Study on Influencing Factors of Innovation System Evolution of Pearl River Delta Region Based on Structural Equation Model

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Abstract
The PRD region is one of the regions with the strongest independent innovation capability in our country. The study on the influencing factors of its innovation system evolution provides the basis for decision-making on enhancing the capability of independent innovation and competitiveness in the PRD region. Based on the structural equation model, this paper has analyzed the comprehensive system, and the interaction and influence degree of various factors that affect the evolutionary ability of the innovation system in the Pearl River Delta, and put forward corresponding countermeasures and suggestions according to the existing problems. In this paper, we have used market-oriented method to improve the effectiveness of the innovation system in the Pearl River Delta region, and established the innovation system evolution model of Pearl River Delta region, which is a basic market demand-oriented applied research.

Keywords: Pearl River Delta region; Innovation system evolution; Influencing factors; Structural equation model

1. Introduction

American scholar Porter first put forward the elements of regional innovation capability. He believes that the construction of infrastructure and the environmental conditions supporting innovation cluster are important components. The evolution of regional innovation system is defined as the continuous generation of business-related innovation in the region potential. The research on the evolvement ability of regional innovation system started quite late in our country, but developed rapidly. Zhenfeng et al divided the evolutionary capabilities of regional innovation system into multiple modules, and established an index evaluation system to evaluate the evolutionary capabilities of innovation systems in 13 provinces and cities. For the first time, quantitative research was used to evaluate the evolutionary capabilities of regional innovation systems. Sun Li-jie and others have taken the cluster analysis method to cluster the evolutionary ability of innovation system in 31 provinces and cities in the interior of China. Scholars have studied on the evolution ability of regional innovation system which mainly focuses on the relationship between input-output, including the establishment of innovation index evaluation system and the effective utilization of resources for technological innovation in the region. This study is based on the examination of the status, the discovery of problems and the solution of the problems. The research focuses on the status of the economic development in the Pearl River Delta and the existing problems. Based on the structural equation model, the influencing factors are studied on the evolution of the innovation system in the Pearl River Delta.

2. Research methods of structural equation model

2.1. The basic principles of structural equation model

Structural equation model is referred to as SEM, and is a covariance structure analysis, and multivariate analysis is an important issue, which is widely used in economics, sociology, psychology and other disciplines. Structural equation modeling is a statistical method for analyzing the correlation between latent variables. Latent variables belong to variables that cannot be directly observed and measured. Explicit variables are variables that can be observed directly. We can indirectly measure latent variables with explicit variables, and study the relationship between latent variables by structural equation modeling. Structural equation model includes measurement models and structural models. The measurement model is used to analyze the relationship between latent variables and variables that can be directly observed. The latent variables are generally considered as an important factor, and the hypothetical relationship between the research factor and the observed index, as well as the measurement equation are shown in equation (1):

$$\begin{cases} X = \Lambda_x \xi + \delta \\ Y = \Lambda_y \eta + \varepsilon \end{cases} \tag{1}$$

In the above formula, X is the exogenous variable, and Y is the endogenous variable, and ξ is the exogenous latent variable, and η is the endogenous latent variable, and δ is the measurement error of X, and ε is the measurement error of Y, and Λ_x is exogenous factor, and loading matrix of exogenous variables is exogenous variable, and Λ_y is the factor loading matrix of endogenous latent variables. Structural models are first-order factor analysis of a higher degree of modeling process, which is used to analyze the relationship between latent variables, as well as the variables that cannot be explained, and the model. Structural equation is shown in equation (2):

$$\eta = B\eta + \Gamma\xi + \theta \tag{2}$$

Where η is the endogenous latent variable, and B is the relationship between endogenous latent variable, and Γ is the exogenous latent variable with endogenous latent variable, and ξ is the exogenous latent variable, and θ is the residual term, which is used to explain the part of the endogenous latent variable of η in the structural equation.

2.2. Analysis steps of structural equation model

Structural equation model analysis steps include five steps of model construction, model fitting, model fitting test, model modification and model evaluation.

