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The Impact of the Industrial Internet on the Innovation and Development Level of China's Manufacturing Industry: Under the Perspective of Government Incentives

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Abstract: In the era of the digital economy, it has become an inevitable trend for manufacturing enterprises to establish industrial Internet platforms toward achieving transformation and innovative development. However, the current development model of industrial Internet platforms is still imperfect, wherein the application scenario is complex, the investment cost is too high, the return-on-investment cycle is too long, and other factors have hindered the willingness of manufacturing enterprises to employ cloud services and capital investment. For this reason, governments have introduced a series of relevant incentive policies to promote the development of industrial Internet platforms and the transformation and upgrading of manufacturing enterprises. Considering the role of government incentives, this study first constructs an evolutionary game model with local governments, manufacturing enterprises, and industrial Internet platforms as the main players. Then, the dynamic change process of each game player's strategy choice and the stable state of the system evolution under multiple scenarios are analyzed, and the validity of the conclusions is verified through a numerical simulation analysis. Finally, the statistical data of 28 provinces in China from 2018 to 2020 are used to conduct an empirical test to explore the impact of the industrial Internet on the transformation and innovation development of the manufacturing industry and the role of government incentives. The results show that the development of the industrial Internet has a significant role in promoting the innovation and development of the manufacturing industry; government incentives can promote the innovation and development of the industrial Internet and manufacturing industry, but incentives should not be too generous; and the impact of developing the industrial Internet on the level of innovation input/output of the manufacturing industry shows obvious regional differences. This study takes the local government as an independent game participant into consideration, which enriches the research field of combining evolutionary game theory with the transformation and innovative development of the manufacturing industry. In addition, this study provides theoretical guidance and practical references for the government to formulate incentive policies to promote the development of industrial Internet platforms and for manufacturing enterprises to utilize these platforms to carry out innovation and perform upgrades.

Keywords: industrial Internet; innovation level of manufacturing industry; government incentives; evolutionary game

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1. Introduction

In recent years, under the complex and volatile international situation and highly uncertain market conditions, the development of enterprises has faced unprecedented challenges due to various uncertainties such as social and economic factors, international politics, and technological changes. The new generation of digital technologies represented by big data, cloud computing, and artificial intelligence are rapidly evolving, giving rise to the digital economy as a new form of economic development. Digital impact is everywhere, and digital reinvention is inevitable. Digital transformation is no longer a "multiple-choice" question, but has gradually become a "must-answer" question in the development of many industries [1,2]. By deepening the application of digital technology in many aspects of production, operation, management, and marketing; by realizing the digital, networked, and intelligent development of enterprises as well as industries; and by continuously releasing the driving effect of digital technology on economic development, traditional industries can realize important changes in quality, efficiency, and power, thus promoting the high-quality development of the national economy. As the pillar industry of China's national economy, the high-quality development of the manufacturing industry is not only a key component in the strategy of building a manufacturing powerhouse, but is also closely related to the realization of the task of comprehensive construction of a modern socialist country. However, despite being fundamental to achieving high-quality economic development, the traditional development and operation model of the manufacturing industry is characterized by high energy consumption, pollution, low development quality, and a lack of innovation capabilities, all of which urgently require improvement [3]. Therefore, how to enhance the independent innovation capabilities of the manufacturing industry and promote its high-quality development has become an urgent issue that needs to be addressed in order to meet people's aspirations for a better life, achieve continuous optimization of the economic structure, and gain national competitive advantages.

In the era of the digital economy, most aspects of economic activities are gradually being integrated with Internet technology. The manufacturing industry, as a traditional sector, is also deeply integrating with, and developing a series of, new technologies such as big data and the Internet of Things (IoT). At the same time, the industrial Internet, as a means of support for the integration and development of new information technology and manufacturing technology, can effectively implement digitization, networking, and intelligence in manufacturing equipment. It plays an important role in improving production efficiency and quality, reducing the cost of new product development, and shortening the innovation cycle in the manufacturing industry [4]. The following processes have become a standard trend in industry: carry out a basic transformation of the industrial Internet for manufacturing enterprises; promote the deployment and implementation of low-cost, modular equipment and systems; vigorously promote the new model of intelligent manufacturing; open up the full data chain of the various links in the production process of manufacturing enterprises; promote the digital transformation of the industry by focusing on platform empowerment; and reduce the digitalization threshold of manufacturing enterprises by relying on the resources of industrial Internet platforms. For this reason, many large industrial enterprises, Internet platforms, and information technology companies have begun to focus on the construction and development of industrial Internet platforms. Since GE created the Predix platform in 2013, international industrial giants such as Siemens and Bosch have begun to build platforms of their own. In China, more than 30 industrial Internet platforms were initially formed, such as the collaborative manufacturing platform represented by Aerospace Cloud, the product lifecycle service platform represented by RootCloud, the personalized customization platform represented by Haier, the new manufacturing platform represented by Ali's ET Industrial Brain, etc. These platforms cater to a wide range of industries, including aerospace, information and electronics, equipment manufacturing, petrochemicals, and so on [5]. Covering aerospace, information electronics, equipment manufacturing, petrochemical, and other industries, a series of innovative applications have emerged in personalized customization services, quality optimization, process optimization, process optimization, asset management, collaborative innovation, and other aspects, greatly improving the competitive advantage of manufacturing enterprises.

Industrial Internet platform application scenarios are complex; industrial infrastructure requirements are high; deployment is difficult; the operation mode involves a wide range of participants; platform construction and the application process require a large amount of human, material, and financial input; the platform industry has a long return-on-investment cycle; and the intuitive benefits are not obvious. Compared with developed countries, China has a weak industrial foundation, a low degree of digitalization development, uneven levels of economic development and industrial structure in various regions, and a weak capacity for independent innovation, all of which represent constraints that will have an impact on the promotion of the development of industrial Internet platforms. In addition, the profit model of China's industrial Internet platforms is mostly based on common business models such as the purchase of services and products, with a long return-on-investment cycle, which leads to the low willingness of most enterprises to apply a platform's cloud-based services and the low investment of related capital. Therefore, in order to promote the development of the industrial Internet and the transformation and upgrading of the manufacturing industry, various countries have successively introduced a series of relevant policies in the industrial Internet field. In 2012, U.S. industrial manufacturing companies, Internet companies, and industrial service companies conducted research on interconnected systems covering smart factories, smart products, and enterprise collaboration. In 2013, the German government put forward the "Industry 4.0" strategy, and in 2015, the German Machinery Manufacturers' Association (DMM), the German Electronics Industry Association (DEIA), and other departments jointly launched the construction of the upgraded "Industry 4.0 Platform". In 2018, the Ministry of Industry and Information Technology introduced the "Action Plan for the Innovation and Development of the Industrial Internet" for a three-year cycle. This marks the deep-level development stage of China's industrial Internet, and the continuous development of the industrial Internet has been included in the national "Report on the Work of the Government" for five consecutive years [6].

In summary, the manufacturing industry plays a pivotal role in the development of the national economy, and the application of industrial Internet platforms is an effective way for the manufacturing industry to carry out innovation and perform upgrades. However, the development of industrial Internet platforms in various countries is still in the exploratory stage, which further restricts the willingness of manufacturing enterprises to exploit the cloud services of these platforms and limits their capital investment. Against the above background, it becomes necessary to study the necessity and role of government incentives in the process of the industrial Internet empowering manufacturing innovation and upgrades, and how exactly the benefit–cost problem among the participating subjects of the industrial Internet affects the economic decisions of all parties. Therefore, this study constructs a three-party evolutionary game model under the assumption of finite rationality, explores the dynamic evolution mechanism among the three game subjects, and further tests the relevant conclusions through empirical analysis. On this basis, it tries to provide a theoretical basis and practical reference for the government to formulate economic and administrative policies to promote the development of industrial Internet platforms and facilitate the application of these platforms toward innovation and upgrades in the development of manufacturing enterprises.

2. Literature Review

2.1. Industrial Internet Boosts the Development of Manufacturing Innovation

The development level of manufacturing industries worldwide has long been the focus of research by scholars in various countries. Compared with the traditional manufacturing industry, the innovation and upgrading of modern manufacturing industries are mainly embodied in the four aspects of improving production efficiency, optimizing the quality of supply, and improving innovation ability at the level of green development. Scholars have mainly focused on green development, innovation, competitiveness, and sustainability perspectives in the development of the transformation and upgrading of the manufacturing industry [7–11]. Asif et al. (2024) surveyed members of 350 manufacturing companies and analyzed the data using structural equation modeling, finding that corporate culture, leadership change, and digital transformation have a significant impact on the sustainability of manufacturing companies [12]. Feng (2023) took Chinese manufacturing firms as a research sample and through their analysis established that manufacturing firms can promote green and innovative behaviors by focusing on smart manufacturing, which in turn promotes sustainable manufacturing firms [13].

