

# *The Model of Collaborative Development of Technological Innovation and Technological Finance - Taking Maoming as an Example*

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**Abstract:** Based on the research on the mechanism of the synergy between the innovation of science and technology and the financial level of science and technology, this paper chooses Maoming's innovation of science and technology and the synergistic development of the financial composite system of science and technology to build a synergy measure model. After the model is established, we analyze the data and conduct research on the selected Maoming's technology innovation and technology finance coordinated development. We analyze the research results of the coordinated development model to understand the level and status quo of the coordinated development of Maoming 's technology innovation and technology finance.

## 1. Introduction

Technological innovation is inseparable from the support of technological finance. Technological finance plays a key role in promoting technological innovation, as technological. Financial capital is the soil that nurtures technological innovation. Under the catalysis of science and technology finance, the promotion and promotion of scientific and technological innovation is accelerated, which in turn promotes the corresponding industrial transformation and upgrading. Between Technological Innovation and Technological finance. It is an organic whole that interacts with each other, and the two are continuously integrated and transformed, thereby generating spillover effects and promoting the high-level deepening and development of the industry.

Zhang Ling et al believe that, the participation of venture capital in the technological innovation process of enterprises can reduce the uncertainty of innovation, improve the risk appetite of technological enterprises, and then motivate entrepreneurs to more Participate in technological innovation activities to have a positive impact on technological innovation [1]. At the same time, many scholars have studied the impact of financial development through empirical analysis. The impact of technological innovation. Li Ying et al. used panel data from Guangdong Province to analyze the impact of financial development on the efficiency of technological innovation. The results show that my country's technological innovation The efficiency of innovation is positively related to financial development, and compared with banks and insurance, the positive effect of capital market on technological innovation is more obvious [2]. Based on the three-stage DEA-

Tobit model, Cui Xuehai et al. The efficiency of financial support technology transfer is measured, and the results show that there are obvious differences in the efficiency of different provinces and cities [3]. Zhang Jiangpeng and others classified 29 provinces in my country according to their geographic locations. It is divided into five regions, and the synergy degree model is used to measure the synergy of technological innovation and technological finance in different regions. The results show that the synergy in the southeastern region. The situation is the best, followed by the central and southern regions, while the northeast and northwest regions are in a non-coordinated state with the lowest level of development [4]. Technological innovation and technological finance are an organic whole that interacts and promotes each other with capital flow as the carrier. On the one hand, technological innovation. It is inseparable from the support of technology and finance. Saint-Paul pointed out that a sound financial market can diversify risks for investors and provide socialized mass production and professional to provide financial support for technological advancement and better promote technological progress and economic development [5]. Continuous deepening will put higher requirements on the financial industry. In response to the financing needs of scientific and technological innovation entities, the financial industry should make full use of advanced technology to reshape the industry [6]. In order to provide customers with better financial services, the result will prompt the financial industry to intensify the innovation of financial services, and meet the needs of innovative enterprises [7]. Financial products, business models, business processes, and organizational forms continue to emerge, thereby further accelerating the transformation and upgrading of the financial industry and promoting modern technology finance. high-quality development. Secondly, technological innovation promotes the continuous improvement of the technological financial service system. Maoming is located in the western part of Guangdong Province. If it can form a financial system through the support and support of science and technology finance, it can provide financial support for the development of local science and technology innovation in Maoming. We intend to establish a model for the coordinated development of technological innovation and technological finance [8].

## 2. The model of collaborative development

### 2.1. Symbol Description

Table 1: Symbols in this article

$e_i$	order parameters in development
$G$	The driving force of collaborative development
$g$	Resistance to collaborative development
$F_i$	Growth rate of subsystem order parameter
$f_i$	Loss rate of subsystem sequence parameter
$\alpha_i$	Growth factor
$\beta_i$	loss factor
$\alpha_{ij}$	The upper limit of the critical point of system stability
$\beta_{ij}$	The lower limit of the critical point of system stability
$u_i^0(e_i)$	The order degree of parameters of technological innovation and technological finance subroutines at the start time
$u_i^1(e_i)$	The order degree of the parameters of technological innovation and technological finance subroutines at the intermediate moment
$X_{ij}$	The i-th input of the j-th decision-making unit
$Y_{ij}$	The rth output of the jth decision unit

## 2.2. The Model of Collaborative development

The composite system of innovation and technology finance is as follows:

$$S = \{S_1, S_2\},$$

Where  $S_1$  is the subsystem of technological innovation,  $S_2$  is the subsystem of technological finance.

