sustainability

MDPI

Article

# Evolutionary Game and Numerical Simulation of Enterprises' Green Technology Innovation: Based on the Credit Sales Financing Service of Supply Chain

**Liping Wang [1], Zhijia Wang [2], Lili Tian [2] and Chuang Li [3,*]**

[1] Finance and Economics College, Jimei University, Xiamen 361021, China
[2] School of Business Administration, Henan Polytechnic University, Jiaozuo 454000, China
[3] School of Business Administration, Jimei University, Xiamen 361021, China
* Correspondence: lichuang@jmu.edu.cn

**Abstract:** In the context of economic transformation and ecological civilization construction, breaking financing constraints and carrying out green technology innovation has become an urgent task for enterprises to achieve green and sustainable development in China. As a financing method of the supply chain, can credit sales effectively promote enterprises' green technology innovation? This paper constructs an evolutionary game model between upstream and downstream enterprises. Firstly, the interaction between credit sales and green technology innovation is explored through an evolutionary equilibrium analysis. Secondly, the influencing factors of credit sales and green technology innovation decisions are analyzed through a numerical simulation. The study found that: (1) Under the condition of evolutionary equilibrium, the credit sales of upstream enterprises and the green technology innovation of downstream enterprises can form a virtuous circle mode of "financing—income generation—benefit sharing". That is, a win-win situation can be achieved through the internal circulation of the supply chain. (2) Profit distribution is one of the key issues in the game between upstream and downstream enterprises. The willingness of upstream enterprises to provide credit sales and downstream enterprises to carry out green technology innovation is positively related to the benefits they enjoy from green technology innovation. (3) The supervision cost is an obstacle for upstream enterprises' credit sales. A practical and inexpensive account recovery guarantee mechanism is an effective way to improve the willingness of upstream enterprises to provide credit sales. (4) The government's green subsidy is beneficial to the whole supply chain's "credit sales—green technology innovation" mode, which not only directly stimulates downstream enterprises' green technology innovation but also stimulates upstream enterprises' credit sales through benefit sharing. This paper enriches the relevant research on green technology innovation of the supply chain and provides a reference for green technology innovation and financing interaction between upstream and downstream enterprises.

**Keywords:** green technology innovation; credit sales; evolutionary game; supply chain; numerical simulation



**Citation:** Wang, L.; Wang, Z.; Tian, L.; Li, C. Evolutionary Game and Numerical Simulation of Enterprises' Green Technology Innovation: Based on the Credit Sales Financing Service of Supply Chain. *Sustainability* **2023**, *15*, 702. https://doi.org/10.3390/su15010702

Academic Editor: Davide Settembre-Blundo

Received: 30 November 2022
Revised: 25 December 2022
Accepted: 27 December 2022
Published: 30 December 2022



## 1. Introduction

Green technology innovation (GTI) is an inevitable choice with the focus of China's economic development shifting from speed to quality. At the 20th Communist Party of China National Congress held in October 2022, it was proposed that China will comprehensively build a modern socialist country, while "achieving high-quality development" is one of the essential requirements of China's modernization. Moreover, the Chinese government has identified high-quality development as a top national priority. In terms of how to achieve high-quality development, the guideline given by the government is to "accelerate the green transformation of development mode", which means promoting high-quality development with green and low-carbon economic and social development. Many theories and practices have proved that GTI is the main driving force for green development [1,2]. It can promote high-quality economic development, help the country establish a green and low-carbon economic system, and help enterprises gain core competitiveness and achieve long-term growth [3–5]. However, GTI is a high-risk project with high investment and a long period of time, and there are many obstacles in the enterprises' implementation process [6]. Therefore, how to identify and remove the obstacles to enterprises' GTI has aroused widespread concerns and discussion among the government and scholars.

In terms of breaking the financing dilemma, the diversified development of financial structures benefits enterprises carrying out GTI to achieve high-quality development which is friendly to the environment [7]. The government, academia, and other stakeholders have made many efforts to enrich the financing channels of enterprises. Taking Latin America as an example, since 1990, international aid agencies, governments, banks, and non-governmental organizations have provided many fiscal policies to encourage enterprises to carry out cleaner production, such as "*Pathways to Cleaner Production in the Americas*", a multinational project enabling professionals and SME managers to promote GTI [8]. China launched green credit in 2013 to strengthen the credit support of banks in the fields of pollution prevention, energy conservation, and environmental protection [9]. Further, in 2019, China issued the *"Guiding Opinions on Building a Market-Oriented GTI System"*, which clearly stated that it is necessary to guide banking financial institutions to actively strengthen the support for GTI. It encourages GTI enterprises to use domestic and foreign markets for listing and financing [10]. In short, the continuous enrichment of green financial reform measures, such as green credit and green bonds, provides a solid financial guarantee for enterprises to implement GTI. Since COVID-19, most countries have been experiencing frequent full or partial lockdowns. Reduced economic activity and traffic restrictions have optimized the environment but have inevitably hindered and worsened the financing environment for businesses [11,12]. In this context, it is difficult for enterprises with limited access to the capital market to meet the funding gap for GTI through traditional bank loans, listing financing, and other means. With the recovery of China's economy, the global economy is gradually improving [13]. It has important value for enterprises' GTI to solve the financing dilemma by expanding informal financing channels.

A credit sale is a financing method for supply chain enterprises. Its decision-making process is an interest game between upstream and downstream enterprises, and it is difficult to become a fixed financing channel due to its great uncertainty. To improve the stability of credit sales and make them a stable source of funds for GTI, it is necessary to discuss the following issues intensely: When are upstream enterprises willing to provide credit sales to GTI enterprises? What factors will affect the decision results of supply chain enterprises' credit sales and GTI? Therefore, this paper constructs an evolutionary game model between upstream and downstream enterprises and analyzes the evolutionary stability of credit sales and GTI under different benefit scenarios. Combined with the numerical simulation, this paper analyzes the influence of contribution income, supervision cost, and green subsidy on the decision results of credit sales and GTI. The main contributions of this paper are as follows: (1) Innovation in research perspectives. Currently, the research on credit sales mostly treats problems from the perspective of upstream enterprises to ensure the normal operation and income of their credit sales activities. This paper takes the downstream enterprises that obtain credit funds as a foothold and focuses on how the downstream enterprises can urge the upstream enterprises to provide credit sales for their GTI. (2) Innovation in research content. The past research on credit sales mostly focuses on how to improve the activity itself to ensure the interests of enterprises providing credit sales, rarely as a fixed financing channel for enterprises' economic activities. This paper seeks to determine the method of obtaining upstream enterprises' credit sales through game research to take credit sales as a stable financing channel for GTI activities. (3) Innovation in research methods. Scholars mostly use static analysis methods such as empirical analysis to study the financing dilemma of enterprises' GTI, ignoring the dynamic changes among subjects. This paper uses the evolutionary game and numerical simulation to dynamically analyze the evolution process of the decision of enterprises' credit sales and GTI. It provides a more specific research framework for solving the financing dilemma of enterprises' GTI.

This paper is organized as follows: Section 2 is the literature review. Section 3 is the evolutionary game model. Section 4 is the evolutionary equilibrium analysis. Section 5 is the numerical simulation. Section 6 is the conclusion, policy implications, limitations, and future research methods.

## 2. Literature Review

### 2.1. Research on Financing and Enterprises' GTI

Obtaining long-term financial support is important for enterprises to continue carrying out GTI [14,15]. Due to the high investment needs for GTI, enterprises often cannot provide all the working capital for the activity and require additional funds [16]. Ghisetti and Montresor [17] surveyed 2000 European SMEs and confirmed the necessity of financing in the circular economy. Financing constraints directly restrict enterprises' GTI and weaken environmental regulations' driving effect on enterprises' GTI [18,19]. Chen et al. [20] took Chinese enterprises as a sample. They confirmed that behaviors that deteriorate the financing environment, such as local governments' high debt, increase enterprises' financing costs. To effectively alleviate financing constraints and promote funds flow into green industries, countries have introduced a series of green financial policies. Irfan et al. [21] argued that green finance policy affects enterprises' GTI by optimizing industrial structure and promoting competitive growth and R&D investment. In addition, the allocation effect of credit resources generated by green financial policies helps to guide the financial resources flow from heavily polluting industries to green industries [22]. This resource flow forces polluting enterprises to carry out GTI by easing green industries' financing constraints and increasing polluting enterprises' financing costs [23]. In terms of financing channels, Liu and Chu [24] pointed out that green financing channels include corporate self-financing, banks, government financial funds, bonds, stocks, venture capital, private placement, and international clean development mechanism funds. Bank loans are the main source of funds for enterprises' green production and innovation activities [25]. Li et al. [26] found that bank loans and government subsidies have a significant threshold effect on the effectiveness of cleaner production. That is, not all enterprises can benefit from both sources of financing. Opening and utilizing non-bank financing channels is necessary to promote SMEs' financing performance [27]. Diversified financing channels such as green bonds, emission rights-based lending, and P2P have eased the constraints of green financing, thereby promoting enterprises' GTI [28–30]. Digital finance, an emerging financing tool developed with internet technology, has the advantages of speed, efficiency, and low-cost. It can effectively alleviate financing constraints and financing inequality, which has become an important driving force for GTI [31,32]. Li et al. [33] found that digital finance has a poor green promotion effect in private enterprises, economically underdeveloped areas, and low-pollution industries. Yu et al. [34] also believed that private enterprises are more vulnerable to financing constraints than state-owned enterprises. Although financial policies can effectively alleviate the financing constraints of GTI in general, private enterprises are less likely to obtain green financing. So, it is necessary to explore ways to improve private enterprises' access to green financing from various aspects. To this end, the General Office of the State Council of China issued the *"Guiding Opinions on Actively Promoting Supply Chain Innovation and Application"* in October 2017 [35]. The opinion pointed out that enterprises in the supply chain can achieve financing through mutual investment, which provides a new path for solving financing constraints. Dong et al. [36] and Roh et al. [37] took supply chain enterprises in China and South Korea as samples, respectively. They confirmed the positive role of supply chain cooperation in GTI.