In the era of the digital economy, the manufacturing industry has gradually integrated and developed with emerging information technology, and scholars at home and abroad have used different research methods to verify that the digital economy and the various digital technologies it contains have a driving effect on the transformation and upgrading of the manufacturing industry. Initially, some scholars started from the degree of association between the two and found a correlation between them. For example, Shi et al. (2017) found that “Internet+” can play an effective role in promoting both the rationalization and heightening of the transformation in China’s manufacturing industry [14]. Giudice (2016) and Caputo et al. (2016) argued that the rapid development of IoT technology has successfully promoted the transformation and upgrading of the manufacturing industry [15,16]. Alexopoulos et al. (2018) pointed out that industrial Internet platform construction is of great significance to the digitalization and transformation of enterprises by exploring the connection between the industrial Internet platform construction and the industrial development mode [17]. Wang et al. (2018) found that the application of the Internet improves the innovation performance of enterprises, and better reflects the promotion effect of the input of technical personnel and R&D funds on innovation performance [18]. Cai and Qi (2021) found that the construction of the industrial Internet can promote the digital transformation of the manufacturing industry from point to point, so as to improve its innovation ability and risk resistance, and ultimately improve the overall competitiveness of China’s manufacturing industry [19]. Since then, some scholars have verified the driving effect of the digital economy on the upgrading of the manufacturing industry through empirical evidence as well as theoretical analysis. For example, through a questionnaire survey of 126 managers from 65 different manufacturing enterprises, Maware et al. (2023) found that Industry 4.0 technology regulates the lean production of manufacturing enterprises to enhance the sustainable production performance of enterprises [20]. Wang et al. (2022) found that factors such as the configuration of informationization workshops and enterprise network security mechanisms can affect the production and economic benefits of enterprises through research, which provides a reference for enterprises to utilize the industrial Internet in order to achieve quality and efficiency [21]. In addition, Internet technology has increased enterprise innovation investment and promoted the intelligent transformation of the traditional manufacturing industry, and the development of industrial Internet platforms has greatly enhanced the innovation ability of industrial enterprises and effectively boosted the transformation and upgrading of the manufacturing industry [22]. From the perspective of innovation economics, the widespread application of the Internet in the manufacturing industry R&D sector can accelerate the inherent technological innovation of enterprises. The wide application of digital technology enables enterprises to realize the rapid penetration of knowledge and information at a low cost in the construction of advanced technology, so that the technological resources of enterprises can be expanded both horizontally and vertically, and enterprises can accelerate their own technological innovation process and promote industrial upgrading [23].

2.2. Impact of Government Incentives

Government subsidies are one of the most important tools of government incentive support policies, playing an indispensable role in stimulating enterprise innovation and guiding industrial development. Many scholars have studied the impact of government incentives on the transformation and innovative development of manufacturing enterprises. Zhang and Huang (2021) studied and compared the impacts of different subsidy schemes on manufacturers’ production line strategies, corporate profits, and the environment based on the government’s consumer subsidy and R&D subsidy schemes [24]. Bigerna et al.

(2019) analyzed how the varying forms of government subsidies can impact the optimal investment decisions of manufacturing firms, and based on this, they designed an optimal subsidy policy [25].

However, domestic and foreign scholars have not yet reached a unified conclusion on the policy effects of government subsidies on enterprise innovation. Some scholars believe that government subsidies directly promote firms' innovation activities by increasing the capital invested in innovation, while indirectly attracting external investors. For example, Lu and Lv (2019) took the R&D investment of manufacturing enterprises as the research object and found that government subsidies have a significant promotional effect on the R&D investment of manufacturing enterprises in China [26]. Ye and Liu (2020) studied the role of government support and the degree of marketization on the scientific and technological progress of the manufacturing industry, and found that government support strongly promotes scientific and technological progress in the high-end manufacturing industry [27]. Jung et al. (2020) found that government subsidies have an important role in promoting the development of green technology in manufacturing enterprises [28]. Bronzini and Iachini (2014) showed that government subsidies only bring about short-term growth in firms' innovation expenditures and do not tap into long-term development potential, while also noting that the increase in innovation output is limited, and subsidies can even impede innovation [29]. Thomson (2013) used data from 25 OECD countries as a sample for his analysis, and found that government subsidies did not increase firms' R&D investments [30].

2.3. Evolutionary Game Theory (EGT)

Evolutionary game theory originated from Darwin's theory of evolution [31]. Traditional game theory posits that the actors are completely rational, the information between the game parties is completely symmetric, and the equilibrium state of the system can be reached by only one game between the game subjects. However, in fact, when the actors are making decisions, they are easily affected by irrational factors such as emotion, experience, intuition, etc., and due to the limitation of individual perception and cognitive ability, it is impossible for the subjects to be accurate in the process of acquiring, storing, and using information. Therefore, for participants in real economic life, it is difficult to realize the conditions of complete rationality and complete information of the actors. Differently from traditional game theory, evolutionary game theory believes that the actors are limited in their rationality, whereby the achievement of game equilibrium not only relies on the results of a single game, but also depends on continuous evolution, such that the players can improve their own benefits by learning and imitating others' behavior through continuous improvement of their strategy. In addition, unlike traditional game theory, which focuses on the static equilibrium analysis, evolutionary game theory starts from the system, and regards the adjustment process of individual and group behaviors as a dynamic system, so it can incorporate various factors affecting the equilibrium state of the system into the evolutionary game model, and it constitutes a macro-model with a micro basis, which can truly respond to the diversity and complexity of the behaviors of economic subjects [32].

Many scholars have already considered establishing a game model to study the impact of different government subsidies on the transformation and development of manufacturing enterprises. For example, Bian et al. (2020) established a game model between the government, manufacturers, and consumers under consumer environmental concerns, and analyzed the impact of two different government incentives on manufacturers' emission reduction outcomes [33]. Yang et al. (2021) performed their analysis by building a game model incorporating the government and two competitive manufacturing firms, and found that government subsidies can incentivize firms to improve their production technology by reducing the financial burden of technological improvements, which in turn reduces energy consumption [34].

In summary, in the choice of research object, the existing research mainly focuses on either the impact of the government's industrial policy on the development of the industrial

Internet, the impact of government incentive policies on the development of manufacturing innovation, or the role of the industrial Internet in promoting the high-quality development of the manufacturing industry, yet lacks the study of the relationship between the three. In addition, in the choice of research methods, scholars mostly used questionnaire research and other ways to measure the level of development in the manufacturing industry, using structural equation modeling or traditional game methods to analyze the role of the relationship between the various parties involved in the industrial Internet, and there is a little research on the relationship between the government, the industrial Internet, and manufacturing enterprises in the evolution of the game. However, for industrial Internet platforms, local government, and manufacturing enterprises as limited rational decision-making subjects, the behavior of decision-making parties reflects the results of market competition in order to explore how the optimal strategies of the parties evolve in the process of long-term interaction, and the method of evolutionary game is undoubtedly the most suitable tool. This is because the study can be started from the perspective of finite rationality, revealing the dynamic game and the strategy selection process between individuals. It helps to portray complex problems more effectively through the participation of multi-party subjects [35]. Therefore, taking into account the influence of government incentive factors, and factoring in the local government as an independent game participant, we constructed a three-party evolutionary game model between the local government, industrial Internet platforms, and manufacturing enterprises, analyzed the dynamic process of strategy selection in the main body of the game as well as the system's evolutionary stable state under different circumstances, and explored the initial willingness relating to strategy selection and government incentive coefficients in the main body of the game through MATLAB R2016a numerical simulation analyses. Through these MATLAB R2016a numerical simulation analyses, we investigated the effects of the initial willingness of each game subject's strategy selection, as well as the government incentive coefficients and the cost of the manufacturing enterprises, applying the platform to achieve transformation and innovation on an evolutionary stable path. Finally, the influence of the industrial Internet on the level of manufacturing innovation and development and the role of government incentives therein is further analyzed through empirical tests.

3. The Model

3.1. Basic Assumptions of the Model

The participants of the game are manufacturing enterprises, industrial Internet platforms, and local governments. All three parties are under the condition of incomplete information. They are limited rational subjects, while the strategy choices of the three parties in the game gradually evolve toward the optimal strategy over time. The basic assumptions of the parameters involved in this study were made concerning the studies conducted by Yousuf et al. (2018), Chen et al. (2023), and He and Liu (2023) pairs, and the specific assumptions are shown below [36–38].

3.1.1. Assumptions of Local Government

Local governments' strategies include "incentive" and "no incentive". "Incentive" represents local governments providing policy support and economic incentives to manufacturing enterprises who employ the platform toward transformation and innovation development, and to industrial Internet platforms who choose to improve their own services, with probability z; meanwhile, the probability of local governments choosing "no incentive" is $1 - z$. The highest strengths of incentives local governments provide to industrial Internet platforms and manufacturing enterprises are represented by E_P and E_C; the incentive coefficients for manufacturing enterprises and industrial Internet platforms are a and b, respectively. If the industrial Internet platforms choose to enhance their own services and manufacturing enterprises choose to apply the platform for transformation and innovative development, then the local governments can obtain the economic benefits of R_{G1}; at this time, the local governments who choose an incentive strategy need to pay the cost of incentives, namely, aE_P and bE_C. If the industrial Internet platforms choose not to enhance their services and manufacturing enterprises choose to apply the platform for transformation and innovative development, the local governments can obtain economic benefits R_{G2}; at this time, the local governments who choose the incentive strategies need to pay incentive costs aE_C. In addition, the local government can also obtain the social reputation F generated by the implementation of incentives, and at the same time, needs to pay the publicity and management costs arising from the development and implementation of incentive policies C_G. According to reality, $R_{G1} > R_{G2}$.

