Research on the Innovation of Small and Medium-Sized Enterprises from the Perspective of Business Gene

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Abstract It's the first attempt for us to identify the business genes which might affect the innovation of small and medium-sized enterprises (SMEs) through an questionnaire survey and a quantitative analysis based on structural equation model (SEM). The main finding of the research is that the innovation orientation of SMEs is strongly determined by such business genes as capabilities of R&D, technology innovation, innovation management and learning, within which, the capability of learning is the most significant one comparing with all other factors.
Key words Innovation gene of business; Small and medium-sized enterprises; Structural equation model(SEM); Business evolution

1 Introduction

It is well known that the mortality rate of SMEs is extremely high around the world, thus according to the view of points of most management researchers and practitioners, the ultimate solution for them is to innovate continuously. Since 1960s, gene theory began to come into the domain of management research. Business gene can either affects business performance independently or dependently combining with external environment, which might perform as innovation of technology, thought and culture. From the perspective of business gene, business' innovation mechanism might involve the mechanisms of business gene's mutation and reorganization. The previous literatures were used to define the key factors which influence business' evolution as business gene. Moreover, it was believed that business' innovation gene might refer to the capabilities of innovation management, R&D, technology innovation and learning, etc. Actually, we argue that the contents of business innovation gene are very abundant, and they vary depending on business' internal and external environment. As well, if a business wants to reinforce its genes, it must make sense of the critical factors which affect the performance of genes significantly. Therefore, by means of the structural equation model and its relevant research fruits, we attempt to propose some hypotheses to disclose the relationship between the innovation genes and its affecting factors, and then construct a SEM model to test their causalities, by which we can also tell how can the business innovation gene affect a business' directional evolution.

2 Hypotheses and Model

2.1 Hypotheses

Previous studies referred to innovation management mainly focused on technology innovation and its process, as well how to design a innovation system to encourage the innovation behavior (Xie and Chen, Liu and Yu, etc.). Thus following the traditional paradigm, we have proposed hypotheses H1~H7 to disclose the key genes that will influence SMEs' innovation as well how can they react with each other.

H1: R&D gene has positive effect on technology innovation gene.
H2: R&D gene has positive effect on innovation management gene.
H3: R&D gene has positive effect on learning gene.
H4: technology innovation gene has positive effect on innovation management gene.
H5: innovation management gene has positive effect on learning gene.
H6: innovation management gene has positive effect on innovation orientation.
H7: learning capability gene has positive effects on innovation orientation.

2.2 Determination of the variables and indicators

According to the SEM, we initially scrutinize the initial relations and select corresponding measurable variables as the substitutes of latent variables, which can reflect the meaning of latent variables comprehensively, shown in Table 1.

Table 1　Variables, Indicators and Explaining

Latent variables		Observable indicators	Explaining
Exogenous latent variables	R&D gene ξ_1	External environment x_1	The external environmental factors affecting business' innovation, such as macroeconomic environment, degree of competing in the market, etc.
		Understanding of innovation policy x_2	Capability of understanding governmental innovation polices
		Research equipments x_3	Advancement and completeness of research equipments
	Technology innovation gene ξ_2	Inputs of manpower x_4	Inputs of manpower into innovation behavior
		Inputs of money x_5	Expenditure on innovation behavior
		Capability of output x_6	Output as a result of innovation
		achievement x_7	Benefit or performance brought about by innovation
Endogenous latent variables	Innovation management gene η_1	Organization management y_1	Level of innovation organization management
		Sustainable innovation y_2	Capability of creating sustainable innovation
		Supporting power y_3	Degree of supporting innovation behavior
		Innovation mechanism y_4	The completeness of innovation mechanism
	Learning Gene η_2	Structure of team y_5	The structure of innovation teams
		Culture y_6	The maturity of innovative culture
		Organizing learning y_7	The level of organizing learning in a business
	Innovation orientation η_3	Strategic goal y_8	If there is a correct strategic innovation goal
		Group target y_9	If there is a innovation target for specific groups
		Individual target y_{10}	If there is a innovation target for individual employee

We can construct an initial SEM to study the relationships between latent variable according to hypotheses H1~H7 with the help of observable indicators listed in Table 1. The corresponding structural model, denoted as M1 could be depicted as Figure 1.

