Modelling and simulating for coupling development mechanism of regional logistics-economic complex system

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Abstract

The concept and composing parts of Regional Logistics-Economic Complex System have been established firstly. System dynamics model for the coupling interactive development of RLECS has been constructed. According to Heilongjiang Province Economic and logistics data, the effectivity of the model has been tested. Coupling development evolution paths for adaptive development, logistics system exceed moderately and other industry priority have been simulated. The results show that adaptive adjustment mechanism exists in RLECS. Logistics system exceed moderately is the most favorable for priority to the long-term growth of the regional economy.

Keywords: regional logistics, regional logistics-economic complex system (RLECS), system dynamics, coupling development

1 Introduction

With the globalization of the world economy, the modern logistics industry has developed rapidly. Its function in supporting and promoting the social economy is becoming so obvious that it has become an important symbol of a country and regional development levels. Meanwhile, with the deepening of reform and opening, the economic development level in China is increasing rapidly. Some regions in it have some conspicuous characteristics of regional economic, such as the Yangtze River Delta, Pearl River Delta, Bohai Bay, and Northeast Economic Zone.

Regional logistics system is an organic entirety that is composed by some dynamic elements which are mutual restraint, such as logistics demand, facilities, resources, information, capital and personnel within the specific scope and area.

The close relationship between regional logistics system and economic system reflects not only the interaction between the two systems directly, but also the conjunctions and coupling among the internal elements in the two systems.

From a higher point of view, regarding the two systems as a unified complex large system, the description and analysis for internal structural are more clear, and the system multiple feedback phenomenon of variables can be dealt effectively.

As a concept of physical, coupling means the influence phenomena was brought by two (more than two) systems or movements interaction effect. Coupling can be considered as two different things turn to a system by mutual promotion, restraint, and linked, that means every subsystems have dynamic association relationship based on interdependence, mutual coordination and promotion.

There's a coupling mechanism between regional logistics and economy. They relate and promote mutually. Zhang used regional economy theory and transaction cost theory to analyze the relationship between regional logistics and regional economy [1]. Yamaguchi studied Pair Wise Coupling is a popular multi-class classification approach that prepares binary classifiers separating each pair of classes, and then combines the binary classifiers together [2]. Lu constructed RLECS model based on SD [3]. Zeng had analyzed the interactive mechanism of regional logistics and economy based on the polar theory of the regional economy [4]. Fan and Zhang used regional economy theory and transaction cost theory to analyze the relationship between regional logistics and regional economy [5]. Gui and Zhu, who analyzed the basic causal relationship of the regional logistics system through the system dynamics and established the system dynamics model of the regional logistics [6].

System Dynamics has been used to study regional logistics by many scholars, but no one apply it to study the coupling development mechanism of regional logistics-economic complex systems. In this background, we hope to find the coupling development regulars between the regional logistics system and regional economic in order to achieve long-term sustainable development.

2 Analysis on regional logistics-economic complex system

Regional logistics-economic system is a complex system which exist strong "Trade-off" phenomenon between the elements. It is a multi-objective function system with causal systems, dynamic, non-linear, delay and other characteristics.

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2.1 THE STRUCTURE OF REGIONAL LOGISTICS-ECONOMIC SYSTEM

Regional logistics-economic complex systems is composed of regional logistics subsystem and regional economic subsystem that they coordinate, promote, restrict, couple mutely. It is made of four parts regional logistics entities, regional logistics carrier, regional logistics environment and regional economic entities. It is shown in Fig. 1:

1. Regional logistics entities subsystem: regional logistics entities subsystem is the organization which participates in the activities of regional logistics, including the third party logistics enterprises, transport enterprises, warehousing, freight forwarding enterprises, etc.
2. Regional logistics carrier subsystem: regional logistics carrier subsystem refers to the objective carrier and infrastructure to realize logistics activities, such as highway, railway, aviation, port operations, transport hub and logistics park, logistics center, etc.
3. Regional logistics environment subsystem: regional environment subsystem is an exchanging space system of material, energy and information which exist in logistics main body and carrier subsystem. It is composed by not only information and network for logistics but also the natural resources, human resource, technology, policies and regulations, financial education environment, etc.
4. Regional economic entities subsystem: regional economic entities subsystem is consisted of enterprises which are principal parts of the regional economic operation. It includes the first, second and third industry enterprises which produce logistics demand. It is the supply of the regional logistics system.