3.1.2. Assumptions of Manufacturing Enterprises

The strategies of manufacturing enterprises include "application of platforms" and "no application of platforms". If the enterprises choose "application of platforms", the probability of applying the industrial Internet platforms for transformation and innovative development is x; if the enterprises choose "no application of platforms", the probability of maintaining a traditional business model without utilizing industrial Internet platforms is $1 - x$. Further, if the enterprise chooses to apply the platforms for transformation and innovative development, then when the platforms choose to enhance their service, the enterprise can obtain the economic gain of R_{C1}, and at the same time, the enterprise also needs to pay for the loss cost $\alpha_1 Q$ of information leakage due to the application of the platforms; if the platforms choose not to enhance their service, the enterprise can obtain the economic gain of R_{C2}, and at the same time, the enterprise also needs to pay for the loss cost $\alpha_2 Q$ of information leakage due to the application of the platforms. Here, Q is the maximum loss amount, and α_i is the possibility of the enterprises generating information leakage loss under different strategy choices of the platform. In addition, enterprises need to pay the cost C_I of applying the platform for transformation and innovation development; if the government chooses the strategy of "no incentive", the enterprise can also obtain the government incentive reward aE_C; if the enterprises choose the strategy of "no application of platforms", the enterprise maintains the traditional daily business and can obtain the net income R_C. According to the reality, $R_{C1} > R_{C2}$ and $\alpha_1 < \alpha_2$.

3.1.3. Assumptions of Platforms

The essence of the industrial Internet platforms is to create "services" for enterprises through data and modeling. Therefore, the strategy of industrial Internet platforms includes two kinds of "service enhancement" and "no service enhancement". Not enhancing services means that the platforms only provide basic services, such as the optimized allocation of production resources and the analysis and management of industrial data due to the cost pressure and the limitation of knowledge and information technology; enhancing services means that the platforms provide enterprises with better services through the training of technical personnel, accelerating the research and development of critical technologies such as industrial extensive data systems, and developing low-cost and fast-deploying industrial Internet application products, and so on. The strategies of the industrial Internet platforms include "service enhancement" and "no service enhancement". The probability that the platforms choose "service enhancement" is y, and the probability of choosing "no service enhancement" is $1 - y$. If the platforms choose to enhance their services, the platforms can obtain a direct economic benefit of R_{P1}, and an indirect benefit of I, and at the same time, they need to cover the costs C_{P1} of upgrading their platform services as well as maintaining the platform's daily operation. If the government chooses "incentive", the platform can also receive government incentives as bE_P. If the platforms choose "no service enhancement", they can receive direct economic benefits R_{P2}, and at the same time, they also need to cover the cost C_{P2} of maintaining the platform's daily operation. According to reality, $R_{P1} > R_{P2}$ and $C_{P1} > C_{P2}$.

Based on the model assumptions, the parameters involved are defined, and their symbols and meanings are shown in Table 1.

Table 1. Parameter symbols and meanings.

Parameter Symbols	Symbol Meaning
x	Probability of choosing the "application platform" strategy, $x \in [0, 1]$
y	Probability of choosing the "service enhancement" strategy, $y \in [0, 1]$
z	Probability of choosing the "incentive" strategy, $z \in [0, 1]$
E_P	Maximum policy support and economic incentives for industrial Internet platforms
E_C	Maximum policy support and economic incentives for manufacturing enterprises
a	Incentive coefficients for manufacturing enterprises, $a \in [0, 1]$
b	Incentive coefficients for industrial Internet platforms, $b \in [0, 1]$
R_{G1}	Economic benefits to the government when manufacturing enterprises apply platforms and the platforms enhance their services
R_{G2}	Economic benefits to the government when manufacturing enterprises apply platforms and the platforms do not upgrade their services
F	Social reputation benefits for local governments in developing and implementing incentive policies
C_G	Publicity and administrative costs incurred by local governments for the development and implementation of incentive policies
R_{C1}	Economic benefits available to enterprises applying the platform when industrial Internet platforms enhance their services
R_{C2}	Economic benefits available to enterprises applying platforms when industrial Internet platforms do not enhance their services
Q	Maximum amount of loss caused by information leakage in manufacturing enterprises applying industrial Internet platforms
α_1	Likelihood of business losses due to information leakage when industrial Internet platforms enhance their services, $\alpha_1 \in [0, 1]$
α_2	Likelihood of enterprise losses due to information leakage when industrial Internet platforms do not enhance their services, $\alpha_2 \in [0, 1]$
C_I	Costs of applying industrial Internet platforms for transformation and development in the manufacturing industry
R_C	The net benefits for manufacturing enterprises that do not apply the platforms and maintain the traditional operations
R_{P1}	Direct economic benefits when industrial Internet platforms enhance their services
R_{P2}	Direct economic benefits when industrial Internet platforms do not enhance their services
C_{P1}	Costs of industrial Internet platforms to enhance their services and maintain their daily operations
C_{P2}	Costs of industrial Internet platforms maintaining daily operations
I	Indirect benefits that can be gained when industrial Internet platforms enhance their services

3.2. Income Matrix

Based on the above assumptions, the mixed-strategy game matrix of local governments, industrial Internet platforms, and manufacturing enterprises is constructed, as shown in Table 2.

Table 2. Mixed-strategy game matrix.

Enterprises	Platforms	Local Governments	
		"Incentive" (z)	**"No Incentive" (1−z)**
"application of platforms" (x)	"service enhancement" (y)	$R_{C1} - C_I + aE_C - \alpha_1 Q$ $R_{P1} - C_{P1} + I + bE_P$ $R_{G1} - aE_C - bE_P + F - C_G$	$R_{C1} - C_I - \alpha_1 Q$ $R_{P1} - C_{P1} + I$ R_{G1}
	"no service enhancement" (1 − y)	$R_{C2} - C_I + aE_C - \alpha_2 Q$ $R_{P2} - C_{P2}$ $R_{G2} - aE_C + F - C_G$	$R_{C2} - C_I - \alpha_2 Q$ $R_{P2} - C_{P2}$ R_{G2}
"no application of platforms" (1 − x)	"service enhancement" (y)	R_C $-C_{P1} + bE_P$ $-bE_P + F - C_G$	R_C $-C_{P1}$ 0
	"no service enhancement" (1 − y)	R_C $-C_{P2}$ $-C_G$	R_C $-C_{P2}$ 0

3.2.1. Expected Returns for Manufacturing Enterprises

Assuming that the expected returns of manufacturing enterprises choosing the strategy of "application of platforms" is U_{11}, the expected returns of choosing the strategy of "no application of platforms" is U_{12}, and the average expected returns is U_C.

$$\begin{cases} U_{11} = \mathrm{yz}(R_{C1} - C_I + \mathrm{a}E_C - \alpha_1 Q) + (1-\mathrm{y})\mathrm{z}(R_{C2} - C_I + \mathrm{a}E_C - \alpha_2 Q) + \mathrm{y}(1-\mathrm{z}) \\ \quad (R_{C1} - C_I - \alpha_1 Q) + (1-\mathrm{y})(1-\mathrm{z})(R_{C2} - C_I - \alpha_2 Q) \\ U_{12} = \mathrm{yz}R_C + (1-\mathrm{y})\mathrm{z}R_C + (1-y)(1-z)R_C \end{cases} \tag{1}$$

$$U_C = xU_{11} + (1-x)U_{12} \tag{2}$$

3.2.2. Expected Returns for Industrial Internet Platforms

Assuming that the expected returns of industrial Internet platforms choosing the strategy of "service enhancement" is U_{21}, the expected returns of choosing the strategy of "no service enhancement" is U_{22}, and the average expected returns is U_P.

$$\begin{cases} U_{21} = xz(R_{P1} - C_{P1} + I + bE_P) + (1-x)z(-C_{P1} + bE_P) + x(1-z) \\ \quad (R_{P1} - C_{P1} + I) + (1-x)(1-z)(-C_{P1}) \\ U_{22} = xz(R_{P2} - C_{P2}) + (1-x)z(-C_{P2}) + x(1-z)(R_{P2} - C_{P2}) \\ \quad (1-x)(1-z)(-C_{P2}) \end{cases} \tag{3}$$

$$U_P = yU_{21} + (1-y)U_{22} \tag{4}$$

3.2.3. Expected Returns for Local Governments

Assuming that the expected returns of local governments choosing the strategy of "incentive" is U_{31}, the expected returns of choosing the strategy of "no incentive" is U_{32}, and the average expected returns is U_G.

$$\begin{cases} U_{21} = xz(R_{P1} - C_{P1} + I + bE_P) + (1-x)z(-C_{P1} + bE_P) + x(1-z) \\ \quad (R_{P1} - C_{P1} + I) + (1-x)(1-z)(-C_{P1}) \\ U_{22} = xz(R_{P2} - C_{P2}) + (1-x)z(-C_{P2}) + x(1-z)(R_{P2} - C_{P2}) \\ \quad (1-x)(1-z)(-C_{P2}) \end{cases} \tag{5}$$

$$U_P = yU_{21} + (1-y)U_{22} \tag{6}$$

3.3. The Replication Dynamic Equation

Based on the assumptions and formulas of the model above, the equation for the local governments selecting "incentive" is:

$$F(x) = x(1-x)(R_{C2} - C_I - R_C - \alpha_2 Q + yR_{C1} - yR_{C2} + zaE_C - y\alpha_1 Q + y\alpha_2 Q) \quad (7)$$

The equation for the industrial Internet platforms selecting "service enhancement" is:

$$F(y) = y(1-y)(C_{P2} - C_{P1} + xI + xR_{P1} - xR_{P2} + zbE_P) \quad (8)$$

The equation for the manufacturing enterprises selecting "application of platforms" is:

$$F(z) = z(1-z)(xF - C_G + yF - xaE_C - ybE_P - xyF) \quad (9)$$

4. Analysis of Evolutionary Stable Strategy

4.1. Evolutionary Stable Strategy of Manufacturing Enterprises

According to the equation for the manufacturing enterprises selecting "application of platforms", find the first-order partial derivative of (7) with respect to x.

$$\frac{\partial F(x)}{\partial x} = (1-2x)(R_{C2} - C_I - R_C - \alpha_2 Q + yR_{C1} - yR_{C2} + zaE_C - y\alpha_1 Q + y\alpha_2 Q) \quad (10)$$

If $G(z) = R_{C2} - C_I - R_C - \alpha_2 Q + yR_{C1} - yR_{C2} + zaE_C - y\alpha_1 Q + y\alpha_2 Q$, and it is a monotonically increasing function.