### 2.2. Research on Credit Sales

Supply chain enterprises have many investment and financing methods, such as accounts receivable, inventory pledges, and prepayment financing [38]. This paper focuses on the supply chain's credit sales between upstream and downstream enterprises. Credit sales have a long history and is the product of the development of commodity circulation. Taking credit sales as a financing channel is aimed at different subjects. For sellers, credit sales are a marketing strategy. For buyers, they are a channel for obtaining financing [39]. According to Demica, a world-renowned electronic platform provider for supply chain finance, in developed countries, supply chain finance has long been an important financing channel for SMEs [40]. According to the Prospective Industry Research Institute, China's enterprises using supply chain financing only account for 30% of the respondents [41], and so there is ample space for China's supply chain finance [42]. The key factors that affect supply chain enterprises choosing credit sales from various financing channels include financing cost, order quantity, inventory, and profit distribution [8,43,44]. Chen et al. [45] pointed out a significant positive correlation between national ownership and trade credit, and the proportion of trade credit is higher in countries with underdeveloped financial markets. A survey conducted by Murro and Peruzzi [46] with a sample of Italian manufacturing enterprises showed that maintaining close and long-term relationships with lending banks or enterprises is associated with obtaining trade loans. With the development of commercial credit, credit sales generally exist in transactions between upstream and downstream enterprises, and their role in financing between supply chain enterprises has gradually increased [47]. On the one hand, credit sales in the supply chain expand upstream enterprises' sales scale, and on the other hand, ease downstream enterprises' financial pressure [48]. Wu et al. [49] constructed a low-carbon supply chain between manufacturers and retailers and compared the profits of the supply chain under three modes: no financing, trade credit financing, and bank credit financing. The results show that trade credit financing is the most profitable in the supply chain. Credit sales boost supply chain business by reducing costs and order cancellation rates, ultimately enabling supply chain enterprises to gain more profits [50–52]. The supply chain game model constructed by Aljazzar et al. [53] showed that credit sales not only increase the supply chain's economic performance but also optimize environmental performance. Yang and Lin [54] took an automobile enterprise in southwest China as an example to verify the positive effect of supply chain credit sales on GTI performance. They argued that supply chain collaboration is a core component of GTI. Of course, credit sales are not a perfect financing method. Due to the imperfect internal management mechanism and the lack of an effective risk management system, the problem of arrears between enterprises caused by credit sales is serious [55]. To summarize, credit sales are a financing method for interaction between upstream and downstream enterprises. How to promote enterprises' GTI through credit sales is a subject worth studying.

Based on the above analysis, this paper starts with credit sales and establishes an evolutionary game model of supply chain enterprises' GTI to explore the stable relationship between both parties. It provides new ideas for supply chain enterprises to open financing channels for GTI.

## 3. Evolutionary Game Model

This paper uses the evolutionary game model to analyze the strategy selection of GTI and the supply chain's credit sales behavior of upstream and downstream enterprises to provide a new financing channel for GTI.

### *3.1. Problem Descriptions and Assumptions*

This paper considers the supply chain composed of upstream suppliers and downstream manufacturers, in which upstream suppliers can or cannot provide raw materials with downstream manufacturers by credit sales and downstream manufacturers can or cannot carry out GTI. On the supplier side, there are three disadvantages of providing credit sales: ① There is a risk of bad debts. ② In order to reduce the risk of bad debts, some supervision measures should be taken for downstream enterprises. ③ The unpaid funds on credit sales and the supervision cost will lessen the liquidity, and excessive credit sales may cause losses to the enterprise's other economic activities. There are two advantages of providing credit sales: ① The successful sales of products increase the operating income. ② Upstream suppliers can obtain a shared payment if downstream enterprises carry out GTI. These advantages and disadvantages are not inevitable but probabilistic events with uncertainties. Moreover, these uncertainties are not controlled by upstream enterprises but have a great relationship with downstream manufacturers. Regarding downstream manufacturers, the benefits of GTI are as follows: ① Obtaining green benefits. ② Obtaining government subsidies. ③ Improving competitiveness. The difficulties in carrying out GTI are: ① High R&D costs of GTI. ② It is not necessarily possible to obtain credit sales. ③ Other financing costs. The difficulty of downstream enterprises lies in whether they can obtain low-cost financing, such as credit sales, to ensure the profitability of GTI. Similarly, this difficulty is not completely controlled by downstream manufacturers, but largely depends on upstream suppliers. From the above analysis, the decision for credit sales and GTI require many interested negotiations between upstream and downstream enterprises. This process of continuous trials can be discussed by evolutionary game. Evolutionary game is developed from game theory. Unlike traditional game theory, evolutionary game theory does not require both parties to be completely rational but to have limited rationality. The final equilibrium strategy results from continuous learning rather than a decision. That is, equilibrium is a dynamically adjustable learning process [56,57]. The evolutionary game is widely used in the study of supply chain enterprise problems [58–60]. Based on this, this paper makes the following basic assumptions about the supply chain participants.

In this paper, we assume that the upstream and downstream enterprises of the supply chain are respectively upstream supplier A and downstream manufacturer B (for convenience, the following are collectively referred to as Enterprise A and Enterprise B), and both subjects have bounded rationality. Enterprise A is the party that may provide a credit sales financing service, and Enterprise B is the party that accepts the credit sales financing service, and the credit sales fund is used for GTI. Enterprise A can choose to provide a credit sales financing service to Enterprise B or not. Therefore, we assume that H1 = {credit sales, non-credit sales} is the policy set of Enterprise A. Enterprise B can choose to carry out GTI to improve production efficiency and reduce environmental governance costs, or it can choose not to carry out GTI. Therefore, H2 = {innovation, no innovation} is the strategy set of Enterprise B. We assume that under the original stable production mode, the current earnings of Enterprise A and B are $m$ and $n$, respectively. Considering that the problems referred to are economic benefits or costs, the values of variables in this paper are all positive unless otherwise specified.

First of all, the probability of a credit sales service provided by Enterprise A is $x$, and the probability of a credit sales service not provided is $1 - x$. The probability of Enterprise B choosing to carry out GTI is $y$, and the probability of Enterprise B choosing not to carry out GTI is $1 - y$, and there is $0 \leq x \leq 1, 0 \leq y \leq 1$.

Secondly, we assume the profit and loss of upstream company A in the credit sales service. On the premise of Enterprise B's GTI, sharing the revenue of Enterprise A obtained by the credit sales service is $s$. Due to the technology spillover effect, even if Enterprise A does not provide credit sales, it can still get the spillover benefits of Enterprise B's GTI. Here, we assume that it is $\lambda s$ [61], and there is $0 < \lambda < 1$. $c_1$ is the loss caused to Enterprise A by the default risk of credit sales where Enterprise A provides a credit sales financing service to Enterprise B. The regulatory cost of Enterprise A is to avoid moral hazard caused by information asymmetry in credit sales financing services, $c_2$. After Enterprise A makes a credit sales decision, the impact on its enterprise caused by the slow flow of capital is $c_3$ [62]. It should be noted that the size relationship between $S$ and $c_i$ ($i$ = 1, 2, 3) is uncertain, which will be discussed in the following text according to different situations.

Finally, we assume the gains and losses of downstream Enterprise B in the credit sales service. $d_1$ is the cost of Enterprise B's GTI excluding the financing cost. When Enterprise B obtains financing through credit sales, its financing cost is negligible. $d_2$ is the financing cost of Enterprise B to obtain GTI from non-credit sales channels (such as bank loans, etc.) [63]. Then, the comprehensive cost of Enterprise B's GTI through non-credit sales channel financing is $d_1 + d_2$. $\mu n$ is the new income of Enterprise B for green technological innovation, where there is $0 < \mu \leq 1$. The government's green subsidy or reward to Enterprise B is $e$, and generally, the state will provide certain rewards to encourage enterprises to carry out GTI actively [64]. After Enterprise B carries out GTI, it can enhance the enterprise's competitiveness and the supply chain [65], and the enhancement of competitiveness leads to the increase of $p$. The following paper will discuss the relationship between the variables in detail. The symbols and meanings of the above parameters are shown in Table 1.