$$x = \Lambda_x \xi + \delta \Rightarrow \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \end{bmatrix} = \begin{bmatrix} \lambda_1 & 0 \\ \lambda_2 & 0 \\ \lambda_3 & 0 \\ 0 & \lambda_4 \\ 0 & \lambda_5 \\ 0 & \lambda_6 \\ 0 & \lambda_7 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \\ \delta_7 \end{bmatrix} \tag{1}$$

$$y = \Lambda_y \eta + \varepsilon \Rightarrow \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \\ y_7 \\ y_8 \\ y_9 \\ y_{10} \end{bmatrix} = \begin{bmatrix} \lambda_8 & 0 & 0 \\ \lambda_9 & 0 & 0 \\ \lambda_{10} & 0 & 0 \\ \lambda_{11} & 0 & 0 \\ 0 & \lambda_{12} & 0 \\ 0 & \lambda_{13} & 0 \\ 0 & \lambda_{14} & 0 \\ 0 & 0 & \lambda_{15} \\ 0 & 0 & \lambda_{16} \\ 0 & 0 & \lambda_{17} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \\ \varepsilon_9 \\ \varepsilon_{10} \end{bmatrix} \tag{2}$$

The model M1 includes the measurement model and structural equation, shown in equation (1) and equation (2).

3 An Empirical Study

3.1 Questionnaire and reliability testing

In order to test the theoretical model, we have designed a questionnaire, in which there are five major categories, including 17 items. In the questionnaire survey, 145 respondents from small and medium-sized enterprises in Wuhan City of China were involved, and 129 of them had responded, while among them, 117 returned ones were valid, with a valid return rate of 80.69%. The five-point Likert Measurement was employed to describe each evaluation item, in which 1 to 5 indicates the transition from low to high of influence degree in turn.

Reliability Analysis command in SPSS 13.0 were used to obtain Cronbach α of latent variables and total variables. Test results tell that each Cronbach α is over the threshold 0.7, which demonstrates that the internal consistency of all items in the questionnaire is good. The testing results are shown in Table 2.

Table 2 Results of Reliability Testing

Latent variable	Number of observable variables	*Cronbach α*
R&D gene ξ_1	3	0.749
Technology innovation gene ξ_2	4	0.824
Innovation management gene η_1	4	0.803
Learning Gene η_2	3	0.756
Innovation orientation η_3	3	0.772
total	17	0.787

3.2 Model fitting and evaluation

Based on the data obtained by questionnaire survey, by means of Maximum likelihood method package contained in software AMOS, we can get the analytical results shown in Figure 1.

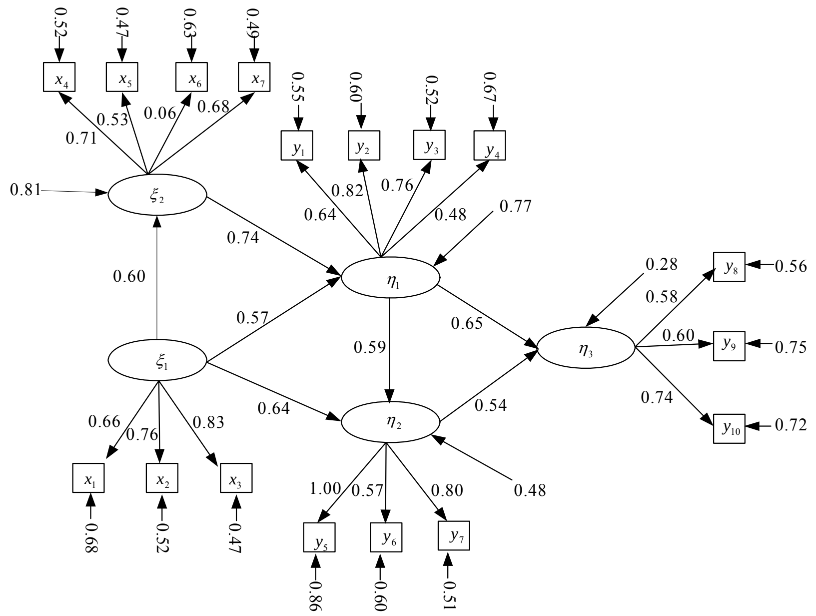

Figure 1 Estimated Value of Parameters (Model M1)

In AMOS, we use CR (Critical Ratio) to conduct the significance test of route-system or load coefficient (coefficient of the null hypothesis is zero). According to AMOS variance estimates, the CR value of x_6 to technology innovation gene is 0.52, with the associated probability of 0.001, thus x_6 can not explain ξ_2 well. Meanwhile, in other latent variables, the correction index (MI) of the indicator is low, which means observable indicator x_6 is not attributed to other latent variables too. So we can delete the observable indicator x_6. Very similarly, we have also tested the other indicators to get a new parameter estimation, by which we can modify the model M1 to obtain model M2 (shown in Figure 2).