When $z = z* = \frac{[C_I + R_C - R_{C2} + \alpha_2 Q + y(R_{C2} - R_{C1}) + y(\alpha_1 Q - \alpha_2 Q)]}{\mathrm{aE_c}}$, $G(z) = 0$ and $F(x) \equiv 0$. This shows that manufacturing enterprises are in a steady state regardless of the strategy they choose, and the proportion of strategy choices does not change over time. According to the theory of evolutionary stability, manufacturing enterprises are in a stable state if there exists a behavioral strategy $x*$, which makes Equation (7) equal to zero and Equation (10) less than zero.

When $z \neq z*$ and $G(z) \neq 0$, we can obtain two possible evolutionary stable points with Equation (7) equal to zero at $x_1* = 0$ and $x_2* = 1$. Specifically, when $z < z*$, if $x = 0$, then Equation (10) is less than zero, which means the evolutionary stable point is $x* = 0$, which indicates that the manufacturing enterprises adopt a "no application of platforms" strategy as a stabilization strategy; when $z > z*$, if $x = 1$, then Equation (10) is less than zero, which means the evolutionary stable point is $x* = 1$, which indicates that the manufacturing enterprises adopt an "application of platforms" strategy as a stabilization strategy.

According to the above analysis, it can be seen that the evolutionary stable state of the manufacturing enterprises' strategy choice is influenced by the proportion of industrial Internet platforms adopting the strategy of "service enhancement" and the proportion of local governments adopting the strategy of "incentive", and the dynamic evolution of the decision making of manufacturing enterprises is shown in Figure 1. From Figure 1, it can be seen that when the government's initial strategy selection ratio z is less than $z*$, the initial state of the game is located in space V_1, and the strategic choice of manufacturing enterprises will eventually evolve into not applying the platform; when the government's initial strategy selection ratio z is more than $z*$, the initial state of the game is located in space V_2, and the strategic choice of manufacturing enterprises will eventually evolve into applying the platform. According to $z = z* = \frac{[C_I + R_C - R_{C2} + \alpha_2 Q + y(R_{C2} - R_{C1}) + y(\alpha_1 Q - \alpha_2 Q)]}{\mathrm{aE_c}}$, we can see that when the incentive coefficient a of the local government for manufacturing enterprises increased, $z*$ will decrease; at this time, the volume of V_2 in Figure 1 has increased, indicating that the probability of the manufacturing enterprises choosing to employ platforms has increased.

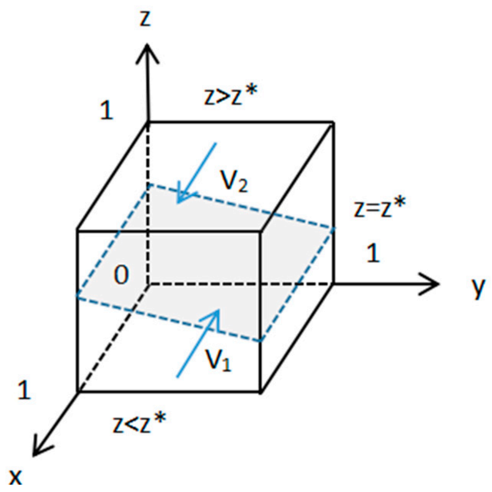


Figure 1. The dynamic evolution chart of manufacturing enterprises.

4.2. Evolutionary Stable Strategy of Industrial Internet Platforms

According to the equation for the industrial Internet platforms selecting "service enhancement", find the first-order partial derivative of Equation (8) with respect to y.

$$\frac{\partial F(y)}{\partial y} = (1-2y)[C_{P2} - C_{P1} + xI + x(R_{P1} - R_{P2}) + zbE_P] \quad (11)$$

If $G(x) = C_{P2} - C_{P1} + xI + x(R_{P1} - R_{P2}) + zbE_P$, and it is a monotonically increasing function.

When $x = x* = \frac{C_{P1} - C_{P2} - zbE_P}{I + R_{P1} - R_{P2}}$, $G(x) = 0$ and $F(y) \equiv 0$. This shows that the industrial Internet platforms are in a steady state regardless of the strategy they choose, and the proportion of strategy choices does not change over time.

When $x \neq x*$ and $G(x) \neq 0$, we can obtain two possible evolutionary stable points with Equation (8) equal to zero at $y_1* = 0$ and $y_2* = 1$. Specifically, when $x < x*$, if $y = 0$, then Equation (11) is less than zero, which means the evolutionary stable point is $y* = 0$, which indicates that the industrial Internet platforms adopt a "no service enhancement" strategy as a stabilization strategy; when $x > x*$, if $y = 1$, then Equation (11) is less than zero, which means the evolutionary stable point is $y* = 1$, which indicates that the industrial Internet platforms adopt a "service enhancement" strategy as a stabilization strategy.

According to the above analysis, it can be seen that the evolutionary stable state of manufacturing enterprises' strategy choice is influenced by the proportion of manufacturing enterprises adopting the strategy of "application of platforms" and the proportion of local governments adopting the strategy of "incentive", and the dynamic evolution of the decision making of industrial Internet platforms is shown in Figure 2. From Figure 2, it can be seen that when the manufacturing enterprises' initial strategy selection ratio is x is less than $x*$, the initial state of the game is located in space V_1, and the strategic choice of industrial Internet platforms will eventually evolve into the strategy of "no service enhancement"; when the manufacturing enterprises' initial strategy selection ratio is x is more than $x*$, the initial state of the game is located in space V_2, and the strategic choice of industrial Internet platforms will eventually evolve into the strategy of "service enhancement". According to $x = x* = \frac{C_{P1} - C_{P2} - zbE_P}{I + R_{P1} - R_{P2}}$, we can see that when the incentive coefficient b of the local government for industrial Internet platforms increased, $x*$ will decrease; at this time, the volume of V_2 in Figure 1 has increased, indicating that the probability of the industrial Internet platforms choosing to enhance their services has increased.

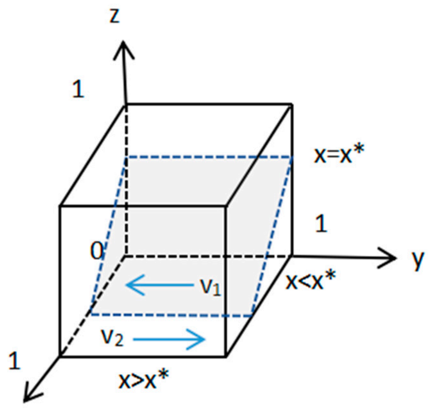


Figure 2. The dynamic evolution chart of industrial Internet platforms.

4.3. Evolutionary Stable Strategy of Local Governments

According to the equation for the local governments selecting "incentive", find the first-order partial derivative of (9) with respect to z.

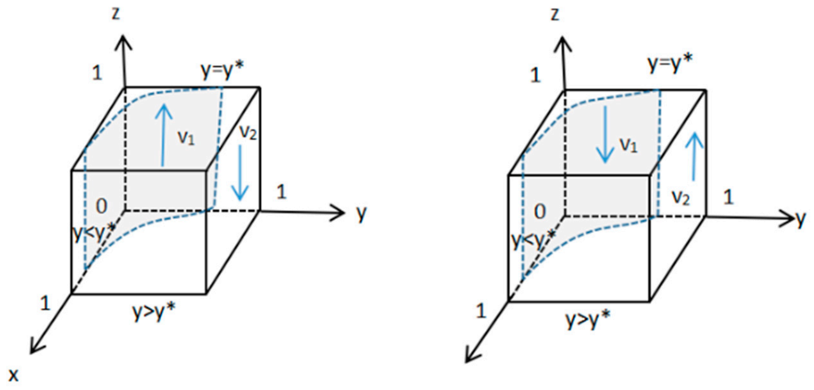
$$\frac{\partial F(z)}{\partial z} = (1-2z)(xF - C_G + yF - xaE_C - ybE_P - xyF) \tag{12}$$

If $G(y) = xF - C_G + yF - xaE_C - ybE_P - xyF$, when $y = y* = \frac{C_G - xF + xaE_C}{F - bE_P - xF}$, $G(y) = 0$ and $F(z) \equiv 0$. This shows that the local governments are in a steady state regardless of the strategy they choose, and the proportion of strategy choices does not change over time.

When $y \neq y*$ and $G(y) \neq 0$, we can obtain two possible evolutionary stable points with Equation (9) equal to zero at $z_1* = 0$ and $z_2* = 1$.