**Table 1.** Parameters description.

| Parameters | Description |
|---|---|
| $m$ | Current earnings of Enterprise A. |
| $n$ | Current earnings of Enterprise B. |
| $s$ | Shared revenue of GTI gained by Enterprise A when providing a credit sales service. |
| $\lambda$ | The percentage of technology spillover income derived from Enterprise A not providing credit sales services. |
| $c_1$ | Loss caused to Enterprise A by default risk of credit sales. |
| $c_2$ | The supervision cost of credit sales paid by Enterprise A. |
| $c_3$ | The negative impact of Enterprise A's provision of credit sales on its capital operation. |
| $d_1$ | Cost of GTI in Enterprise B. |
| $d_2$ | Enterprise B obtains financing costs of GTI from non-credit sales channels. |
| $\mu$ | The new revenue multiple brought by GTI to Enterprise B. |
| $e$ | Government green subsidies or incentives for Enterprise B. |
| $p$ | The enhancement of Enterprise B's competitiveness after GTI. |

### 3.2. Model Construction

Based on the above assumptions and variables, when Enterprise A provides a credit sales service, and Enterprise B chooses GTI, the earnings of Enterprise A and B are: $m + s - c_1 - c_2 - c_3$, $(1 + \mu)n + e + p - d_1$. When Enterprise A provides a credit sales service, and Enterprise B does not carry out GTI, the earnings of Enterprise A and B are $m - c_1 - c_2 - c_3$, $n$. When Enterprise A does not provide a credit sales service, and Enterprise B carries out GTI, the earnings of Enterprise A and B are $m + \lambda s$, $(1 + \mu)n + e + p - d_1 - d_2$. When Enterprise A does not provide a credit sales service, and Enterprise B does not carry out GTI, the earnings of Enterprise A and B are $m$, $n$. Therefore, the earnings of Enterprise A and Enterprise B are shown in Table 2.

**Table 2.** The return matrix of Enterprise A and Enterprise B.

| Enterprise B / Enterprise A | Innovation | No Innovation |
|---|---|---|
| Credit sales | $(m + s - c_1 - c_2 - c_3, (1 + \mu)n + e + p - d_1)$ | $(m - c_1 - c_2 - c_3, n)$ |
| Non-credit sales | $(m + \lambda s, (1 + \mu)n + e + p - d_1 - d_2)$ | $(m, n)$ |

## 4. Evolutionary Equilibrium Analysis

### 4.1. Equilibrium Analysis

Suppose that $u_{11}$ is the expected earnings of upstream Enterprise A of the supply chain when it chose to provide a credit sales service strategy, $u_{12}$ is the expected earnings of upstream Enterprise A of the supply chain when it chose not to provide a credit sales service strategy, and $u_1$ is the average expected earnings of Enterprise A, then there is:

$$u_{11} = y(m + s - c_1 - c_2 - c_3) + (1 - y)(m - c_1 - c_2 - c_3) \quad (1)$$

$$u_{12} = y(m + \lambda s) + (1 - y)m \tag{2}$$

$$u_1 = xu_{11} + (1 - x)u_{12} \tag{3}$$

Suppose that $u_{21}$ is the expected earnings of upstream Enterprise B of the supply chain when it chose to carry out GTI, $u_{22}$ is the expected earnings of upstream Enterprise B of the supply chain when it chose not to carry out GTI, and $u_2$ is the average expected earnings of Enterprise B, then there is:

$$u_{21} = x[(1 + \mu)n + e + p - d_1] + (1 - x)[(1 + \mu)n + e + p - d_1 - d_2] \tag{4}$$

$$u_{22} = xn + (1 - x)n \tag{5}$$

$$u_2 = yu_{21} + (1 - y)u_{22} \tag{6}$$

*4.2. Stability Analysis of Equilibrium Points*

The replicator dynamics equation for Enterprise A and Enterprise B is as follows:

$$F(x) = \frac{dx}{dt} = x(u_{11} - u_1) = x(1 - x)(sy - c_1 - c_2 - c_3 - \lambda sy) \tag{7}$$

$$F(y) = \frac{dy}{dt} = y(u_{21} - u_2) = y(1 - y)(\mu n + e + p - d_1 - d_2 + d_2 x) \tag{8}$$

In order to find out the equilibrium points of the evolutionary game, there is: $\frac{dx}{dt} = 0$, $\frac{dy}{dt} = 0$, when $x = 0$, $x = 1$, or $x = 1 - \frac{\mu n + e + p - d_1}{d_2}$, the proportion of Enterprise A providing credit sales services is stable. When $y = 0$, $y = 1$, or $y = \frac{c_1 + c_2 + c_3}{(1 - \lambda)s}$, the proportion of Enterprise B choosing GTI is stable. Apparently, there are five special equilibrium points, namely (0, 0), (0, 1), (1, 0), (1, 1), and ($x^*$, $y^*$), and then there is:

$$\begin{cases} x^* = 1 - \frac{\mu n + e + p - d_1}{d_2} \\ y^* = \frac{c_1 + c_2 + c_3}{(1 - \lambda)s} \end{cases} \tag{9}$$

The above equilibrium point is not necessarily the point of the evolutionary stability strategy (EES). The key is whether these equilibrium points resist a certain amount of deviation. Therefore, the Jacobian matrix of the replicating dynamic equations is constructed to analyze the stability of the equilibrium point. The Jacobian matrix $H$ is as follows:

$$H = \begin{bmatrix} (1 - 2x)(sy - c_1 - c_2 - c_3 - \lambda sy) & x(1 - x)(s - \lambda s) \\ d_2 y(1 - y) & (1 - 2y)(\mu n + e + p - d_1 - d_2 + d_2 x) \end{bmatrix} \tag{10}$$

The trace of the matrix is:

$$tr(H) = (1 - 2x)(sy - c_1 - c_2 - c_3 - \lambda sy) + (1 - 2y)(\mu n + e + p - d_1 - d_2 + d_2 x) \tag{11}$$

Each equilibrium point is put into Equation (10) of the Jacobian matrix, and the matrix's corresponding trace and determinant values are calculated, as shown in Table 3.

**Table 3.** The Jacobian matrix corresponds to the determinant and trace of the equilibrium point.

| Equilibrium | The Sign of the Determinant | The Sign of the Trace of the Matrix $H$ |
|---|---|---|
| $(0, 0)$ | $-(c_1 + c_2 + c_3)(\mu n + e + p - d_1 - d_2)$ | $-(c_1 + c_2 + c_3) + (\mu n + e + p - d_1 - d_2)$ |
| $(0, 1)$ | $-(s - c_1 - c_2 - c_3 - \lambda s)(\mu n + e + p - d_1 - d_2)$ | $(s - c_1 - c_2 - c_3 - \lambda s) - (\mu n + e + p - d_1 - d_2)$ |
| $(1, 0)$ | $(c_1 + c_2 + c_3)(\mu n + e + p - d_1)$ | $(c_1 + c_2 + c_3) + (\mu n + e + p - d_1)$ |
| $(1, 1)$ | $(s - c_1 - c_2 - c_3 - \lambda s)(\mu n + e + p - d_1)$ | $-(s - c_1 - c_2 - c_3 - \lambda s) - (\mu n + e + p - d_1)$ |
| $(x^*, y^*)$ | T | 0 |

Then there is:

$$T = \frac{(\mu n + e + p - d_1 - d_2)(c_1 + c_2 + c_3)(\mu n + e + p - d_1)[(1-\lambda)s - c_1 - c_2 - c_3]}{d_2 s(1-\lambda)} \quad (12)$$

To sum up, the different values of each parameter will lead to different evolutionary stability strategies, and there are the following six scenarios.

Case 1: If $(\mu n + e + p) > (d_1 + d_2)$, that is, when the newly added comprehensive benefit of the GTI of Enterprise B is greater than the comprehensive cost; when $[(1-\lambda)s] < (c_1 + c_2 + c_3)$, in other words, when Enterprise A provides a credit sales service on the premise of GTI by Enterprise B, the new shared revenue is less than the cost loss. The stability of the equilibrium points is shown in Table 4.

**Table 4.** The stability of the equilibrium in Case 1.

| Equilibrium | The Sign of the Determinant | The Sign of the Trace of the Matrix *H* | Local Stability |
|---|---|---|---|
| (0, 0) | − | * | Saddle point |
| (0, 1) | + | − | ESS |
| (1, 0) | + | + | Instability point |
| (1, 1) | − | * | Saddle point |
| $(x^*, y^*)$ | − | 0 | Saddle point |

Note: * indicates that the value of the symbol is uncertain.

Case 2: If $(\mu n + e + p) > (d_1 + d_2)$, that is, when the newly added comprehensive benefit of Enterprise B's GTI is greater than the comprehensive cost; when $[(1-\lambda)s] > (c_1 + c_2 + c_3)$, in other words, when Enterprise A provides a credit sales service on the premise of GTI by Enterprise B, the newly increased shared revenue is greater than the resulting cost loss. The stability of the equilibrium points is shown in Table 5.

**Table 5.** The stability of the equilibrium in Case 2.

| Equilibrium | The Sign of the Determinant | The Sign of the Trace of the Matrix *H* | Local Stability |
|---|---|---|---|
| (0, 0) | − | * | Saddle point |
| (0, 1) | − | * | Saddle point |
| (1, 0) | + | + | Instability point |
| (1, 1) | + | − | ESS |
| $(x^*, y^*)$ | + | 0 | — |

Note: * indicates that the value of the symbol is uncertain.

Case 3: When $(\mu n + e + p) < (d_1 + d_2)$ and $(\mu n + e + p) < d_1$, that is, when Enterprise B's new comprehensive income from GTI is less than the comprehensive cost; if $[(1-\lambda)s] < (c_1 + c_2 + c_3)$, in other words, when Enterprise A provides a credit sales service on the premise of GTI by Enterprise B, the newly increased shared revenue is less than the resulting cost loss. The stability of the equilibrium points is shown in Table 6.