(1) Model construction. The construction of the model includes theoretical analysis and model setting. The structural equation model requires a certain theoretical basis to do the support, so scholars must read a lot of relevant literature before setting the model to find out the potential variables that affect the second-order factors, and the reasonable selection of all possible variables that influence the latent variables.

(2) Model fitting. The key to the success of the model construction is whether the model fitting is good or not. The key to judge whether the model fits successfully is to judge whether the model constructed by the selected sample data can obtain the unique solution to the parameter estimation, and whether it can reach the minimum sample data that cannot be identified by structural equation models makes no sense.

(3) Model correction. When the model parameters are estimated, the model should be corrected if it is found that the adaptive effect between the theoretical model and the observed sample data is not good. The real purpose of the model modification is to improve the adaptability of the theoretical model. The revised model should be reasonable and can not violate the real meaning.

(4) Model evaluation. Through the above series of theoretical research, model setting, model fitting, model fitness test and constant revision of the model can get the final model variable parameter map, and then based on the relationship between variables and variables model to explain and evaluate. Therefore, it provides the basis for the practical application of the model.

(5) Test of model fitness. The index of model fitness test is to explain the extent to which the sample data selected by the researcher matches with the theoretical structure model that is constructed, and cannot explain the quality of the model itself. Because in addition to the theoretical model proposed by researchers, there may be a more reasonable theoretical model. The model fitness index includes basic fitness index, extrinsic quality fitness index and inherent quality fitness index.

3. Study on the influencing factors of innovation System evolution of Pearl River Delta region based on structural equation model

3.1. Sample selection

This paper uses a unilateral study to collect data, that is, the same questionnaire in the Pearl River Delta region to conduct business surveys and collect data. The purpose of this study is to ask the respondents of the survey to grasp the overall situation of the innovation system in the Pearl River Delta region. The survey will mainly focus on the Pearl River Delta region. In order to ensure the consistency of this research measurement, all the variables adopt Likert seven-point calibration method. In essence, seven specific calibration values are given for each problem. According to the PRD actual situation, the region should choose the appropriate scale value. The questionnaire survey was from September to November 2017, and a total of 200 questionnaires were distributed, which is excluding 29 invalid questionnaires and 171 were valid questionnaires, and the effective rate of the questionnaire was 85.5%.

3.2. Descriptive statistical analysis

This paper's survey mainly includes various types of enterprises in the Pearl River Delta region. In order to make the survey more universal, the process of investigation should pay attention to enterprises with different ownership and scale. Table 1 shows the statistical description of enterprise ownership in the Pearl River Delta region. In terms of ownership of the PRD region, state-owned enterprises accounted for 39.7% of the sample, and private-owned enterprises accounted for 26.3%, and Sino-foreign joint ventures accounted for 12.9% and foreign-owned enterprises accounted for 21.1%.

Table 1. Statistical description of enterprise ownership in the Pearl River Delta region

Enterprise	Frequency	Percentage	Effective percentage	Cumulative percentage
State-owned	68	39.7	39.7	39.7
Private-owned	45	26.3	26.3	66
Sino-foreign joint ventures	22	12.9	12.9	78.9
Foreign-owned	36	21.1	21.1	100.0
total	171	100.0	100.0	

For the industries in the PRD region, manufacturing accounted for 56.7%, and retail accounted for 7.1%, and import / exporters accounted for 15.7% and other companies accounted for 20.5%. The statistical description of the industries in which the enterprises are located is shown in Table 2.

Table 2. Statistical description of industries in the Pearl River Delta region

Industry	Frequency	Percentage	Effective percentage	Cumulative percentage
Manufacturing	97	56.6	56.7	56.7
Retail	12	7.01	7.1	63.8
Import / exporters	27	15.8	15.7	79.5
Other	35	20.5	20.5	100.0
Total	171	100.0	100.0	

From the perspective of the size of the Pearl River Delta region, enterprises with less than 100 employees account for 9.9%, and 100-499 employees account for 30.4%, and 500-999 employers account for 22.3%, and 1000-4999 employers account for 15.8% , and more than 5,000 companies accounted for 21.6%. The statistical description of the size of enterprises in the PRD region is shown in Table 3.