If $(1-x)F - bE_P > 0$, $G(y)$ is a monotonically increasing function. There are two situations: when $y < y*$, if $z = 0$, then Equation (12) is less than zero, which means the evolutionary stable point is $z* = 0$, which indicates that the local governments adopt a "no incentive" strategy as a stabilization strategy; when $y > y*$, if $z = 1$, then Equation (12) is less than zero, which means the evolutionary stable point is $z* = 1$, which indicates that the local governments adopt an " incentive" strategy as a stabilization strategy. The evolutionary stable state of manufacturing enterprises' strategy choice is influenced by the proportion of manufacturing enterprises adopting the strategy of "application of platforms" and the proportion of industrial Internet platforms adopting the strategy of "service enhancement". The dynamic evolution of the decision making of local governments is shown in Figure 3a. From Figure 3a, it can be seen that when the industrial Internet platforms' initial strategy selection ratio y is less than $y*$, the initial state of the game is located in space V_1, and the strategic choice of local governments will eventually evolve into the strategy of "no incentive"; when the industrial Internet platforms' initial strategy selection ratio y is more than $y*$, the initial state of the game is located in space V_2, and the strategic choice of local governments will eventually evolve into the strategy of "incentive".

If $(1-x)F - bE_P < 0$, $G(y)$ is a monotonically decreasing function. There are two situations: when $y < y*$, if $z = 1$, then Equation (12) is less than zero, which means the evolutionary stable point is $z* = 1$, which indicates that the local governments adopt an "incentive" strategy as a stabilization strategy; when $y > y*$, if $z = 0$, then Equation (12) is less than zero, which means the evolutionary stable point is $z* = 0$, which indicates that the local governments adopt a "no incentive" strategy as a stabilization strategy. The evolutionary stable state of manufacturing enterprises' strategy choice is also influenced by the proportion of manufacturing enterprises adopting the strategy of "application of platforms" and the proportion of industrial Internet platforms adopting the strategy of "service enhancement". The dynamic evolution of the decision making of local governments is shown in Figure 3b. From Figure 3b, it can be seen that when the industrial Internet platforms' initial strategy selection ratio is y is less than $y*$, the initial state of the game is located in space V_1, and the strategic choice of local governments will eventually evolve into the strategy of "incentive"; when the industrial Internet platforms' initial strategy selection ratio is y is more than $y*$, the initial state of the game is located in space V_2, and the strategic choice of local governments will eventually evolve into the strategy of "no incentive".



(**a**) (**b**)

Figure 3. (**a**) The dynamic evolution chart of local governments when G(y) is a monotonically increasing function; (**b**) The dynamic evolution chart of local governments when G(y) is a monotonically decreasing function.

4.4. Evolutionary Stable Strategy Analysis of Three-Party Evolutionary Game

When $F(x) = 0$, $F(y) = 0$, and $F(z) = 0$, there are eight equilibrium solutions in the tripartite evolutionary game, which are $A(0,0,0)$, $B(1,0,0)$, $C(0,1,0)$, $D(0,0,1)$, $E(1,1,0)$, $F(1,0,1)$, $G(0,1,1)$, and $H(1,1,1)$, respectively. The following is the Jacobian matrix of the three-party evolutionary game.

$$\begin{pmatrix} (2x-1)(C_I+R_C-R_{C2}+\alpha_2 Q-y(R_{C1}+R_{C2})-zaE_C+y\alpha_1 Q-y\alpha_2 Q) & -x(x-1)(R_{C1}-R_{C2}-\alpha_1 Q+\alpha_2 Q) & -x(x-1)aE_C \\ -y(y-1)(I+R_{P1}-R_{P2}) & (1-2y)(C_{P2}-C_{P1}+xI+xR_{P1}-xR_{P2}+zbE_P) & -y(y-1)bE_P \\ z(z-1)(aE_C-F+yF) & z(z-1)(bE_P-F+xF) & (2z-1)(C_G-xF-yF+xaE_C+ybE_P+xyF) \end{pmatrix}$$

Substitute the above eight equilibrium solutions into the Jacobian matrix of the three-party evolutionary game. The matrix eigenvalues corresponding to the equilibrium points are shown in Table 3.

By observing the judgment of Table 3 on the positive and negative signs of the three eigenvalues under different strategies, it can be seen that we cannot accurately determine the signs of all the eigenvalues. This is because in the development process of an evolutionary game, there are many kinds of factors affecting the strategic choices of local governments, manufacturing enterprises, and industrial Internet platforms, and the change in a certain influencing factor will prompt the change in the strategic choices of at least one of the participating subjects, and the behavioral strategies of the three participating subjects are constrained by each other and influenced by each other, which will result in the continuous adjustment of the strategic choices of the three participating subjects [39].

In order to continue to optimize the structure of the economy and maximize the benefits for all participants in the game, the analysis in this study led to the conclusion that strategy (1, 1, 1) is the only scenario that is beneficial for all three types of participants. For example, China has introduced a series of policies to support the development of the industrial Internet in order to stimulate the high-quality development of the economy by transforming the traditional development mode of the manufacturing industry, enhancing its independent innovation capacity, and improving the quality and efficiency of the development; at the same time, in order to enhance their social reputation, local governments will also formulate relevant policies to incentivize industrial Internet platforms to improve their services and encourage manufacturing enterprises to apply these platforms in order to innovate and upgrade. Therefore, the equilibrium point (1, 1, 1) is the most ideal development state, and its corresponding evolutionary game strategies are "application of platforms", "service enhancement", and "incentive".

Table 3. Matrix eigenvalues corresponding to the equilibrium points.

Equilibrium Solutions	λ_1	λ_2	λ_3
$A(0,0,0)$	$C_{P2} - C_{P1}$	$-C_G$	$R_{C2} - R_C - C_I - \alpha_2 Q$
$B(1,0,0)$	$F - C_G - aE_C$	$C_I + R_C - R_{C2} + \alpha_2 Q$	$C_{P2} - C_{P1} + I + R_{P1} - R_{P2}$
$C(0,1,0)$	$C_{P1} - C_{P2}$	$F - C_G - bE_P$	$R_{C1} - R_C - C_I - \alpha_1 Q$
$D(0,0,1)$	C_G	$C_{P2} - C_{P1} + bE_P$	$R_{C2} - R_C - C_I + aE_C - \alpha_2 Q$
$E(1,1,0)$	$C_I + R_C - R_{C1} + \alpha_1 Q$	$F - C_G - aE_C - bE_P$	$C_{P1} - C_{P2} - I - R_{P1} + R_{P2}$
$F(1,0,1)$	$C_G - F + aE_C$	$C_I + R_C - R_{C2} - aE_C + \alpha_2 Q$	$C_{P2} - C_{P1} + I + R_{P1} - R_{P2} + bE_P$
$G(0,1,1)$	$C_{P1} - C_{P2} - bE_P$	$C_G - F + bE_P$	$R_{C1} - R_C - C_I + aE_C - \alpha_1 Q$
$H(1,1,1)$	$C_G - F + aE_C + bE_P$	$C_I + R_C - R_{C1} - aE_C + \alpha_1 Q$	$C_{P1} - C_{P2} - I - R_{P1} + R_{P2} - bE_P$

5. Data Simulation

According to the previous analysis, the optimal strategy choices of the three parties in the evolutionary game are "application of platforms", "service enhancement", and "incentive". For evolutionary game models, scholars usually use Vensim PLE and MATLAB R2016a software for simulation analysis. In this study, in order to more intuitively observe the evolution of the game subject's strategy choice, MATLAB R2016a numerical simulation is used to analyze the effects of initial willingness probability, different government incentive coefficients, and cost of application platforms on the evolution results.

5.1. The Effect of Different Initial Intentions on Evolutionary Outcomes

Based on the above constraints, let $E_C = 20$, $E_P = 25$, $a = 0.4$, $b = 0.4$, $R_{G1} = 18$, $R_{G2} = 13$, $F = 35$, $C_G = 6$, $R_{C1} = 38$, $R_{C2} = 32$, $Q = 12$, $\alpha_1 = 0.3$, $\alpha_2 = 0.4$, $C_I = 10$, $R_C = 17$, $R_{P1} = 72$, $R_{P2} = 68$, $C_{P1} = 45$, $C_{P2} = 35$, and $I = 8$. Considering the cases of manufacturing enterprises, industrial Internet platforms, and local governments with medium, low, and high proportions of strategy selection, the simulation results are shown in Figure 4a–c, where the initial values of the initial proportions of strategy selection of the three parties, namely, x, y, and z, are 0.5, 0.2, and 0.8, respectively. At this point, the simulation results are consistent with the conclusions of the previous system evolution stability analysis: in the case of parameter assignment to meet the constraints, regardless of how the initial strategy selection ratio of the game participants changes, the game's three-way evolution endpoints are (1, 1, 1).

However, although the evolutionary endpoints are consistent, the evolutionary paths under different initial strategy selection ratios are not the same and are described as follows: with the increase in the initial strategy selection ratio of the three parties of the game, the speed of the three-party evolution path converging to one is also gradually accelerated; the evolution path of the local government significantly continues to converge to one, and compared with the manufacturing enterprises and the industrial Internet platforms, the local government is less affected by the proportion of the initial strategy selection; when the proportion of initial strategy selection is low, the industrial Internet platform evolution path is more affected, and the speed of evolution converging to one is significantly lower; and when the proportion of initial strategy selection is high, the response of manufacturing enterprises is larger, and the evolution path rapidly converges to one, and the speed of its convergence to one exceeds that of the local government.