**Table 6.** The stability of the equilibrium in Case 3.

| Equilibrium | The Sign of the Determinant | The Sign of the Trace of the Matrix *H* | Local Stability |
|---|---|---|---|
| (0, 0) | + | − | ESS |
| (0, 1) | − | * | Saddle point |
| (1, 0) | − | * | Saddle point |
| (1, 1) | + | + | Instability point |
| $(x^*, y^*)$ | − | 0 | Saddle point |

Note: * indicates that the value of the symbol is uncertain.

Case 4: When $d_1 < (\mu n + e + p) < (d_1 + d_2)$, that is, when Enterprise B's new comprehensive revenue from GTI is greater than the cost and less than the comprehensive cost; if $[(1-\lambda)s] < (c_1 + c_2 + c_3)$, in other words, when Enterprise A provides a credit sales service on the premise of GTI by Enterprise B, the newly increased shared revenue is less than the cost loss. The stability of the equilibrium points is shown in Table 7.

**Table 7.** The stability of the equilibrium in Case 4.

| Equilibrium | The Sign of the Determinant | The Sign of the Trace of the Matrix *H* | Local Stability |
|---|---|---|---|
| (0, 0) | + | − | ESS |
| (0, 1) | − | * | Saddle point |
| (1, 0) | + | + | Instability point |
| (1, 1) | − | * | Saddle point |
| $(x^*, y^*)$ | + | 0 | — |

Note: * indicates that the value of the symbol is uncertain.

Case 5: When $(\mu n + e + p) < (d_1 + d_2)$ and $(\mu n + e + p) < d_1$, that is, when Enterprise B's new comprehensive income from GTI is less than the cost; when $[(1-\lambda)s] > (c_1 + c_2 + c_3)$, in other words, when Enterprise A provides a credit sales service on the premise of GTI by Enterprise B, the newly increased shared revenue is greater than the resulting cost loss. The stability of the equilibrium points is shown in Table 8.

**Table 8.** The stability of the equilibrium in Case 5.

| Equilibrium | The Sign of the Determinant | The Sign of the Trace of the Matrix *H* | Local Stability |
|---|---|---|---|
| (0, 0) | + | − | ESS |
| (0, 1) | + | + | Instability point |
| (1, 0) | − | * | Saddle point |
| (1, 1) | − | * | Saddle point |
| $(x^*, y^*)$ | + | 0 | — |

Note: * indicates that the value of the symbol is uncertain.

Case 6: When $d_1 < \mu n + e + p < (d_1 + d_2)$, that is, when the newly added comprehensive benefit of the GTI of Enterprise B is greater than the cost but less than the comprehensive cost; when $[(1-\lambda)s] > (c_1 + c_2 + c_3)$, in other words, when Enterprise A provides a credit sales service on the premise of GTI by Enterprise B, the newly increased shared revenue is greater than the resulting cost loss. The stability of the equilibrium points is shown in Table 9.

**Table 9.** The stability of the equilibrium in Case 6.

| Equilibrium | The Sign of the Determinant | The Sign of the Trace of the Matrix *H* | Local Stability |
|---|---|---|---|
| (0, 0) | + | − | ESS |
| (0, 1) | + | + | Instability point |
| (1, 0) | + | + | Instability point |
| (1, 1) | + | − | ESS |
| $(x^*, y^*)$ | − | 0 | Saddle point |

According to the above analysis, phase diagrams of six cases can be drawn, as shown in Figure 1.

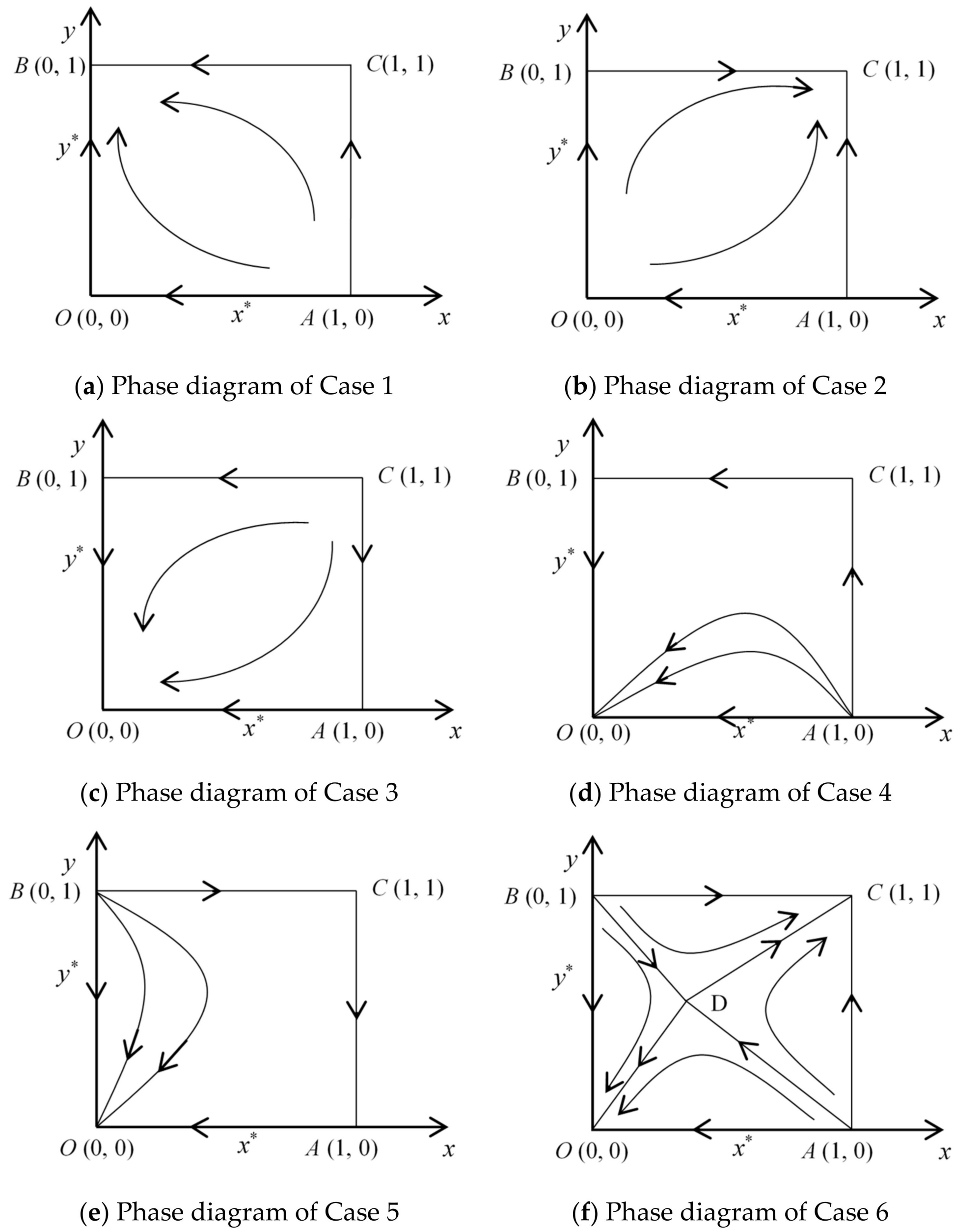



**Figure 1.** Phase diagram of system evolution under six conditions.

*4.3. Results*

According to the stable equilibrium point and dynamic evolution game phase diagram, the following analysis results can be obtained:

(1) For Enterprise B, if the new comprehensive benefit gained from GTI is greater than the comprehensive cost, that is, when $(\mu n + e + p) > (d_1 + d_2)$, Enterprise B will choose the GTI strategy. Even if it cannot get the credit sales financing service from Enterprise A, the upstream of the supply chain, it will not affect the innovation choice of Enterprise B. When Enterprise B chooses to carry out GTI, Enterprise A's shared revenue difference between providing credit services and not providing credit services is less than the cost loss caused by its provision of credit sales, then Enterprise A will not choose to provide a credit sales service to Enterprise B, and there is $[(1 - \lambda)s] < (c_1 + c_2 + c_3)$. At this time, as shown in Figure 1a, the evolutionary stability point is (0, 1). The evolutionary stability strategy provides Enterprise A with no credit sales service and Enterprise B with GTI.

(2) If Enterprise B chooses to carry out GTI, and the newly added comprehensive benefit is greater than the comprehensive cost, that is, when $(\mu n + e + p) > (d_1 + d_2)$, Enterprise B will choose to carry out GTI, which is not directly related to whether Enterprise A provides a credit sales financing service. However, when Enterprise B chooses GTI, and Enterprise A's shared revenue difference between providing a credit sales service and not providing a credit sales service is greater than the cost loss caused by providing a credit sales service, Enterprise A is willing to provide a credit sales service to Enterprise B, and there is $[(1-\lambda)s] > (c_1 + c_2 + c_3)$. At this time, the situation is shown in Figure 1b, and the evolutionary stability strategy point is (1, 1). That is, Enterprise A is willing to provide a credit sales service to Enterprise B, and Enterprise B chooses to carry out GTI, which is exactly what the research expects.

(3) If the new comprehensive income of Enterprise B for GTI is less than the cost, that is, when $(\mu n + e + p) < d_1$, Enterprise B does not carry out GTI; that is, although Enterprise A in the upstream of the supply chain provides a credit sales financing service, it will not change the selection strategy of Enterprise B. If Enterprise A provides a credit sales service, the newly increased shared revenue is less than the newly increased cost, and Enterprise A will not provide a credit sales service to Enterprise B, and there is $[(1-\lambda)s] < (c_1 + c_2 + c_3)$. At this time, the equilibrium point of the evolutionary game in the system is (0, 0). That is, Enterprise A does not provide a credit sales service, and Enterprise B does not carry out GTI, as shown in Figure 1c, which is the most undesirable scenario in the real world.