Table 3. Statistical description of the scale of enterprises in Pearl River Delta region

Scale (number of people)	Frequency	Percentage	Effective percentage	Cumulative percentage
Less than 100	17	9.9	9.9	9.9
100-499	52	30.4	30.4	40.3
500-999	38	22.3	22.3	62.6
1000-4999	27	15.8	15.8	78.4
5000 and above	37	21.6	21.6	100.0
Total	171	100.0	100.0	

From the time when the Pearl River Delta region implemented the development and management of its innovation system, 22.2% of the enterprises did not implement the innovation system development management, and 8.2% of the enterprises took 0-1 years, and 19.9% of the enterprises of 1-3 years, and 3-5 years of enterprises accounted for 21.05%, and 5 years of enterprises accounted for 28.63%. The time taken by PRD enterprises to implement innovation system development and management is shown in Table 4.

Table 4. Implement time of innovation system development management for PRD enterprises

Implement time	Frequency	Percentage	Effective percentage	Cumulative percentage
0 years	38	22.22	22.22	22.22

0-1 year	14	8.2	8.2	30.42
1-3 years	34	19.9	19.9	50.32
3-5 years	36	21.05	21.05	71.37
5 years or more	49	28.63	28.63	100.0
Total	171	100.0	100.0	

3.3. Reliability and validity analysis of structural equation model

Reliability is the consistency or stability of the results obtained from the questionnaire measurement and is a study that reflects the true extent of the measurement data. In this paper, we use SPSS 19.0 to test the reliability of the data.

In the SPSS reliability test, we usually use the Cronbach Alpha coefficient as the standard of reliability test. In general, if the scale's reliability coefficient reaches 0.9 or above, the reliability of the data scale is good, and reliability coefficient of 0.8 or more is acceptable. But if it is less than 0.5, the analysis results of this scale cannot be believed. This paper uses Spss19.0 to analyze the statistical reliability of the Pearl River Delta region, which is shown in Table 5:

Table 5. Statistical reliability analysis table of structural equation model

Reliability value	Enterprise TOE features			--
	Technical characteristics	Organizational characteristics	Environmental characteristics	--
The subscales coefficient	0.933	0.904	0.92	--
Total scale coefficient	0.95			--
Reliability value	Enterprise innovation system evolutionary factors			
	Internal environmental management	Internal social responsibility management	External supplier management	Distribution channel management
The subscales coefficient	0.958	0.889	0.967	0.926
Total scale coefficient	0.974			

As can be seen from Table 5, the Cronbach Alpha coefficient of the TOE characteristic of the PRD region enterprises is 0.95, of which the technical characteristics are 0.933. The organizational characteristics are 0.904, and the environmental characteristics are 0.92. The Cronbach Alpha in practice of innovative system evolutionary factors was 0.974, which is including 0.958 for internal environmental management, and 0.889 for internal social responsibility management, and 0.967 for external supplier management and 0.926 for distribution channel management.

Data analysis is usually performed prior to factor analysis. The KMO test is used to test whether the partial correlation coefficient between variables is too small. If the value is less than 0.5, it is unfavorable to follow-up factor analysis. When the ratio is close to 0.9, the result is the best, and the Bartlett's spherical test is used to test whether the correlation coefficient matrix is an identity matrix. If the conclusion indicates that each variable is independent, then it is suitable for subsequent factor analysis. The KMO coefficients and Bartlett spherical test results for the TOE properties of the Pearl River Delta region are shown in Table 6 below:

Table 6. KMO and Bartlett test of TOE properties of structural equation model

Sampling sufficient Kaiser-Meyer-Olkin measure		.847
Bartlett's sphere test approximates	Chi square	2417.514
	Df.	496
	Sig.	.000