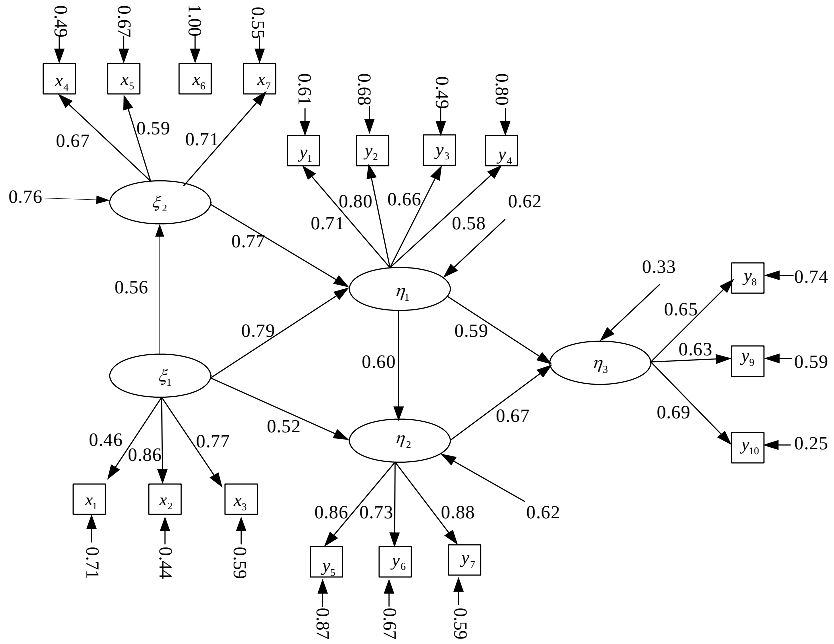

Figure 2　Estimated Values of Parameters (Model M2)

By comparing the indices of goodness of fit in the original model (M1) with those in modified structural model (M2), we find that the fitness indices of M1 are significantly higher than those of M2. Goodness of fit indices for the M2 are shown in Table 3, with which we can conclude that that the modified model is a good fit with the sample data and has a high degree of consistency.

Table 3　Goodness of the Fit Indices for the Modified Model

Model \ Index	χ^2	*df*	*CMINDF*	*GFI*	*RMSEA*	*CFI*	*TLI*
M1	461.83	66	2.78	0.847	0.099	0.83	0.89
M2	357.25	56	2.29	0.902	0.067	0.84	0.97

From the above analyses, we can conclude that our hypotheses are verified. Meanwhile, concerning the values of parameters in structural model M2, we can find that: (1) the influence coefficients of ξ_1 and ξ_2 to η_1 are 0.79 and 0.77 respectively, which means that R&D capability and technology innovation capability are almost equivalent in enhancing innovation management genes, while the former one is slightly more significant that the later one. (2) ξ_1 has a direct impact on ξ_2, η_1 and η_2, meanwhile, ξ_2 affects learning genes indirectly. (3) Learning gene η_2 is not only directly affected by ξ_1, but also directly affected by innovation management gene η_1. Their influence coefficients to η_2 are 0.52 and 0.60 respectively. It demonstrates that, comparing with R&D gene, innovation management gene has a more obvious impact on learning gene. (4) η_1 and η_2 have a combined effect on business innovation orientation, with the influence coefficients of 0.59 and 0.67 respectively, which means that learning contributes more to innovation orientation than innovation management. (5) The factor loading values in the structural model reflect the weight of the observable indicators on corresponding latent variables, namely the degree of significance. By rule of thumb, we can also observe the rationality of the model M2.

4 Conclusion

In this paper, the first attempt to disclose the innovation genes of SMEs and their interrelationship has been made. Employing SEM, we have successfully proved the validity of our proposition, namely, the innovation orientation is really determined by genes of R&D, technology innovation capability, innovation management capability and learning capability, while the learning capability is most significant to innovation orientation comparing with other genes. Therefore, in order to improve the innovation capability of SMEs and realize their strategic innovation goal, managements in SMEs should focus on such strategies as constructing a learning organization, optimizing the conditions of R&D, increasing the input of technology innovation and enhancing the level of innovation management. Anyway, the innovation is really compulsory to SMEs' survival and sustainable development, and is not a final result but a long time ongoing process.

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