(4) If Enterprise B carries out GTI, the new comprehensive revenue is greater than the cost and less than the comprehensive cost. That is, when $d_1 < (\mu n + e + p) < (d_1 + d_2)$, Enterprise B does not carry out GTI, and a financing service alone cannot cover the total innovation cost of Enterprise B. If Enterprise A provides a credit sales service, the newly increased shared revenue is less than the newly increased cost, then Enterprise A will not provide a credit sales service, and there is $[(1-\lambda)s] < (c_1 + c_2 + c_3)$. At this point, the equilibrium point of the evolutionary game existing in the system is (0, 0), as shown in Figure 1d.

(5) If the benefit of Enterprise B's GTI is less than the cost, that is $(\mu n + e + p) < d_1$, Enterprise B does not carry out GTI. That is, because the innovation benefits are too low, Enterprise B's innovation gains are not worth the loss. If Enterprise A provides a credit sales service, the newly increased shared revenue is greater than the newly increased cost. That is, when $[(1-\lambda)s] > (c_1 + c_2 + c_3)$, Enterprise A will provide a credit sales service. Due to the non-innovation of Enterprise B, Enterprise A cannot get innovation benefits, so the game stability point of the system is (0, 0), as shown in Figure 1e.

(6) If Enterprise B carries out GTI, the new comprehensive revenue is greater than the cost and less than the comprehensive cost. That is, when $d_1 < (\mu n + e + p) < (d_1 + d_2)$ and if Enterprise A provides a credit sales service, the newly increased shared revenue is greater than the newly increased cost; that is, when $[(1-\lambda)s] > (c_1 + c_2 + c_3)$, the game stability points of the system are (0, 0) and (1, 1). The results are as follows: Enterprise A does not provide a credit sales service, and Enterprise B does not carry out GTI; enterprise A provides a credit sales service, and Enterprise B carries out GTI, as shown in Figure 1f. The change of the value of parameters will affect the evolution results, so it is necessary to conduct further analysis.

### *4.4. Discussion*

For the sixth case, it is advisable to set the area of quadrilateral ACBDA as $R_1$ and the area of quadrilateral OADBO as $R_2$, then $R_1$ and $R_2$ are expressed as:

$$R_1 = 1 - \frac{1}{2}(x^* + y^*) = 1 - \frac{1}{2}\left(\frac{-\mu n - e - p + d_1 + d_2}{d_2} + \frac{c_1 + c_2 + c_3}{(1-\lambda)s}\right) \tag{13}$$

$$R_2 = \frac{1}{2}(x^* + y^*) = \frac{1}{2}\left(\frac{-\mu n - e - p + d_1 + d_2}{d_2} + \frac{c_1 + c_2 + c_3}{(1-\lambda)s}\right) \tag{14}$$

The probability that the system converges to (1, 1) is greater than the probability that it converges to (0, 0) when $R_1 > R_2$. The probability that the system converges to (1, 1) is less than the probability that it converges to (0, 0) when $R_1 < R_2$. The probability that the system converges to (1, 1) is equal to the probability that it converges to (0, 0) when $R_1 = R_2$. According to Formulas (13) and (14), the factors affecting and $R_1$ and $R_2$ are $\lambda$, $s$, $\mu$, $n$, $e$, $p$, $d_1$, $d_2$, $c_1$, $c_2$, $c_3$. Therefore, the following results can be obtained through analysis.

(1) $\frac{\partial R_1}{\partial \lambda} = \frac{-2s(c_1+c_2+c_3)}{(2s\lambda-2s)^2} < 0$; in this case, $R_1$ is the subtraction function of $\lambda$, and the larger the proportion of spilled benefits of GTI that Enterprise A can obtain by not providing a credit sales service, the smaller the area of $R_1$ is. That is, the smaller the probability of system convergence to the point (1, 1). $\frac{\partial R_1}{\partial \mu} = \frac{n}{2d_2} > 0$; in this case, $R_1$ is the increasing function of $\mu$, and the larger the multiple of $\mu$, the larger the area of $R_1$. That is, the greater the probability that the system converges to the point (1, 1).

(2) $\frac{\partial R_1}{\partial n} = \frac{\mu}{2d_2} > 0$; in this case, $R_1$ is the increasing function of $n$, and the larger the current income of Enterprise B is, the larger the area of $R_1$ is. That is, the greater the probability that the system converges to the point (1, 1). $\frac{\partial R_1}{\partial s} = \frac{-(c_1+c_2+c_3)(2\lambda-2)}{(2\lambda s-2s)^2}$, as $0 < \lambda < 1$, so $\frac{\partial R_1}{\partial s} > 0$, then $R_1$ is the increasing function of $s$, and the greater the shared benefit of GTI that Enterprise A can obtain by providing a credit sales service, the larger the area of t is. That is, the greater the probability that the system converges to the point (1, 1). $\frac{\partial R_1}{\partial e} = \frac{\partial R_1}{\partial p} = \frac{1}{2d_2} > 0$; in this case, $R_1$ is the increasing function of $e$ and $p$, and the larger the government subsidies and incentives to Enterprise B for GTI, the larger the area of $R_1$ is. GTI leads to the enhancement of competitiveness, and the greater the benefit brought to Enterprise B, the larger the area of m is. That is, the greater the probability that the system converges to the point (1, 1).

(3) $\frac{\partial R_1}{\partial d_1} = -\frac{1}{2d_2} < 0$; in this case, $R_1$ is the subtraction function of $d_1$, and the larger the cost of GTI (excluding the financing cost) of Enterprise B, the smaller the area of $R_1$. That is, the smaller the probability that the system converges to the point (1, 1). $\frac{\partial R_1}{\partial d_2} = \frac{-(\mu n+e+p-d_1)}{2{d_2}^2}$, since $(\mu n + e + p - d_1) > 0$, so $\frac{\partial R_1}{\partial d_2} < 0$; in this case, $R_1$ is the subtraction function of $d_2$. The larger the financing cost of the non-credit sales channel for the GTI of Enterprise B, the smaller the area of $R_1$. That is, the smaller the probability that the system converges to the point (1, 1).

(4) $\frac{\partial R_1}{\partial c_1} = \frac{\partial R_1}{\partial c_2} = \frac{\partial R_1}{\partial c_3} = -\frac{1}{2s(1-\lambda)} < 0$ $(0 < \lambda < 1)$; in this case, $R_1$ is the subtraction function of $c_i$ ($i$ = 1, 2, 3), and the greater the default loss $c_1$ faced by Enterprise A, the greater the regulatory cost $c_2$, and the greater the negative impact on Enterprise A after providing a credit sales service, the smaller the area of $R_1$. That is, the smaller the probability that the system converges to the point (1, 1).

## 5. Numerical Simulation

According to the analysis results of the above model, the evolution results of Enterprise A and Enterprise B may be (non-credit sales, innovation), (credit sales, innovation), and (non-credit sales, no innovation). The final equilibrium strategy of both sides of the game depends on the specific value of the matrix variable affecting their returns, and the change of the value of the variable will affect the strategic equilibrium state. In order to deeply explore the specific impact of variables in the income matrix on credit sales financing services and GTI behavior of upstream and downstream enterprises in the supply chain, this paper carried out a numerical simulation based on MATLAB R2018a software, which mainly analyzed the evolutionary stability strategy under different conditions and the influence of the value of variables on the behavior of both sides of the game.

### *5.1. Initial Conditions and Variable Assignment Simulation*

In the simulation graph, the horizontal axis represents time, represented by t, and the vertical axis represents the probability of the evolution of Enterprise A's behavior to provide a credit sales service or Enterprise B's behavior evolution to select GTI, denoted as q. With reference to the evolutionary game model of Sun and Zhang [66] and Zhang et al. [67], the simulation time range is determined as 0~10, the unit is year, and the step size is 0.1.

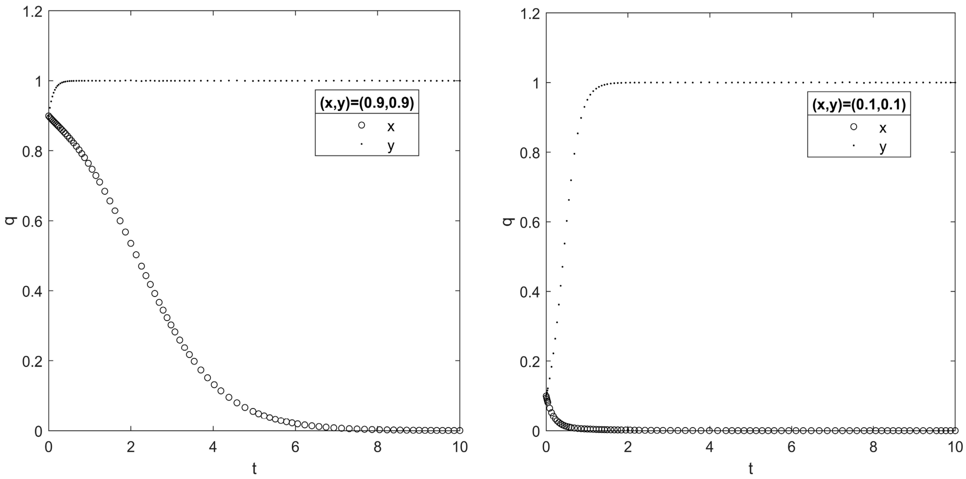
The relationship between the parameters is set as follows: The initial data of credit sales refer to the research of Cui et al. [68], Liu and Peng [69], and Zhou et al. [70]. In order to make the analysis simple, the current profit value $s$ of Enterprise A is preliminarily set to be 10 units, and the default loss $c_1$, supervision cost $c_2$, and the impact of credit sales on its $c_3$ are all smaller than the current income, and the appropriate value is set. The determination of the initial data related to green technology innovation is based on the research of Zhang et al. [71], Chen et al. [72], and Li and Gao [73]. The current profit value $n$ of Enterprise B is set as 20 units, government subsidy $e$ for GTI, and supply chain enhancement revenue $p$ after GTI is generally lower than the cost of GTI. Since this paper is mainly a numerical simulation, the numerical values of all parameters do not represent the real values, but the relationship between them satisfies the basic logic of the real situation.