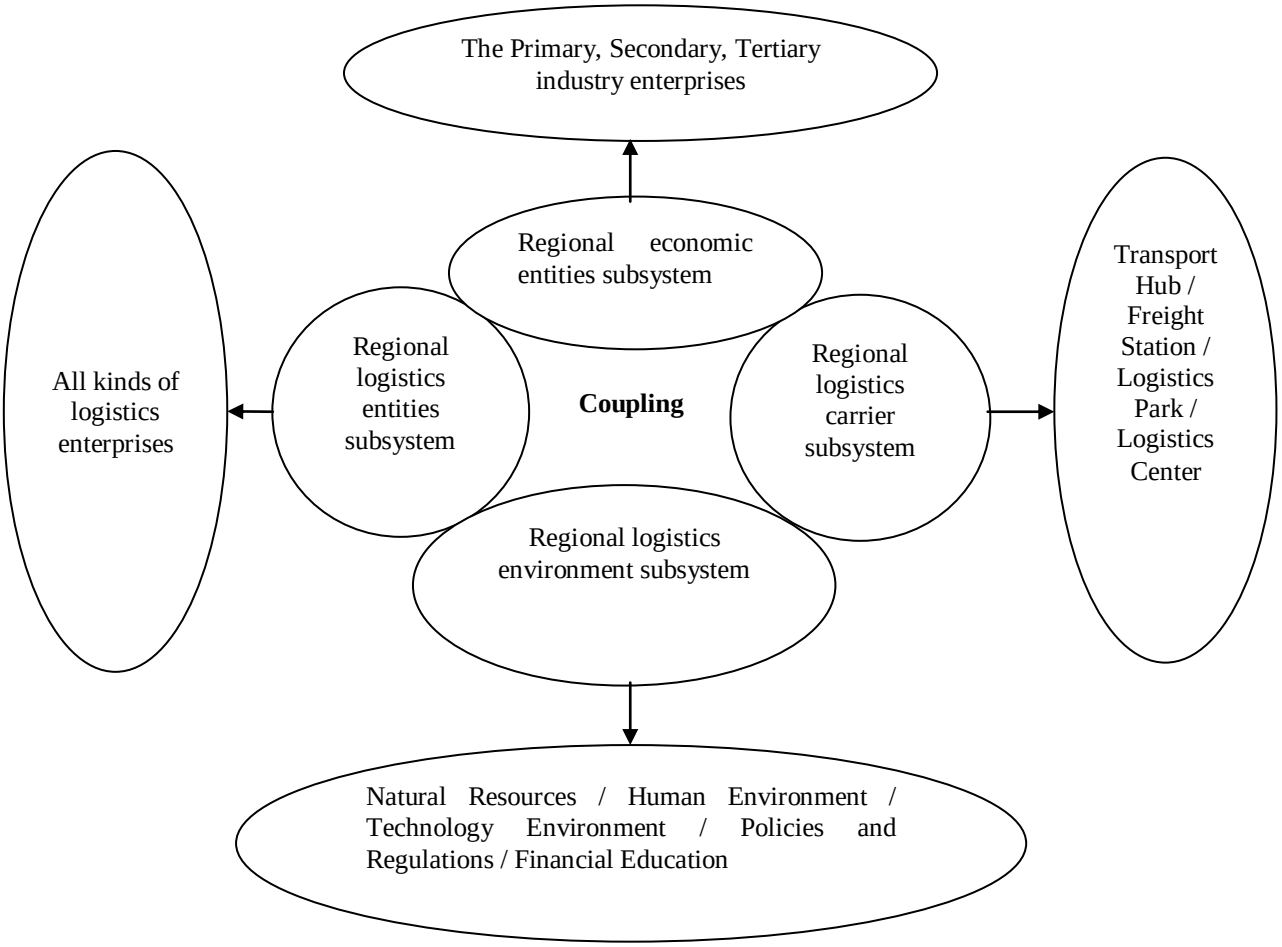

FIGURE 1 Regional logistics-economic complex systems structure

2.2 REGIONAL LOGISTICS-ECONOMIC SYSTEM FEEDBACK STRUCTURE

As a system simulation method, System Dynamics is used to research the dynamic behaviours of the information feedback in dealing with higher-order, nonlinear, delayed. It has a unique advantage in researching on a complex system of multiple feedback causality. Therefore, it is very suitable to study it based on system dynamics.