As can be seen from the above table, the KMO value of the scale is 0.847, which is much higher than the minimum standard of 0.5 for factor analysis. The significance level of Bartlett spherical test value is 0.000 and less than 0.001, which is rejecting the assumption that the correlation coefficient matrix is an identity matrix, and suitable for factor analysis. According to the principal component analysis of the data in the sample, the main factor with root greater than 1 is extracted. The following table lists all the principal components according to descending order values. The values of the six principal components in the front of the table are greater than 1. This shows that the six main factors of the TOE characteristics of the Pearl River Delta region enterprises account for a total of 76.115% of the total variance. The total variance explained in the PRD regional structural equation model is shown in Table 7.

Table 7. Total variances in the structural equation model of the Pearl River Delta region

Components	Initial value			Extract square and load			Rotate squared and load		
	Total	Variance	Accumulated	Total	Variance	Accumulated	Total	Variance	Accumulated
1	12.942	40.443	40.443	12.942	40.443	40.443	5.974	18.668	18.668
2	3.772	11.787	52.230	3.772	11.787	52.230	4.783	14.948	33.616
3	2.364	7.386	59.616	2.364	7.386	59.616	3.885	12.139	45.755
4	1.963	6.134	65.751	1.963	6.134	65.751	3.349	10.465	56.220
5	1.776	5.548	71.299	1.776	5.548	71.299	3.266	10.206	66.426

The KMO coefficients and Bartlett spherical test results of the evolutionary factors of the enterprise innovation system in the PRD region are shown in Table 8:

Table 8. KMO and Bartlett test of the evolutionary factors of enterprise innovation system in the Pearl River Delta region

Sampling sufficient Kaiser-Meyer-Olkin measure		.810
Bartlett Sphere Test	Approximate chi square	4732.319
	df	1275
	Sig.	.000

The principal component analysis of the data in the sample can extract the principal component factor greater than 1, and the following table lists all the principal components in descending order according to the characteristic root, and the first nine principal components of the root are more than 1, and therefore the nine main factors that took the evolutionary factorization of enterprise innovation system in the Pearl River delta can explain a total of 80.12% of the total variance.

In this paper, the confirmatory factor analysis of data is used to test the convergent validity of data. Confirmatory factor analysis can be used to test the hypothetical relationship between measured variables and latent variables. The confirmatory factor analysis of TOE characteristics of enterprises in the Pearl River Delta region is shown in Figure 1.

Table 9. Fitness list of structural equation model

Adaptation Statistics	CMIN/DF	GFI	NFI	RFI	IFI	TLI	CFI	RMSEA
Evaluation criteria	<3	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	<0.08
Statistics	2.683	0.935	0.951	0.903	0.938	0.914	0.921	0.067

Table 9 shows the fit of the bit structure equation model. It can be seen that CMIN/DF=2.683<3, GFI=0.935, NFI=0.951, RFI=0.903, IFI=0.938, TLI=0.914, CFI=0.921 and RMSEA=0.067, which indicates that all listed fit indicators meet the required standards, and the measurement model is more reasonable, and the program analysis results did not prompt to be further amended based on the above analysis results. The Pearl River Delta regional business performance scale is studied through the validity verification, and the measurement model in the structural equation model has also been verified.