(1) The parameter satisfies Case 1.

At first, the initial value of the parameters was set referring to the practical situation as follows:

$$\lambda = 0.5,\ \mu = 0.5,\ \ n = 20,\ \ e = 2,\ \ p = 3,\ d_1 = 5,\ d_2 = 5,\ s = 10,\ c_1 = 2,\ c_2 = 3,\ c_3 = 1$$

The MATLAB simulation is conducted based on the above parameter assumptions, and the results are shown in Figure 2. The simulation results show that when the parameters satisfy that the comprehensive benefit of Enterprise B's GTI is greater than its comprehensive cost, the probability of Enterprise B's GTI evolves in the direction of 1. Further, when the parameters satisfy that the newly increased shared revenue of Enterprise A in providing a credit sales service is less than the newly increased cost, the probability that Enterprise A provides a credit sales service evolves in the direction of 0. At the beginning of the evolution, $x = 0.9$, $y = 0.9$, and $x = 0.1$, $y = 0.1$ cases were selected for simulation to analyze the influence of the initial probability of Enterprise A providing a credit sales financing service and Enterprise B carrying out GTI behavior on its evolution results, as show in Panel (a) and (b). The results show that the final equilibrium evolution result does not change except for the evolution speed. In other words, no matter what the initial intention of Enterprise A and Enterprise B is, if the parameters meet the above conditions, the final choice of both sides is stable and unchanged. Therefore, in order to facilitate the analysis, the initial values of $x$ and $y$ are uniformly set as (0.5, 0.5) in the following cases.




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

**Figure 2.** Influence of different initial intentions on the final evolutionary results. (**a**) is the evolution diagram when the initial point is (0.9, 0.9). (**b**) is the evolution diagram when the initial point is (0.1, 0.1).

(2) The parameter satisfies Case 2.

At first, the initial value of the parameters was set referring to the practical situation as follows:

$$\lambda = 0.5,\ \mu = 0.5,\ n = 20,\ e = 2,\ p = 3,\ d_1 = 5,\ d_2 = 5,\ s = 10,\ c_1 = 1,\ c_2 = 1,\ c_3 = 1$$

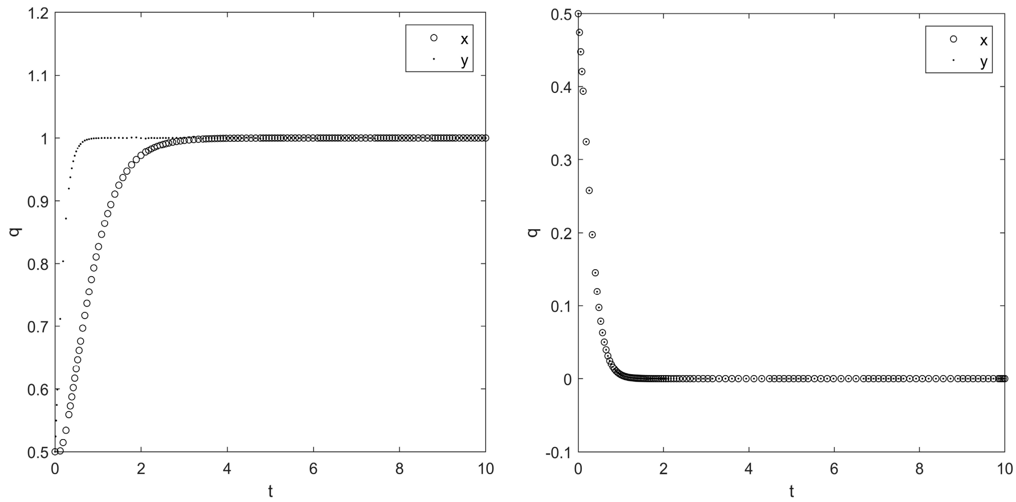
The MATLAB simulation is conducted based on the above parameter assumptions, and the results are shown in Figure 3a. For firms A and B, their combined returns are positive. Therefore, when the benefit of GTI is greater than the cost, and the new revenue generated by credit sales is greater than the new cost, the stabilization strategy of upstream and downstream enterprises in the supply chain is (credit sales, innovation). This situation is also an important embodiment of the GTI credit sales financing mode of supply chain enterprises.

(3) The parameter satisfies Case 3.

At first, the initial value of the parameters was set referring to the practical situation as follows:

$$\lambda = 0.5,\ \mu = 0.05,\ n = 20,\ e = 0,\ p = 3,\ d_1 = 5,\ d_2 = 5,\ s = 10,\ c_1 = 2,\ c_2 = 3,\ c_3 = 1$$

The MATLAB simulation is conducted based on the above parameter assumptions, and the results are shown in Figure 3b. For Enterprise A and Enterprise B, this situation makes the profits of both sides reach the minimum, and the strategy choices are all evolving towards the trend of probability 0. For the supply chain enterprises with the characteristics of "economic man", profit maximization is their ultimate goal. Therefore, when the benefit of GTI is less than the cost and the new revenue generated by credit sales is less than the new cost, the stable strategy of upstream and downstream enterprises in the supply chain is (non-credit sales, no innovation).




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

**Figure 3.** Simulation results of Case 2 and Case 3. (**a**) is the evolution diagram of Case 2. (**b**) is the evolution diagram of Case 3.

(4) The parameter satisfies Case 4.

At first, the initial value of the parameters was set referring to the practical situation as follows:

$$\lambda = 0.5,\ \mu = 0.05,\ n = 20,\ e = 2,\ p = 3,\ d_1 = 5,\ d_2 = 5,\ s = 10,\ c_1 = 2,\ c_2 = 3,\ c_3 = 1$$

The MATLAB simulation is conducted based on the above parameter assumptions, and the results are shown in Figure 4a. The simulation results show that when the parameters satisfy that Enterprise A provides a credit sales service, the newly increased shared revenue is less than the newly increased cost, and the probability that Enterprise A provides a credit sales service evolves in the direction of 0. When the parameters satisfy that the comprehensive benefit of Enterprise B's GTI is greater than its GTI cost and less than its comprehensive cost, the probability of Enterprise B carrying out GTI evolves towards 0. At this time, the stable strategy of upstream and downstream enterprises in the supply chain is (no credit sales, no innovation).

(5) The parameter satisfies Case 5.

At first, the initial value of the parameters was set referring to the practical situation as follows:

$$\lambda = 0.5,\ \mu = 0.05,\ n = 20,\ e = 0,\ p = 3,\ d_1 = 5,\ d_2 = 5,\ s = 10,\ c_1 = 2,\ c_2 = 1,\ c_3 = 1$$

The MATLAB simulation is conducted based on the above parameter assumptions, and the results are shown in Figure 4b. In this case, since the comprehensive benefit of GTI is less than the cost, Enterprise B has an obvious lack of motivation for GTI. For Enterprise A, although the revenue generated by providing a credit sales service is greater than the cost, the premise of this inequality is that Enterprise B makes GTI. Therefore, when Enterprise B does not carry out GTI, the probability of Enterprise A providing a credit sales service is also low, and the final evolution trend is towards the direction of probability 0. At this time, the stability strategy of upstream and downstream enterprises of the supply chain is (no credit sales, no innovation).

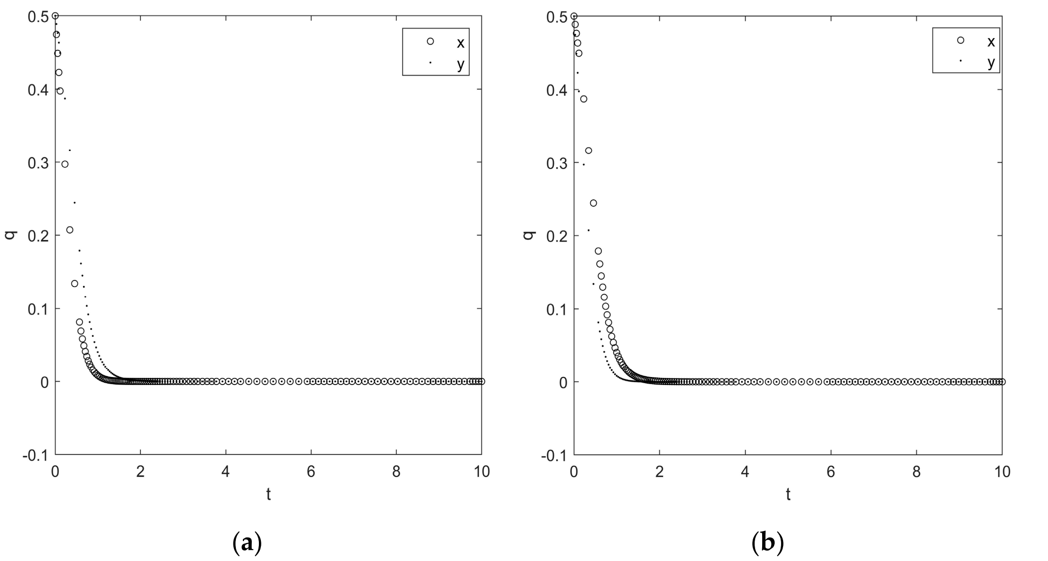



**Figure 4.** Simulation results of Case 4 and Case 5. (**a**) is the evolution diagram of Case 4. (**b**) is the evolution diagram of Case 5.