In the multiple feedback mechanisms, the regional logistics-economic complex systems achieve dynamic equilibrium in the process of fluctuations to form the dynamic coupling mechanism. The overall feedback structure is shown in Figure 2.

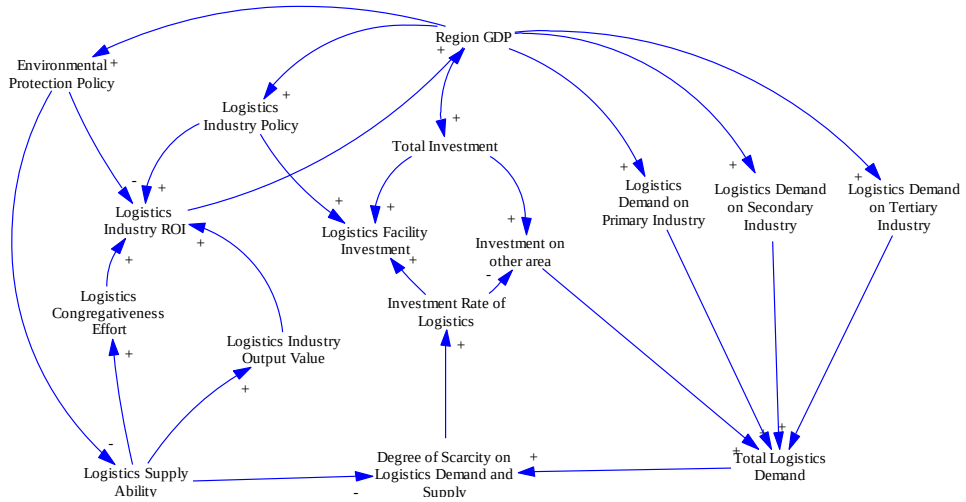

FIGURE 2 System overall feedback structure schematic

3 Modelling for regional logistics-economic system

3.1 REGIONAL LOGISTICS-ECONOMIC SYSTEM FLOWCHART

In the regional Logistics-Economic system, there are four subsystems, such as regional economic entities subsystem, regional logistics carrier subsystem, regional logistics entities subsystem and regional logistics environment subsystem. Regional economic entities subsystem affects the regional logistics carrier subsystem through regional GDP. The more regional logistics carrier, the more improvement regional logistics entities have. All of the economic activities are in the regional logistics environment subsystem. Through the system dynamics model, coupling the cross-links variable of the four subsystems, system dynamic flowchart shown in Figure 3 can be obtained.