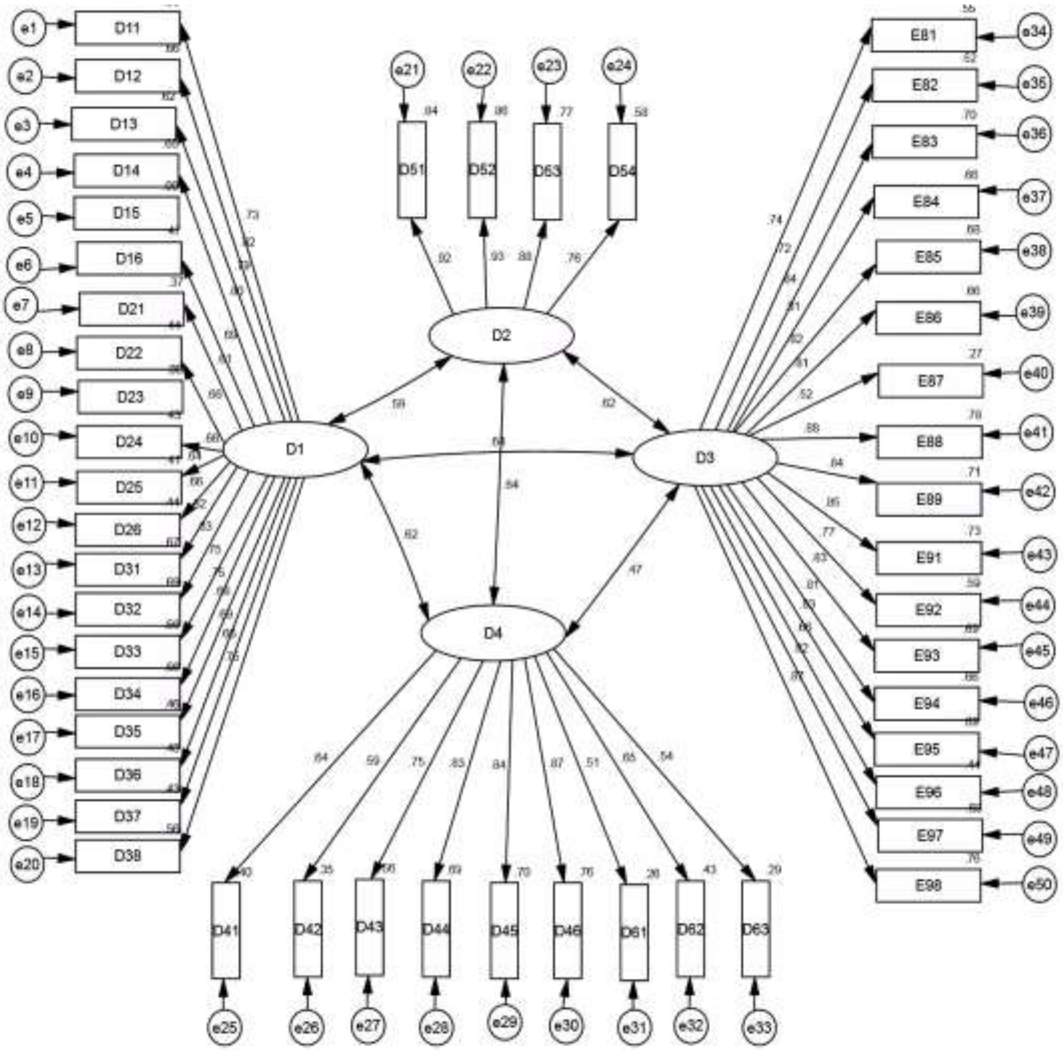

Figure 1. Confirmatory factor analysis of structural equation model

4. Conclusion

In this paper, we have studied the influencing factors of the evolution system of Pearl River Delta regional innovation based on the structural equation model. In order to enhance the government's support for R&D investment, we must increase tax incentives and fiscal expenditures for innovative enterprises, and create a good environment for innovation and innovation and service market, which is also an important source of improving the ability of enterprise innovation system and competitiveness. At the same time, we must take the market as the orientation, and improve the effectiveness of the alliance for enterprise innovation and cooperation, and establish an innovation alliance in the Pearl River Delta region for basic and applied research. Finally, it is necessary to improve the science and technology service market and the science and technology financial services industry, and provide services such as risk assessment, financing, and information and management consultation for enterprise innovation, and establish science and technology service intermediary agencies and commercial service agencies, and provide personalized and specialized service.

Acknowledgement

The research in this paper was supported by Youth Innovative Talents Project in Colleges and universities of Guangdong Province: Research on the Evolution Mechanism and Performance of the Open Innovation System in the Pearl River Delta Region (NO. 2017WQNCX068)

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