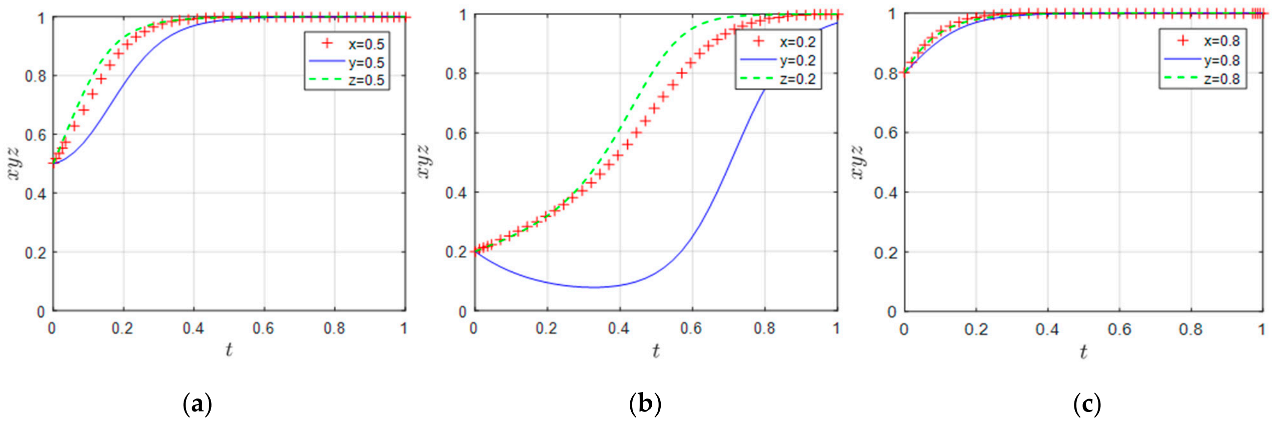
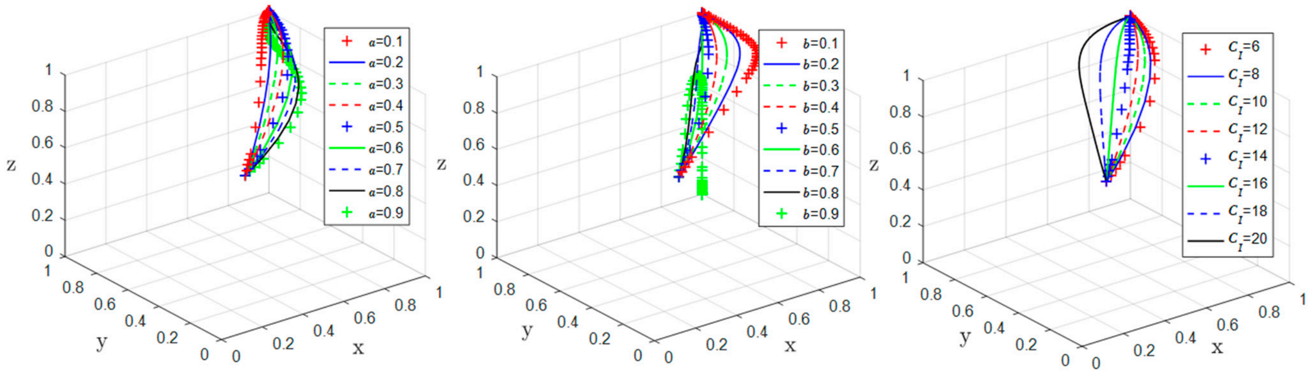


Figure 4. (**a**) Strategy selection when x,y,z are equal to 0.5; (**b**) Strategy selection when x,y,z are equal to 0.2; (**c**) Strategy selection when x,y,z are equal to 0.8.

5.2. The Effect of Different Incentive Coefficients and the Cost of Application Platforms on Evolutionary Paths

Firstly, in order to analyze the impact of the incentive coefficient a of the local government on the manufacturing enterprises, the incentive coefficient of the local government on the enterprises is varied under the constant values of other parameters, which are assigned the values of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. In addition, in order to eliminate the influence of the initial probability on the evolutionary stabilization results, the initial strategy probabilities of the local government, the manufacturing enterprise, and the industrial Internet platform are all set to 0.5. The simulation results of the replicated dynamic equation system evolving over time for 50 times are shown in Figure 5a. Figure 5a shows that when the incentive coefficient of local government to manufacturing enterprises changes, the evolutionary stability point of the system is (1, 1, 1), the local government chooses the strategy of "incentive", the manufacturing enterprise chooses the strategy of "application of platforms", and the industrial Internet platform chooses the strategy of "service enhancement". When the incentive coefficient of local government to manufacturing enterprises rises from 0.1 to 0.5, manufacturing enterprises tend to apply platform strategies at an accelerated rate; when the incentive coefficient of local government to manufacturing enterprises rises from 0.5 to 0.9, manufacturing enterprises tend to apply platform strategies at a slower rate. Therefore, local governments set reasonable incentive coefficients for manufacturing enterprises, which can promote manufacturing enterprises to apply the industrial Internet platform for transformation and innovation.

Secondly, in order to analyze the impact of local government's incentive coefficient b for industrial Internet platforms, it is assigned values of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. The simulation results are shown in Figure 5b. Figure 5b shows the following: when the incentive coefficient of local government to industrial Internet platforms rises from 0.1 to 0.6, industrial Internet platforms tend to enhance their service strategies at an accelerated rate; when the incentive coefficient of local government to industrial Internet platforms rises from 0.6 to 0.8, industrial Internet platforms tend to enhance services strategies at a slower rate. At this time, the evolutionary stability point of the system is (1, 1, 1), and the local government chooses the strategy of "incentive", the manufacturing enterprise chooses the strategy of "application of platforms", and the industrial Internet platform chooses the strategy of "service enhancement". However, when the incentive coefficient rises to 0.9, the evolutionary stability point of the system is (1, 1, 0), and the local government tends to choose the strategy of "no incentive", because at this time, compared with the benefits arising from the development of incentive policies, the cost paid by the local government is too high, which reduces the enthusiasm of the local government to formulate and implement incentive policies. Therefore, local governments set reasonable incentive coefficients for industrial Internet platforms to ensure the enthusiasm of local governments to implement incentive policies and, at the same time, promote industrial Internet platforms to improve their own services in order to attract manufacturing enterprises to use the platform for transformation and innovative development.



(**a**) (**b**) (**c**)

Figure 5. (**a**) Effect of incentive coefficients for manufacturing enterprises variations on evolutionary results; (**b**) Effect of incentive coefficients for industrial Internet platforms variations on evolutionary results; (**c**) Effect of the cost of application platforms variations on evolutionary results.

Finally, in order to explore the impact of the cost C_I of manufacturing enterprises applying the platform to carry out transformation and innovation development, it is assigned the values of 6, 8, 10, 12, 14, 16, 18, and 20. The simulation results are shown in Figure 5c. From Figure 5c, it can be seen that when the cost of manufacturing enterprises applying the platform to carry out transformation and innovation development changes, the evolutionary stability point of the system is (1, 1, 1), the local government chooses the strategy of "incentive", the manufacturing enterprise chooses the strategy of "application of platforms", and the industrial Internet platform chooses the strategy of "service enhancement". As the cost of manufacturing enterprises applying the platform for transformation and innovation development increases, enterprises tend to apply the platform strategy at a slower rate. Therefore, the industrial Internet platform can reduce the cost of the enterprise employing the platform by improving its own development level, so as to attract enterprises to apply the platform and promote the transformation and innovative development of manufacturing enterprises.

5.3. Discussion of the Results of Evolutionary Game Analysis

This study constructs a three-party evolutionary game model of manufacturing enterprises, industrial Internet platforms, and local governments, and based on the stability analysis of the strategy evolution of various situations, we can see the following:

(1) The higher the incentive coefficient of the government for manufacturing enterprises, the higher the probability of enterprises choosing to apply the platforms to carry out the development of innovation and upgrading. In addition, the enterprise strategy choices are also affected by the costs of applying industrial Internet platforms for transformation and development in the manufacturing industry and by the net benefits for manufacturing enterprises that do not apply the platforms and maintain their traditional operations.

(2) The higher the incentive coefficient of the government for the industrial Internet platforms, the higher the probability that the platforms choose to enhance their services. In addition, when the costs of industrial Internet platforms maintaining daily operations, the maximum policy support and economic incentives for industrial Internet platforms, and the direct economic benefits when industrial Internet platforms enhance their services and indirect benefits that can be gained when industrial Internet platforms enhance their services increase, the platforms tend to choose to enhance their

services; and when the costs of industrial Internet platforms to enhance their services and maintain their daily operations, as well as the direct economic benefits when industrial Internet platforms do not enhance their services, increase, the platforms tend to choose not to enhance their services.

(3) Local government strategy choices are related to the social reputation benefits for local governments in developing and implementing incentive policies and the maximum policy support and economic incentives for industrial Internet platforms.