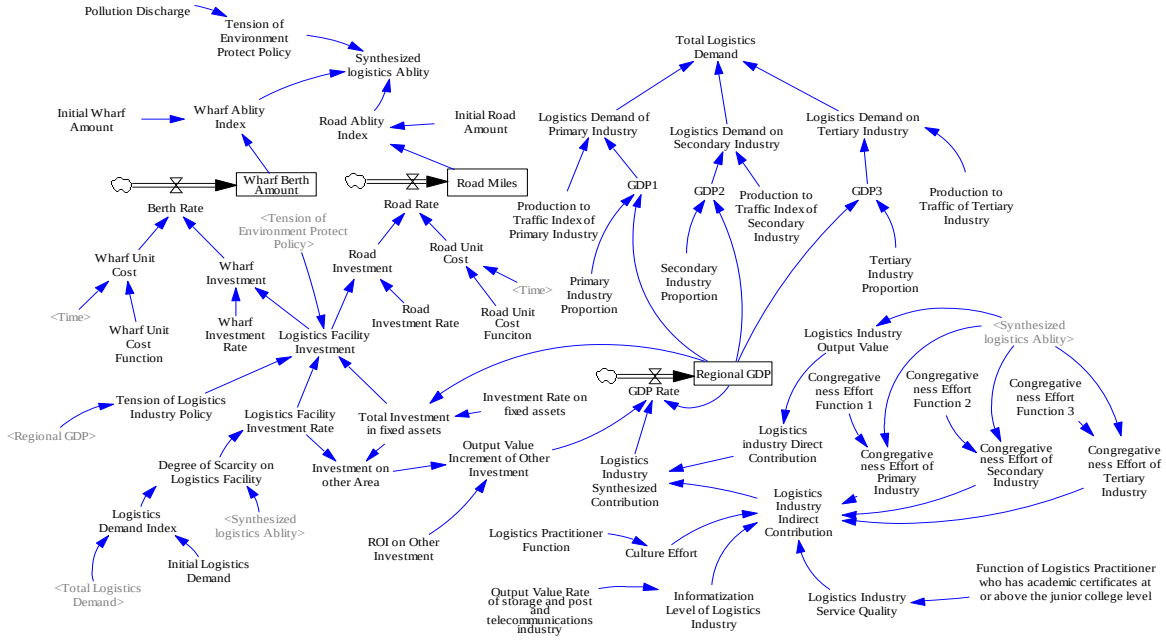

FIGURE 3 Regional logistics-economy system flowchart

3.2 REGIONAL LOGISTICS-ECONOMIC SYSTEM PARAMETERS AND VARIABLES SETTING

In this paper, coupling dynamic model of Regional Logistics-economic Complex Systems was established with Vensim5.8.

Considering the equilibrium relationship between the relevant data availability and variables structure, more than 70 variables are selected to study. Six level variables, six corresponding rate of variables and more than 60 auxiliary variables are included which reflect the development level of regional economic and infrastructure. They are shown in Table 1.

Most variable data can be gotten through Statistical Area Yearbook. Some coefficient can be measured through regional input-output tables.

TABLE l Variables and their categories of SD model

State Variable	Rate Variable	Auxiliary variable			
		Regional economic entities subsystem	Regional logistics carrier subsystem	Regional logistics entities subsystem	Regional logistics environment subsystem
Region GDP	Economic growth rate	Proportion of each industry output	Total fixed asset investment	Number of transport vehicles	Logistics industry policy
Road mileage	New road mileage	Each industry output	Scarcity of logistics facilities	Enterprise warehouse turnover rate	Logistics cultural environment
Railway mileage	New railway mileage	Various industrial production, transportation factor	Logistics facilities investment rate	Logistics capital turnover rate	Logistics services environment
Number of wharf berth	New Wharf berth	Logistics demand in various industries	Investment rate of all kinds transport	Output value of enterprises	Degree of information logistics
Number of airplane routes	Number of airplane routes	Total logistics demand	Investment rate in other areas	Workforce practitioners	Environmental Protection policy
Storage facilities area	New storage facilities area		General index on logistics capability	Enterprise storage utilization	

4 Testing and Simulation –Based on Heilongjiang Economic Zone

Heilongjiang Economic Zone is China's heavy industry and main foodstuff field. It is also an important part of the Northeast Asia Economic Circle and regional logistics center. The 2000-2012 data of Heilongjiang regional logistics and economic are used to simulate. Firstly, the effecttivity of the system dynamics model can be tested. Then, the optimal solutions are simulated through parameter adjustment. At last, the optimal solution is chosen by compared with others.

4.1 MODEL TESTING

Heilongjiang region data of 2000-20012 is selected to test the SD model. According to the model structure and selected parameters, the simulation data of Heilongjiang region can be obtained. The comparative analysis between the simulation and actual data of 2000-2012 years is shown as Table 2.

The deviation rate between the simulation results and actual data maintains at less than 10%. So, the simulation model can be considered as a good reflection of dynamic coupling relationship between Heilongjiang logistics system and economy. It can be used to simulate and predict.

4.2 SIMULATION AND ANALYSIS

There are three interaction modes between regional economic and logistics system. They are adaptive development model, logistics system advance moderately mode and other industries priority mode.

TABLE 2 Comparison between the simulation and actual data of 2000-2012

Years	Heilongjiang Region GDP (hundred million yuan)			Logistics Industry out-put (thousand ton)		
	Actual data	Simulation data	Error rate (%)	Actual data	Simulation data	Error rate (%)
2012	1,369,157	1,376,780	0.56	652,310	664,650	1.89
2011	1,258,200	1,247,690	-0.84	632,160	643,870	1.85
2010	1,036,860	1,048,760	1.15	593,140	602,560	1.59
2009	858,700	861,940	0.38	589,750	583,670	-1.03
2008	831,440	817,960	-1.62	581,680	576,430	-0.90
2007	710,396	700,550	-1.41	578,350	572,890	-0.94
2006	621,184	630,370	1.52	572,530	581,340	1.54
2005	551,370	562,020	1.93	569,780	572,810	0.53
2004	475,060	502,030	5.70	565,640	554,785	-1.92
2003	405,740	436,210	7.51	543,500	557,890	2.65
2002	363,720	359,870	1.06	543,940	551,470	1.38
2001	339,010	320,870	-5.35	542,040	537,648	-0.81
2000	315,140	322,240	2.25	535,500	544,670	1.71