The equation of motion of the order parameter is

$$\frac{\partial e_i}{\partial t} = (G - g)e_i - ke_i^3 + a \quad (1)$$

The potential equation of the order parameter is:

$$E(e_i) = -\frac{1}{2}(G - g)e_i^2 + \frac{1}{4}ke_i^4 \quad (2)$$

Further, we have:

$$\frac{\partial e_i}{\partial t} = F_i(t) - f_i(t) \quad (3)$$

$$F_i = \alpha_i e_i + \beta_i \quad (4)$$

$$f_i = \gamma_i e_i + \delta_i \quad (5)$$

The above equation is simplified as follows:

$$\frac{\partial e_i}{\partial t} = F_i(t) - f_i(t) = (\alpha_i - \gamma_i)e_i \quad (6)$$

We conclude that the relationship between technological innovation and technological finance is as follows:

$$\frac{\partial e_1}{\partial t} = (\alpha_1 + k_1 e_2)e_1 - \gamma_1 e_1 \quad (7)$$

$$\frac{\partial e_2}{\partial t} = (\alpha_2 + k_2 e_1)e_2 - \gamma_2 e_2 \quad (8)$$

When in steady state,  $\frac{\partial e_1}{\partial t} = \frac{\partial e_2}{\partial t} = 0$ , We have:

$$\frac{\partial e_1}{\partial t} = (\alpha_1 + k_1 e_2)e_1 - \gamma_1 e_1 = 0$$

$$\frac{\partial e_2}{\partial t} = (\alpha_2 + k_2 e_1)e_2 - \gamma_2 e_2 = 0$$

Solve the above system of equations, we have:

$$\alpha_1 + k_1 e_2 - \gamma_1 = 0 \quad \alpha_2 + k_2 e_1 - \gamma_2 = 0$$

The order degree of the subsystem order parameter is:

$$\mu(e_{ij}) = \begin{cases} \frac{e_{ij} - \beta_{ij}}{\alpha_{ij} - \beta_{ij}}, i \in [1, k] \\ \frac{\alpha_{ij} - e_{ij}}{\alpha_{ij} - \beta_{ij}}, i \in [k+1, n] \end{cases} \quad (9)$$

The operating formula of  $S_i$  the system order degree is:

$$\mu(e_i) = \sum_{j=1}^n \lambda_j \mu_i(e_{ij}) \quad (10)$$

$$u_i(e_{ij}) = \sum_{i=1}^n \omega_i u_i(e_{ij}), \omega_i \geq 0, \sum_{i=1}^n \omega_i = 1 \quad (11)$$

The degree of coordinated development of technological innovation and technological finance subsystems is stipulated as follows:

$$\text{syn} = \theta \sqrt{|u_1^1(e_1) - u_1^0(e_1)| \times |u_2^1(e_2) - u_2^0(e_2)|} \quad (12)$$

where  $u_1^1(e_1) - u_1^0(e_1) > 0$  and  $u_2^1(e_2) - u_2^0(e_2) > 0$ ,  $\theta = 1$ , otherwise,  $\theta = -1$ .