Based on the results of the ESS analysis, numerical simulation analysis was used to analyze the effects of the proportion of initial strategy selection of each game subject, different incentive coefficients of the government, and the costs of applying industrial Internet platforms for transformation and development in the manufacturing industry on the results of evolutionary stabilization. The results of the study show the following:

(1) Under the condition of different initial strategy selection ratios of each game subject, although the evolution endpoint is identical, the evolution path is not the same. The strategy selection of the local government at the evolution endpoint is least affected by the initial strategy selection ratio. When the proportion of initial strategy choices is low, the rate at which the evolutionary outcome of the industrial Internet platforms converges to the "enhance service" strategy is significantly lower. The rate at which the manufacturing enterprises' evolutionary outcomes converge to the "application of platforms" measure is significantly higher when the proportion of initial strategy choices is higher.
(2) The willingness of manufacturing enterprises to apply the platforms for transformation and innovation is affected by the government incentive coefficient. As the government incentive coefficient for enterprises increases, the willingness of enterprises to apply the platforms increases significantly. However, when the incentive coefficient is raised to the interval of [0.5, 0.9], although the government incentive coefficient still positively impacts enterprises' willingness to apply the platform, the impact effect is significantly weaker.
(3) The willingness of industrial Internet platforms that choose to enhance their services is significantly and positively affected by the coefficient of government incentives for platforms. However, when the coefficients are raised to the interval [0.6, 0.9], this effect is significantly weaker. In addition, when the government's incentive coefficient for platforms is raised to 0.9, the cost to the local government is too high compared to the benefits of developing incentives, which leads to a decrease in the incentive to develop and implement incentives, and the local government tends to choose not to enforce incentives.
(4) The enterprises' willingness to apply the platforms is significantly inhibited by the cost of applying the platform.

6. Empirical Analysis

Based on the evolutionary game theory, the above study constructs a three-party limited rationality evolutionary game model of local government, manufacturing enterprises, and industrial Internet platforms, and analyzes its dynamic replication process and evolutionary stabilization strategy. Through the evolutionary game analysis, it can be seen that the development of industrial Internet platforms will have an impact on the enthusiasm of manufacturing enterprises to utilize the platform for transformation and innovation, and the government's incentive policy can further promote the industrial Internet platform to improve the service, so as to promote the transformation and innovative development of manufacturing enterprises. Next, we will further discuss the impact of the industrial Internet on the level of manufacturing innovation and development and the role of government incentives therein through empirical analysis.

6.1. Variable Selection and Model Construction

6.1.1. The Interpreted Variable

Innovation is the first driving force for development, and innovative research and development is the first step of innovative development, which refers to the creation of knowledge through the investment of human and financial resources to produce scientific and technological achievements of expertise and technology. Therefore, this study chooses the electronics and communication equipment manufacturing industry in the manufacturing industry as the research object and takes the innovation input level (*IN*) and innovation output level (*OUT*) of the electronics and communication equipment manufacturing industry as the interpreted variable. The number of research and experimental development personnel and the internal expenditure of research and experimental development funds are used to measure the innovation input level; the sales revenue of new products and the number of patent applications are used to measure the innovation output level [40–43].

6.1.2. Explanatory Variable

In this study, the level of industrial Internet development (*INET*) is chosen as an explanatory variable. Drawing on existing relevant research, the industrial Internet development level is measured from three aspects: digitalization level, networking level, and intelligence level [44]. Interconnectivity is an important feature of the development of the Industrial Internet industry, so the level of digitization is an essential indicator of the development of Industrial Internet platforms. In this study, the digitalization level is measured by the number of Internet access ports, the number of Internet broadband access users, and the number of computers per 100 people [45]. The level of networking mainly reflects the capacity of the infrastructure of the new generation of information networks represented by the Internet of Things, 5G communication technologies, etc. The networking level is measured by the length of long-distance fiber-optic cable lines, the number of websites owned by enterprises, and the number of domain names [46]. Data are the core of the industrial Internet platform, the network is the foundation of the industrial Internet platform, and the level of enterprise intelligence is the key to measuring the development level of the industrial Internet platform in each province and city. Therefore, the intelligence level is measured by the amount of software business revenue, and the number of e-commerce sales and enterprises in the information transmission, software, and information technology service industry [47].

6.1.3. Control Variable

In this study, government support (*GS*) and the industrial development scale (*IND*) are selected as control variables. The level of government support is measured by the portion of research and experimental development expenditure whose source of funding is government funds [48]; and the scale of industrial development is measured by the number of enterprise units, the total of current assets, and the total amount of assets [49].

The data used in this study mainly come from the 2018–2020 panel data, and the data of each province mainly come from provincial statistical yearbooks, China Statistical Yearbook, China Industrial Statistical Yearbook, and China Tertiary Industry Statistical Yearbook. The primary process of data collection is as follows: (1). Due to the large amount of missing data, from Tibet, Xinjiang, and Hainan, the sample range is determined to be 28 provinces and cities in China, with a total of 84 pieces of data. (2). Convert the collected time-series data into the panel data format suitable for analysis. (3). Use interpolation to deal with the individual missing values in the collected sample data. (4). In order to avoid covariance, eliminate heteroskedasticity, and make the variables conform to the normal distribution as much as possible; logarithmic treatment is carried out on all the data. Descriptive statistics of the variables are shown in Table 4.

Table 4. Results of descriptive statistics.

Variant	N	Min	Max	Mean	Standard
The number of research and experimental development personnel	84	2.29	5.51	3.84	0.77
The internal expenditure of research and experimental development funds	84	3.66	7.07	5.37	0.79
The sales revenue of new products	84	4.60	8.32	6.52	0.83
The number of patent applications	84	1.68	5.03	3.17	0.82
The number of Internet access ports	84	2.55	3.94	3.40	0.31
The number of Internet broadband access users	84	2.18	3.59	3.09	0.32
The number of computers per 100 people	84	1.23	1.89	1.48	0.13
The length of long-distance fiber-optic cable lines	84	3.60	5.10	4.44	0.36
The number of websites owned by enterprises	84	2.99	4.93	4.08	0.45
The number of domain names	84	0.48	2.87	1.96	0.50
The number of software business revenue	84	0.15	4.20	2.75	0.97
The number of enterprises in the information transmission, software, and information technology service industry	84	3.16	5.26	4.38	0.46
E-commerce sales	84	2.23	4.48	3.49	0.55
The portion of research and experimental development expenditure whose source of funding is government funds	84	0.30	5.90	3.87	1.01
The number of enterprise units	84	1.00	3.88	2.32	0.62
The total of current assets	84	1.36	4.46	2.94	0.72
The total amount of assets	84	1.86	4.62	3.18	0.67

6.1.4. Model Construction

The empirical analysis method used in this study is mainly panel data regression analysis. Because the development level of the industrial Internet and manufacturing innovation between cities cannot be considered unilaterally from a single factor, many influencing factors as a whole will be studied and analyzed comprehensively. The panel data combine time series and cross-section data, and the research and analysis results will be more comprehensive and accurate. Therefore, in this study, the entropy method is used to process the data of all the above variables initially, and panel data regression is used to examine the impact of the Industrial Internet on the level of innovation and development of the manufacturing industry, as well as on the role of government incentives therein. In model (13)–(14), IN stands for the level of innovation input, OUT stands for the level of innovation output, $INET$ stands for the level of industrial Internet development, GS stands for the strength of government support, IND stands for the scale of industrial development, and $\varepsilon_{i,t}$ is a random perturbation term.

$$IN_{\mathrm{i,t}} = \beta_0 + \beta_1 INET_{\mathrm{i,t}} + \beta_2 GS_{\mathrm{i,t}} + \beta_3 IND_{\mathrm{i,t}} + \varepsilon_{\mathrm{i,t}} \tag{13}$$

$$OUT_{\mathrm{i,t}} = \gamma_0 + \gamma_1 INET_{\mathrm{i,t}} + \gamma_2 GS_{\mathrm{i,t}} + \gamma_3 IND_{\mathrm{i,t}} + \varepsilon_{\mathrm{i,t}} \tag{14}$$

6.2. General Regression Analysis

According to the empirical results in Table 5, it can be seen that models (13) and (14) are based on the results of the econometric model of Equations (13) and (14). Specifically, model (13) tests the impact of the level of industrial Internet development on the level of innovation input in the manufacturing industry, and the regression coefficient of $INET$ is positive and significant at the 1% significance level, indicating that the development of the industrial Internet helps to enhance the innovation input in the manufacturing industry; model (14) tests the impact of the level of industrial Internet development on the level of innovation output in the manufacturing industry, and the regression coefficient of $INET$ is positive and significant at the 1% significance level, which indicates that the development of the industrial Internet helps to enhance the innovation output of the manufacturing industry; and the coefficient of government support IN on the level of innovation input OUT and innovation output of the manufacturing industry is positive and significant at the 1% significance level, which indicates that overall government support has a significant positive impact on both the innovation input and innovation output of the manufacturing industry. Therefore, the government should develop appropriate incentive policies to help promote the development of innovation and upgrading of manufacturing enterprises.

Table 5. General regression results.

Variant	***IN***	***OUT***
	(13)	**(14)**
$INET$	0.163 ***	0.191 ***
	(0.0436)	(0.0440)
IND	0.364 ***	0.299 ***
	(0.0432)	(0.0436)
GS	0.0702 ***	0.146 ***
	(0.0233)	(0.0236)
$Constant$	0.00624	−0.00745
	(0.00886)	(0.00896)
R^2	0.727	0.715
N	84.000	84.000

*** represent significant levels of 1%.

6.3. Regression Analysis by Region

Based on the overall analysis, in order to examine the impact of the industrial Internet on the level of manufacturing innovation and development in each region and the role of government incentives therein, the national region is divided into three sample sets in the eastern, central, and western regions to carry out the study separately. The eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, and Guangdong; the central region includes Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan; and the western region includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, and Ningxia.