Note: The actual data of the table come from "China Statistical Yearbook" 2000-2012 edition

4.2.1 Adaptive development model (A)

As regional logistics and economic system can construct a self-adjusting mechanism, its core is the supply and demand of logistics can balance automatically. Thus, it is an adaptive collaborative development model that both systems fluctuate together. The premise of this model is that local governments provide logistics facilities mainly. It can determine the level of investment in accordance with the balance of logistics facilities supply and demand.

4.2.2 Logistics System exceed moderately mode (B)

Although there is the adaptive mechanism between logistics system and economic growth, the balance is difficult to realize at a certain time because of the longer period of logistics system construction and payback than other industries. In order to realize the optimal, it is necessary to increase investment on logistics system appropriately to advance the development.

4.2.3 Other industry priority mode (C)

Because it is longer for the investment payback period of logistics facilities, it is short of capital accumulation in the early development period. Thus, there is another view that the capital should be invest on faster return industries in developing countries and regions to achieve the original capital rapid accumulation, especially manufacturing industry. Many developing countries take this mode.

The comparing results of regional economic growth for three modes show as Figure 4.

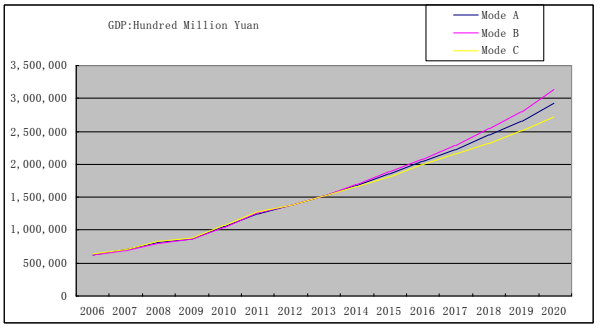

FIGURE 4 Simulation results of regional economy growth for three modes

Figure 4 compares the results of regional economic development in 2020, B model is the highest. A mode is the second, and C mode is the lowest. It is shown that logistics system exceed moderately is the most favorable for priority to the long-term growth of the regional economy. However, other industries priority will lead to logistics facilities lagged development which constrains the long-term growth of regional economy. The results also demonstrate that the economy scales under three modes are opposite in front five years. It indicates that increasing investment on productive industries can achieve results faster in the short term. While, due to the delay effect in logistics system, it can reduce the development speed of regional economy.

5 Policy recommendations

By analyzing the mechanism and simulation with SD, in order to exert the positive effect of modern logistics in the regional economy development, we need to start from the following aspects.

First, in regional economic development, logistics system plays a significant positive role. But this effect is reflected mainly in the contribution of long-term growth. So it requires local governments overcome the short-sighted behavior, increase investment on logistics, expand the sources and channels of capital actively and improve regional logistics service capabilities. So that logistics system can exceed moderately regional economic development in order that regional economic grow rapidly for long-term.

Second, adaptive mechanism exists in between logistics system and regional economic growth. This mechanism depends on the perfect environment of market. Local government should promote the formation of logistics market actively, support and nurture professional and integrated logistics enterprises vigorously, rationalize the formation mechanism of market price. So the supply and demand of logistics can be balanced effectively. It can also reduce delays and frictional costs.

Third, in order to make the aggregation effect of logistics industry to be exerted, a favorable investment environment of the industry should be created through the provision of comprehensive logistics service system. The government should guide actively the manufacturing, commercial enterprises and logistics industry to establish a strategic alliance. So the interactive mechanism of manufacturing and logistics industry would be formed. Then, logistics service could be the real boosters of regional economic growth.

6 Conclusions

From the dynamic coupling relation between regional logistics system and regional economic system, the structure of Regional Logistics-Economic Complex System has been established. System dynamics model for it has been constructed to simulate the coupling development mechanism between the various subsystems. Logistics system exceed moderately is the most favorable for priority in order that it can grow rapidly for long-term.

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