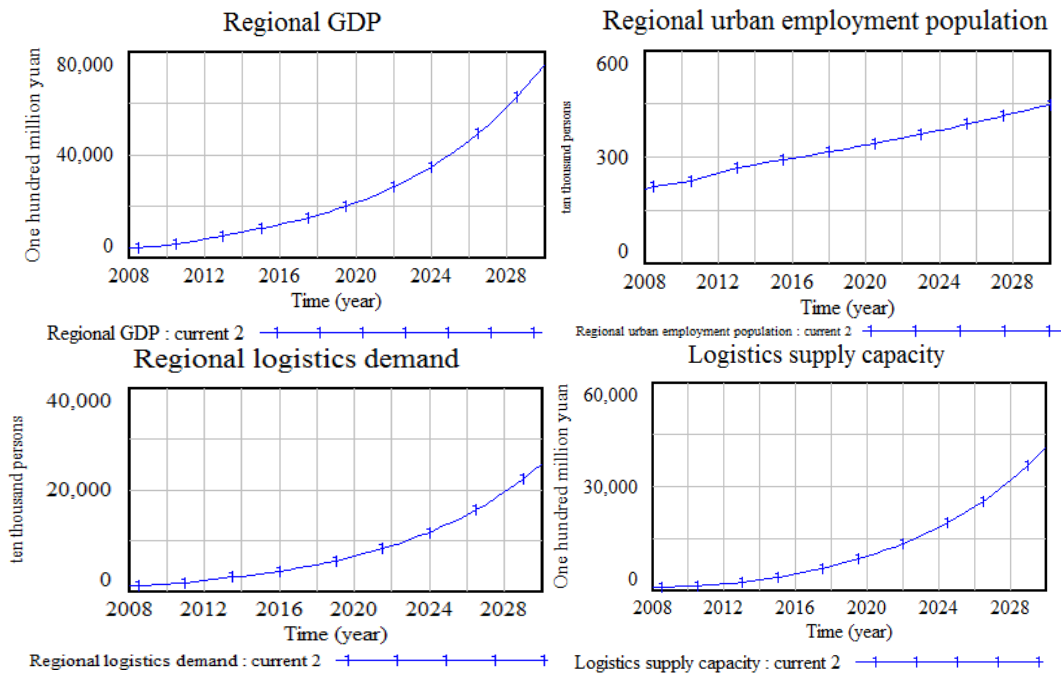## 5. Model's Predicted Simulation and Analysis

Figure 4 Simulation curve of each integral variable

Fig 4 shows the predicted value of four variables. From Fig 4 we can draw the following conclusions:

The GDP, logistics demand, logistics supply capacity of Guizhou province will grow slowly and slightly from 2016 to 2020, but since 2020, the growth was significantly accelerated;

Urban employment population has been risen in a stable and almost linear way;

Logistics demand growth lags behind the growth of logistics supply capacity, which implies that we need to expand our logistics demand in order to take full advantage of the logistics supply capacity, while stimulate the regional economic growth in a greater extent.

6. Policies & Recommendation

To realize the simultaneous growth of both, make full use of the constructed logistics supply ability, this paper proposes an improvement scheme to drive the logistics demand: Adjusting the related index between logistics and economy from 0.3 to 0.38, which means that economic growth can more effectively drive the local logistics needs, and logistics can also make a greater contribution to economic development. As is shown in the Fig5, the logistics demand predicted by the new scheme is improved, which enlightens us Guizhou province should strengthen the link of economy and logistics needs by vigorously promoting the logistics industry in the future, so that local residents can enjoy more convenience brought from logistics.
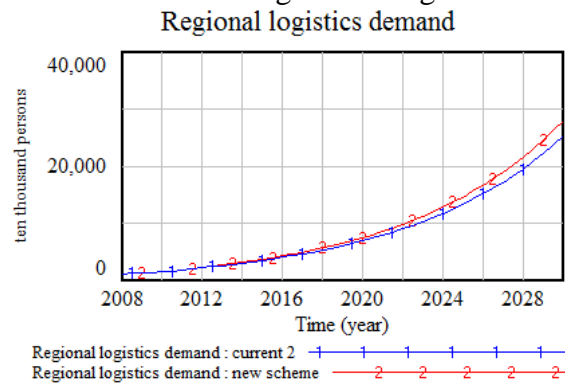

Figure 5 Simulation comparison

In recent years, the economy of Guizhou Province is gradually increasing, whereas, a number of major economic indicators are still lower than the national average (Yuanlan Zhu, 2016). The shortage of logistics demand in Guizhou Province is a consequence of the limited promotion of logistics and e-commerce, the lack of effective mechanism of rural information and the enormous difficulties on promoting information platform and resources to the rural areas. (Jianzhong Chen 2010). Prosperity of e-commerce is constantly creating opportunities and profits to the logistics industry, Guizhou Province should vigorously promote the convenience of e-commerce and logistics service to strengthen online transactions, in particular, publicize the online shopping and its superiority in the vast rural areas; at the same time speed up the construction of rural infrastructure and information platform to develop more online economic activities. Such measures can help to boost the provincial logistics needs greatly while maintaining promising growth GDP growth.

7. Conclusions

This paper establishes a system dynamics model of correlation between regional logistics and economy and makes two improvements: firstly, the logistics demand growth rate is impacted by the related index between logistics and economy based on the economic growth rate. Secondly, using the total retail sales of social consumer goods and the sum of total retail sales of wholesale goods and total inventories to respectively represent logistics demand and logistics supply capacity, avoid the difficulties in collecting and determining data of indicators. The simulation indicates that the four variables in the system will increase continuously, but the logistics demand is lagging behind the logistics supply capacity. In order to make full use of the logistics supply capacity, this paper gives advices to driving the growth of logistics demand.

Acknowledgement

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