Table 6 shows the sub-regional regression results of the industrial Internet on the level of manufacturing innovation and development. From the statistical results, we can observe the following: The industrial Internet has a significant impact on the level of manufacturing innovation and development in the eastern, central, and western parts of the country, but there is a difference in the pathway of the role. For the eastern part of the country, the level of development of the industrial Internet on the level of manufacturing innovation inputs and innovation outputs are all positive and significant at a significance level of 5%, which indicates that in the eastern part of the country, the level of development of the industrial Internet has a significant impact on the level of manufacturing innovation and outputs. For the eastern region, the level of industrial Internet development on the level of innovation and development of manufacturing industry is positively significant at a 5% significance level, indicating that in the eastern region, the level of industrial Internet development has a significant role in promoting the level of innovation and development of manufacturing industry; for the central region, the industrial Internet promotes the transformation and innovative development of manufacturing industry mainly by influencing the innovation output of manufacturing industry; for the western region, the development of the industrial

Internet has a significant role in promoting the level of innovation output of manufacturing industry, and to a certain degree suppresses the innovation input of manufacturing industry.

Table 6. Regression results by region.

Variant	Eastern		Central		Western	
	IN	***OUT***	***IN***	***OUT***	***IN***	***OUT***
	(13)	**(14)**	**(13)**	**(14)**	**(13)**	**(14)**
$INET$	0.228 **	0.208 **	0.237 **	0.137	−0.073 *	0.072 **
	(0.082)	(0.074)	(0.080)	(0.125)	(0.039)	(0.027)
IND	0.362 ***	0.353 ***	0.342 **	0.358	0.376 **	0.322 ***
	(0.074)	(0.067)	(0.134)	(0.208)	(0.143)	(0.100)
GS	0.069	0.188 ***	0.011	0.032	0.005	0.060
	(0.044)	(0.040)	(0.028)	(0.043)	(0.084)	(0.059)
$Constant$	0.011	−0.007	−0.015	−0.006	0.013 **	−0.007 *
	(0.028)	(0.026)	(0.010)	(0.016)	(0.005)	(0.004)
R^2	0.785	0.815	0.773	0.526	0.327	0.740
N	30.000	30.000	24.000	24.000	30.000	30.000

***, ** and * represent significant levels of 1%, 5% and 10%.

6.4. Discussion of Empirical Analysis

Based on the provincial panel data, this study empirically analyzes the level of industrial Internet development and the specific role path of government incentives to enhance the level of manufacturing innovation and development, and the results show the following:

(1) The level of industrial Internet development, government support, and industrial development scale has a significant positive impact on the level of innovation input and output of the manufacturing industry, and the formulation of appropriate incentive policies by the government can help promote the transformation and upgrading of the manufacturing industry.

(2) The level of industrial Internet development has a significant positive impact on the level of manufacturing innovation inputs and innovation outputs in the eastern region. In contrast, the effect on manufacturing innovation outputs in the central area is insignificant, and the effect on the level of manufacturing innovation inputs in the western region has a negative impact. Government support has a significant positive effect on manufacturing innovation output in the eastern region. In contrast, it has a negligible impact on manufacturing development in the central and western areas. This is because the industrial Internet infrastructure construction in the eastern region has been practical, the network construction and transformation support capacity has been strengthened, and the area is rich in scientific and technological innovation resources, with many research institutions, and professional talents, which provides strong support for the technological innovation and application of the industrial Internet. In addition, compared with other regions, the eastern region has a higher level of economic development, a more complete industrial system, and a higher level of economic growth, which provides a solid material foundation and financial support for the transformation and upgrading of the manufacturing industry. In contrast, in the central and western regions of the manufacturing industry structure, the traditional sector accounts for a high proportion, and there is a lack of a diversified industrial structure to promote innovation, and compared with other regions, the policy support and market environment are relatively immature, and the innovation incentive mechanism is not perfect, which affects the enthusiasm of manufacturing enterprise innovation and the effective allocation of innovation resources.

7. Discussion and Recommendations

This study considers the role of government incentives, taking the local government as an independent game participant. Firstly, we construct a tripartite evolutionary game model of the local government, manufacturing enterprises, and industrial Internet platforms, then analyze the stability of the strategic choices of the parties and the influence of the relationship between the elements, and verify the validity of the conclusions through a simulation analysis, and finally analyze the impact of the development of the industrial Internet on the transformation and innovation of the manufacturing industry through empirical testing. Finally, the impact of industrial Internet development and the coefficient of government support on manufacturing transformation and innovation is analyzed through empirical testing, and the following conclusions are obtained:

(1) As the government's incentive coefficient for manufacturing enterprises increases, the stronger the enterprise's willingness to apply the industrial Internet platform for innovation upgrading and development, but if the government's incentive coefficient is too high, the effect of this influence will gradually diminish, which will gradually be transformed into an inhibitory effect.
(2) The willingness of industrial Internet platforms to choose the "enhance service" strategy is affected by the government's incentive coefficient for platforms. Within a specific range, the higher the incentive coefficient is, the more the industrial Internet platforms tend to improve the quality of their services. Still, if the incentive coefficient is too high, the effect of this influence will gradually diminish. When the government's incentive coefficient for platforms reaches 0.9, compared with the reputational and economic benefits generated by the development of incentive policies, the cost to be paid by the government is too high. At this time, local governments tend to refrain from implementing incentive policies.
(3) The level of industrial Internet development has a significant positive impact on the level of manufacturing innovation inputs and innovation outputs, but this impact in the eastern, central, and western regions shows noticeable regional differences; the level of industrial Internet development has a significant positive impact on the level of manufacturing innovation inputs and innovation outputs in the eastern region. However, this impact is insignificant for the manufacturing innovation output level in the central area, and the level of manufacturing innovation inputs in the western region has a negative impact.
(4) Government support significantly affects manufacturing innovation inputs and outputs in the eastern region but not in the central and western areas.

Based on the above research conclusions, this study further puts forward the following countermeasure suggestions:

(1) Give full play to the supportive and guiding role of government incentives, the formulation of incentive policies should be consistent with the long-term goal of national manufacturing upgrading and innovative development; promote industrial structure optimization and transformation and upgrading; continuously adjust and improve incentive policies according to the domestic and international economic environment and technological development trends; ensure the timeliness and effectiveness of the policies; and, at the same time, set up a scientific system of the innovation evaluation system to regularly monitor and evaluate the effect of the policy implementation, control appropriate incentives, and to ensure that the policy objectives are achieved.
(2) To formulate and implement regional industrial Internet development policies according to local conditions, clarify development goals and paths, provide policy and financial support, and accelerate the construction of digital infrastructure such as 5G networks and data centers to provide a solid network foundation for the industrial Internet, demonstrate the application effect of the industrial Internet through demonstration projects and pilot projects, and encourage various regions to explore ways to promote the development of mutual development between the industrial Internet and

the manufacturing industry. To draw on the actual cases of the successful integration of the industrial Internet and the manufacturing industry and make improvements by the exact differences between different regions, and thus lead to the development of deeper integration of the industrial Internet and the manufacturing industry in this region.

(3) Create a provincial industrial Internet innovation center, carry out theoretical research and technical research in the fields of equipment access, platform frameworks, and mechanism models, guide the transformation of the platform to sustainable operation, accelerate the deep integration of the Internet and manufacturing industry, and boost the transformation, upgrading, and development of manufacturing enterprises by applying the industrial Internet platform. With the support of new-generation information technology, improve the efficiency and quality of the manufacturing enterprises in the links of customization, production, sales, and service, and further enhance the independent innovation capability of the manufacturing industry. Efficiency and quality of manufacturing enterprises, from customization, production, and sales to service, further enhance the independent innovation capability of the manufacturing industry.

8. Limitations and Further Study

This study constructs a tripartite evolutionary game model of local governments, industrial Internet platforms, and manufacturing enterprises, explores the evolutionary stabilization strategies of each game subject under different circumstances, verifies the validity of the conclusions through simulation analysis, and empirically examines the panel data of 28 provinces in China from 2018 to 2020. It is found that government incentives have a significant impact on the development of industrial Internet platforms and the transformation and innovation of manufacturing enterprises, but the incentive coefficient should not be too high; the level of industrial Internet development and the strength of government support have a significant positive impact on the level of innovation and development of the manufacturing industry, but this impact shows noticeable regional differences. Finally, the above findings provide practical, theoretical guidance for the government to formulate policies to promote the development of the industrial Internet and the transformation and upgrading of the manufacturing industry.

In addition, this study has some limitations. Firstly, this study focuses on the evolutionary game relationship between local governments, industrial internet platforms, and manufacturing enterprises. Still, in the complex actual market situation, industrial internet platforms are a complex network of relationships between the various participants, and in future research, the game relationship between other stakeholders can be taken into account; in addition, this study mainly uses the panel data of Chinese provinces in 2018–2020 for empirical analysis, the sample size is relatively small, and the role of the relationship between the parties may be affected by the market environment and policy making in different countries; therefore, in future research, international related data should be collected more extensively to compare the influence relationship between the participants in various global contexts.

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