(6) The parameter satisfies Case 6.

At first, the initial value of the parameters was set referring to the practical situation as follows:

$$\lambda = 0.5,\ \mu = 0.05,\ n = 20,\ e = 2,\ p = 3,\ d_1 = 5,\ d_2 = 5,\ s = 10,\ c_1 = 2,\ c_2 = 1,\ c_3 = 1$$

The MATLAB simulation is conducted based on the above parameter assumptions, and the results are shown in Figure 5a, and on this basis, appropriately increase the value of income variables and reduce the value of cost variables. That is, suppose $\mu$ increases from 0.05 to 0.1 and $s$ from 10 to 20. Meanwhile, $d_1$ and $d_2$ decrease from 5 to 4 and $c_1$ from 2 to 1, respectively. Then, the new parameter value is:

$$\lambda = 0.1,\ \mu = 0.1,\ n = 20,\ e = 2,\ p = 3,\ d_1 = 4,\ d_2 = 4,\ s = 20,\ c_1 = 1,\ c_2 = 1,\ c_3 = 1$$

The MATLAB simulation is conducted based on the above parameter assumptions, and the results are shown in Figure 5b. Thus, in Case 6, the upstream and downstream enterprises of the supply chain have two evolutionary stabilization strategies, namely (non-credit sales, no innovation) and (credit sales, innovation).

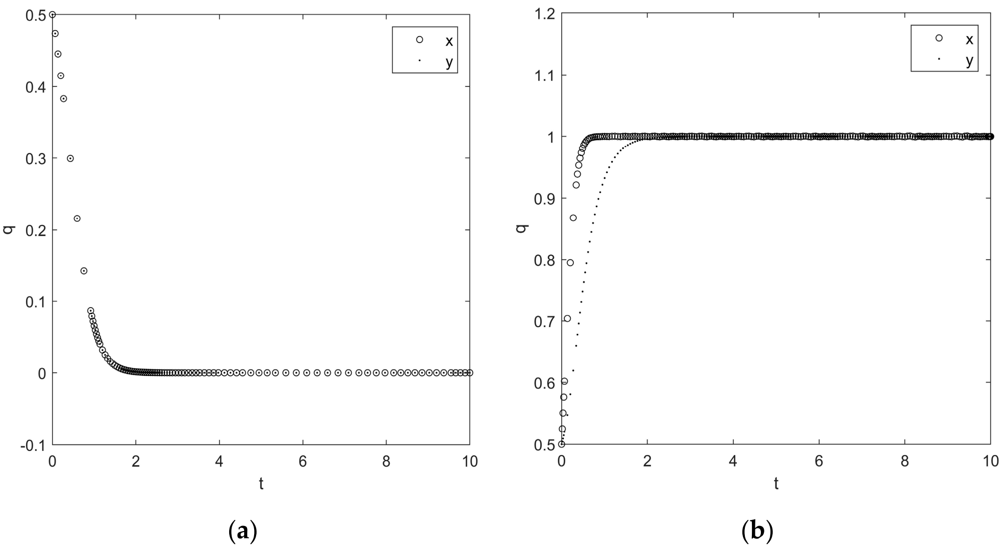



**Figure 5.** Simulation results of Case 6. (**a**) is the first evolution result of Case 6. (**b**) is the second evolution result of Case 6.

*5.2. Influence of Parameters on Simulation Results*

The parameters set in this paper can be divided into two categories: one belongs to the variables affecting Enterprise A, and the other belongs to the variables affecting Enterprise B. In the above six cases, the equilibrium point of Case 1 is (0, 1), and the final choice of Enterprise B is innovation, which meets the research expectation. Therefore, the influence of parameter changes on the GTI behavior of Enterprise B can be studied under condition 1. However, the final choice of Enterprise A is not to provide credit sales, which does not meet the research expectation. Therefore, we will not take Enterprise A as the research object. Similarly, the equilibrium point of Case 2 is (1, 1), and the strategy combinations of Enterprise A and B meet the expectation. Therefore, under the condition of Case 2, both enterprises can be taken as research objects. The evolutionary stability strategies of Case 3, Case 4, and Case 5 are all (0, 0), so the final behavior selection of Enterprise A and B is not what this paper expects to study, and the stable strategy set of Case 6 has appeared in the first five cases. Therefore, we chose Case 1 to analyze the influence of parameter changes on the behavior of Enterprise B and choose Case 2 to analyze the influence of parameter changes on the behavior of Enterprise A. The specific analysis is as follows.

(1) The impact of government green subsidies or incentives on evolutionary outcomes.

The value of the government's green subsidy or reward $e$ will have an impact on enterprises' GTI decisions. In order to obtain obvious results, under the condition of satisfying the Case 1 parameter inequality, we conducted a numerical simulation by resetting the $e = 1$ and $e = 8$ two cases, respectively. The simulation results are shown in Figure 6. The greater the government's subsidy to Enterprise B for GTI, the faster the probability of Enterprise B's GTI tends to 1. The simulation result is highly consistent with the expected results in real life. Indeed, China's GTI achievements are closely related to the policies issued by the government [74]. The government's green subsidies or incentive policies include environmental taxes, incentives for green manufacturing, penalties for non-green manufacturing, and rewards and penalties for achieving the minimum green manufacturing ratio. These government incentives and punishments have a significant positive impact on enterprises' GTI. That is because the more governments subsidize or reward innovation in green technologies, the more money enterprises will have to do it, and the capital increase can reduce the cost burden to some extent. It also increases the possibility of GTI. In addition, the incentive effect of the government on enterprises' green transformation can produce a diffusion effect, which further causes social production to change to the green direction. Existing research supports this conclusion. For example, Hussain et al. [75] studied the decision-making behavior of enterprises' green technology under the emission reduction subsidy policy and concluded that government subsidies can make enterprises maximize profits while developing green technology, while supply chain enterprises will not adopt GTI without subsidies or authorization. Zhang [76] pointed out in his research that government intervention should gradually shift from tax to subsidies to help enterprises achieve green sustainable development. Therefore, government subsidies play an important role in implementing GTI by supply chain enterprises.

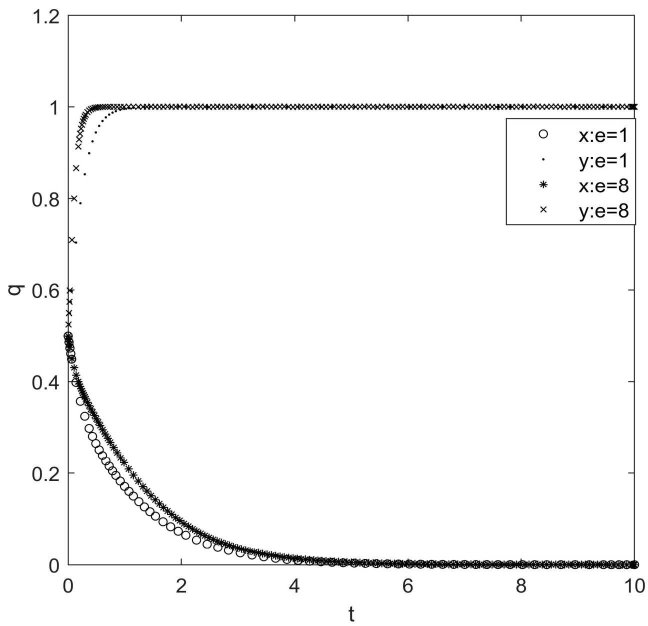



**Figure 6.** The influence of *e* on the final evolution result.

(2) The impact of the new revenue multiple brought by GTI on the evolution results.

The new revenue multiple $\mu$ brought by GTI can stimulate enterprises to decide to implement GTI. In order to obtain obvious results, under the condition of satisfying the Case 1 parameter inequality, we conducted a numerical simulation by resetting the $\mu = 0.4$ and $\mu = 1$ two cases, respectively. The simulation results are shown in Figure 7. The greater the multiple benefits brought by GTI to Enterprise B, the faster the probability of Enterprise B's choice of GTI will approach 1. If other parameters are not changed, the increase in revenue will undoubtedly stimulate the motivation of supply chain Enterprise B to choose GTI. It is worth noting that in reality, the benefit of GTI is a multidimensional concept, which can be either corporate financial performance or non-financial performance, such as corporate reputation and social image. Xie et al. [77] believed that GTI could improve the financial performance of enterprises. In addition, there may be a time lag between the successful development of green technology and the actual generation of benefits, which leads to the fact that the effect of GTI cannot be fully manifested in that year, thus affecting the enthusiasm of enterprises to implement GTI. For example, Xie et al. [78] conducted an empirical study on the Chinese A-share listed companies in Shenzhen and on the Shanghai

Stock Exchange from 2008 to 2013 and concluded that the R&D investment in the GTI of enterprises had a certain lag effect on their business performance.