### 3. Results and analysis

Table 2: Maoming Science and Technology Innovation and Technology Finance Index

order parameter	first-level indicator	secondary indicators
Technological innovation	Enterprise innovation investment	Internal expenditure of R&D funds
		Full-time equivalent of R&D personnel
		business expenses
	Enterprise innovation output	Number of patents granted
		New product sales revenue
Industrialization of scientific and technological innovation	new product output	
Tech Finance	Market Tech Finance	Total Venture Capital Management
	public technology finance	Government funding

Table 3: Original data of scientific and technological innovation in Maoming

year	Internal expenditure of R&D funds (10,000 yuan)	Full-time equivalent of R&D personnel (person-year)	Number of patents granted (pieces)	Output value of new products (ten thousand yuan)	New product sales revenue (10,000 yuan)	Enterprise expenditure (10,000 yuan)
2010	39414	2036	322	934935.9	929913.5	34876.9
2011	54934	3862	396	1075563.1	1030664.2	52242.2
2012	96442	4307	694	1104835.2	1010145.5	88736.6
2013	107079	3956	1089	909220	862077	98512.7
2014	124359	4102	1179	1117851	1123109	116897.46
2015	140167	4180	1991	1116429	1100510	130355.3
2016	161523.3	4309	1593	878466	880226	153722
2017	177681.2	4630	1867	1048053	1003952	167161.2
2018	124969.3	3829	2591	1142395	1112661	111415.4
2019	146014.5	5308	2506	1202365	1112475	129996.6

The data comes from the Guangdong Science and Technology Statistical Network <http://www.sts.gd.cn/> and "China Science and Technology Statistical Yearbook" (2009-2021), "China Science and Technology Statistical Yearbook" (2009-2021).

We select six indicators of R&D expenditure, R&D personnel full-time equivalent, enterprise

expenditure, patent authorization volume, new product sales revenue, and new product output value as scientific and technological innovation indicators, and selects the total amount of venture capital management and government funding. These two indicators serve as indicators of technology finance.

Table 4: Original data of science and technology finance in Maoming

year	Government funding (100 million yuan)	Total amount of venture capital management (100 million yuan)
2010	0.28225	4.4562
2011	0.19109	3.5262
2012	0.27425	30.3221
2013	0.30356	47.8883
2014	0.33262	37.8318
2015	0.39004	26.1203
2016	0.39892	44.4755
2017	0.46691	42.2267
2018	0.44158	28.6399
2019	0.31999	22.8695

In order to find the weight of each indicator, the original data of technological innovation is packaged in the data.xlsx file, and the data of technological finance is packaged in the data1.xlsx file. First, use MATLAB software to normalize the use of the original data of technological innovation and technological finance. After the standardization method, we use the entropy weight method to obtain the weight of each index.

Table 5: The normalized data of Maoming's scientific and technological innovation

year	Internal expenditure of R&D funds	Full-time equivalent of R&D personnel	Number of patents granted	Output value of new products	New product sales revenue	Enterprise expenditure
2010	0	0	0	0.174344163	0.259878099	0
2011	0.112246433	0.55806846	0.032613486	0.608514074	0.645848785	0.13127257
2012	0.412447782	0.694070905	0.163948876	0.698888234	0.567242714	0.407151113
2013	0.489378537	0.586797066	0.338034376	0.094949351	0	0.481053307
2014	0.614353947	0.631418093	0.377699427	0.739072983	1	0.62003246
2015	0.728683303	0.655256724	0.735566329	0.734682725	0.913424408	0.72176668
2016	0.883140036	0.694682152	0.56015866	0	0.069527874	0.898406689
2017	1	0.792787286	0.680916703	0.523579881	0.543515738	1
2018	0.618767864	0.547982885	1	0.814849691	0.959974256	0.578590959
2019	0.770974606	1	0.962538563	1	0.9592617	0.719055096

Table 6: The normalized data of Maoming's science and technology finance:

year	Government funding	Total amount of venture capital management
2010	0.330505402	0.020963841
2011	0	0
2012	0.301500979	0.604026861
2013	0.407765934	1
2014	0.513124501	0.773308748
2015	0.721303749	0.509310876
2016	0.753498659	0.923069467
2017	1	0.872377548
2018	0.908164745	0.566107105
2019	0.467333768	0.436032108

Table 7: The weights of various indicators of scientific and technological innovation obtained by using the entropy weight method

Index	Internal expenditure of R&D funds	Full-time equivalent of R&D personnel	Number of patents granted	Output value of new products	New product sales revenue	Enterprise expenditure
Weights	0.2117	0.0623	0.4804	0.0144	0.0126	0.2186

Table 8: Weights of various indicators of science and technology finance in Maoming

Index	Government funding	Total amount of venture capital management
Weights	0.1471	0.8529

Substitute the data of each index into the formula (9), calculate the order degree of each component of the sub-system order parameters of technological innovation and technological finance, and substitute the obtained results into the formula (10), the calculation results of the order degree of the technological innovation and technological finance subsystems in Maoming are shown in the following table.

Table 9: The orderly degree of technological innovation and technological finance subsystem in Maoming

year	Technological Innovation Subsystem	Technology Finance Subsystem
2010	0.00578502	0.066497405
2011	0.119794235	0
2012	0.315531335	0.559525304
2013	0.409076131	0.912882369
2014	0.509624629	0.735035645
2015	0.728317589	0.540495028
2016	0.696607417	0.898125601
2017	0.821190881	0.891150811
2018	0.795841985	0.616423784
2019	0.871590991	0.440636582

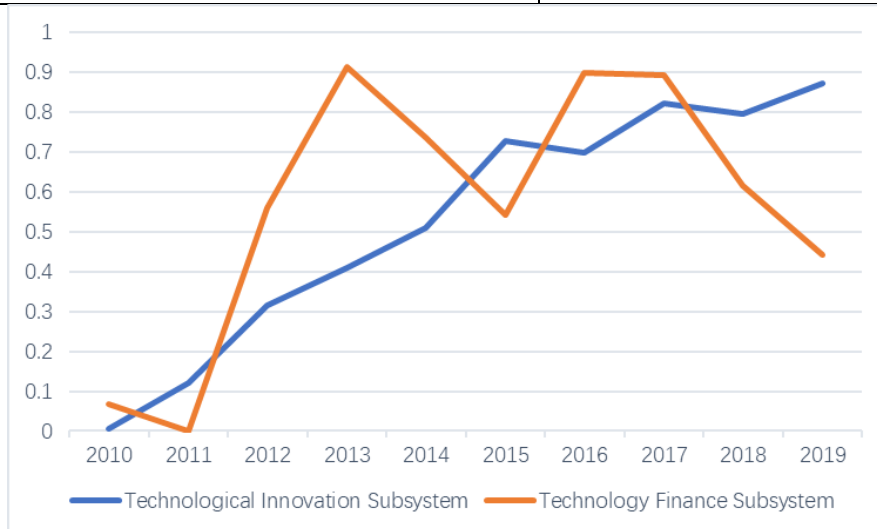


Figure 1: Comparison of the orderliness of technological innovation and technological finance subsystems

Substitute the order degree of technological innovation subsystem and the order degree of technological finance subsystem into formula (11), and obtain the synergy degree of technological innovation and technological finance system in Maoming City, Guangdong Province from 2010 to 2019.

Table 10: The degree of synergy between Maoming's technological innovation and technological finance composite system

year	2011	2012	2013	2014	2015	2016	2017	2018	2019
Synergy	-0.087070758	0.33093785	0.181809556	-0.133724422	-0.206263577	-0.106491909	-0.029477848	0.083450744	-0.115393699

On the whole, there is a relative coordinated development trend between technological finance and technological innovation. The development curves of the two are generally the same, and the levels of the two in the same period are very similar. It shows that the development level of science and technology finance and the development level of science and technology innovation in Maoming City, Guangdong Province can generally be considered to develop in the same trend, but in some years, there is a sudden drop in the orderly degree, indicating that this trend of coordinated development does not unstable, there will be greater volatility.

#### 4. Conclusions and Discussion

According to the solution and analysis of the previous model, we can know that the technological innovation level and technological finance of Maoming are basically in a situation of coordinated development, but the synergy degree of the composite system model fluctuates greatly, not only between individual systems, the entire system also showed a particularly large level of volatility, indicating that there was a situation characterized by large volatility and unstable development.

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