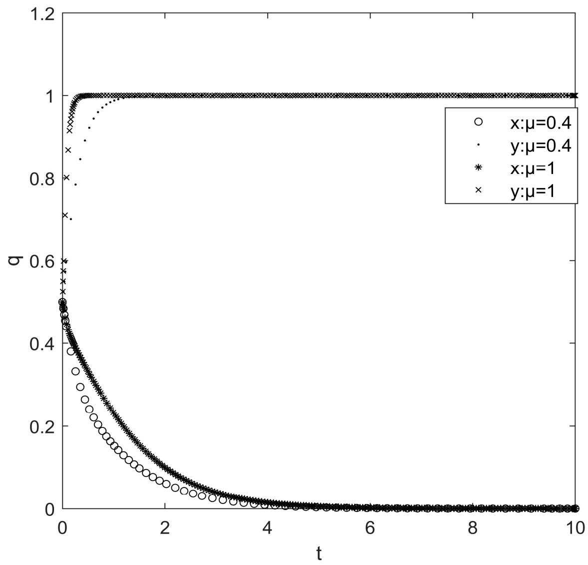
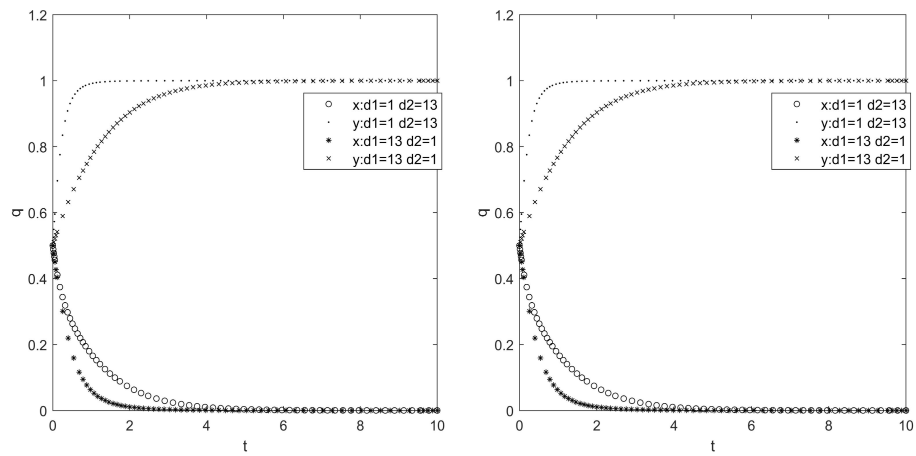



**Figure 7.** The influence of $\mu$ on the final evolution result.

(3) The influence of the comprehensive cost of GTI on the evolutionary results.

Controlling the cost of GTI can improve innovation efficiency. Therefore, under the condition of satisfying the Case 1 parameter inequality, we conducted a numerical simulation by resetting the $d_1 + d_2 = 2$ and $d_1 + d_2 = 14$ two cases, respectively, and the simulation results are shown in Figure 8. As can be seen from Panel (a), the greater the value of $d_1 + d_2$, the faster the probability that Enterprise B chooses to carry out GTI will approach 1. As can be seen from Panel (b), when the total cost of GTI remains unchanged, the smaller the cost of GTI is and the greater the financing cost is (the value of $d_1$ is small and the value of $d_2$ is large), the faster the probability of Enterprise B choosing to make GTI tends to 1. This shows that compared with other financing costs of enterprises, the cost of GTI has a greater impact on enterprise decision-making. This is because if the cost of green innovation is low, less capital is needed to finance it, which in turn reduces the cost of financing. At the same time, the lower the cost of green innovation, the greater the benefit of green innovation. Therefore, Enterprise B is more motivated to carry out GTI.




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

**Figure 8.** The effect of $d_1$ and $d_2$ on the final evolution result. (**a**) is the first effect of $d_1$ and $d_2$ on the final evolution result. (**b**) is the second effect of $d_1$ and $d_2$ on the final evolution result.

(4) The influence of spillover sharing multiple of GTI on the evolution results.

If the shared revenue multiple $\lambda$ obtained by Enterprise A from technology spillover is relatively large, it may cause the enterprise to not provide a credit sales service. Therefore, under the condition of satisfying the Case 2 parameter inequality, we conducted a numerical simulation by resetting the $\lambda = 0.1$ and $\lambda = 0.3$ two cases, respectively, and the simulation results are shown in Figure 9. The larger $\lambda$ is, the higher technology spillover income can be obtained even if Enterprise A does not provide a credit sales service. As a result, the probability that Enterprise A chooses to provide a credit sales service tends to 1 very slowly. From the perspective of dynamic game relations, if Enterprise A does not provide a credit sales service, then Enterprise B may take various measures to reduce the technology spillover effect. Therefore, the innovation achievements shared by Enterprise A through technology spillover will be reduced. On the contrary, if Enterprise A provides a credit sales service, then the financial pressure of Enterprise B to carry out GTI can be alleviated to some extent. In addition, it also improves the innovation efficiency of the green technology of Enterprise B, and thus brings Enterprise A a larger profit than if there are no credit sales. At this time, the income matrix satisfies the conditions that are beneficial to both parties. This point is completely consistent with the research conclusion of Wang and Chen [79]; that is, due to the phenomenon of technology spillover, enterprises benefit more from cooperative innovation than from non-cooperative innovation.

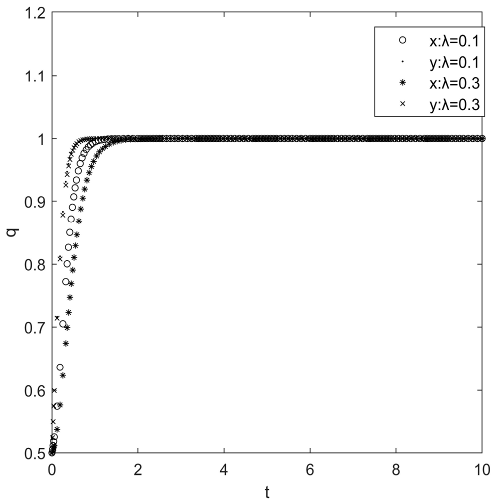



**Figure 9.** The influence of $\lambda$ on the final evolution result.

(5) The influence of shared revenue based on a credit sales service on evolution results.

It is an important guarantee for enterprises to provide credit sales to obtain more GTI-sharing revenue. Therefore, under the condition of satisfying the Case 2 parameter inequality, we conducted a numerical simulation by resetting the $s = 13$ and $s = 18$ two cases, respectively, and the simulation results are shown in Figure 10. As can be seen from the figure, the greater the shared revenue $s$ obtained by Enterprise A when providing a credit sales service to Enterprise B, the faster the ratio of a credit sales service provided by Enterprise A tends to 1. That is, the shared revenue is an important factor considered by Enterprise A when providing credit sales. In addition, the willingness to provide credit sales services also depends on the density of cooperation between Enterprise A and Enterprise B, and the actual benefits of the final operation. Enterprise B's technological innovation can reduce its relative product cost and increase output, so it needs to buy more raw materials from Enterprise A, thus expanding the sales volume and sales profit of Enterprise A. Therefore, the new technology adopted by Enterprise B can improve the profit of Enterprise A. Generally, the greater the shared revenue of Enterprise A, the stronger the willingness to provide a credit sales service.

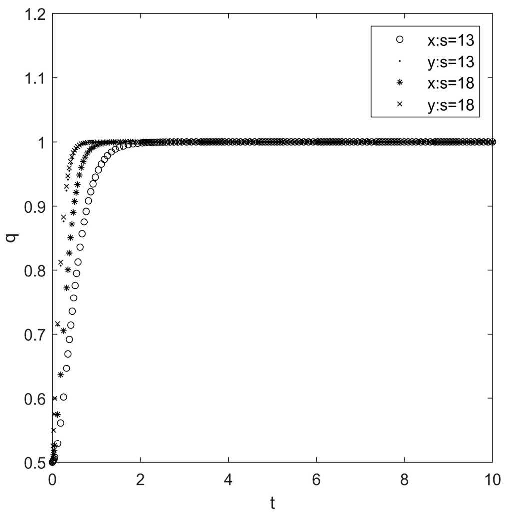



**Figure 10.** The influence of $s$ on the final evolution result.

(6) The impact of default cost of credit sales faced by Enterprise A on the final evolution results.

The default cost of the credit sales of supply chain enterprises directly affects the decision of Enterprise A. Therefore, under the condition of satisfying the Case 2 parameter inequality, we conducted a numerical simulation by resetting the $c_1 = 1$ and $c_1 = 2$ two cases, respectively, and the simulation results are shown in Figure 11. Thus, the smaller the default cost of credit sales faced by Enterprise A, the faster the probability of providing a credit sales financing service tends to 1. In other words, if the default probability of Enterprise B can be reduced, it means the reduction of the default cost of credit sales and the increase of shared income for Enterprise A, to improve the willingness of Enterprise A to provide a credit sales service. The research of Meng et al. [80] shows that technological innovation activities can reduce the default risk.

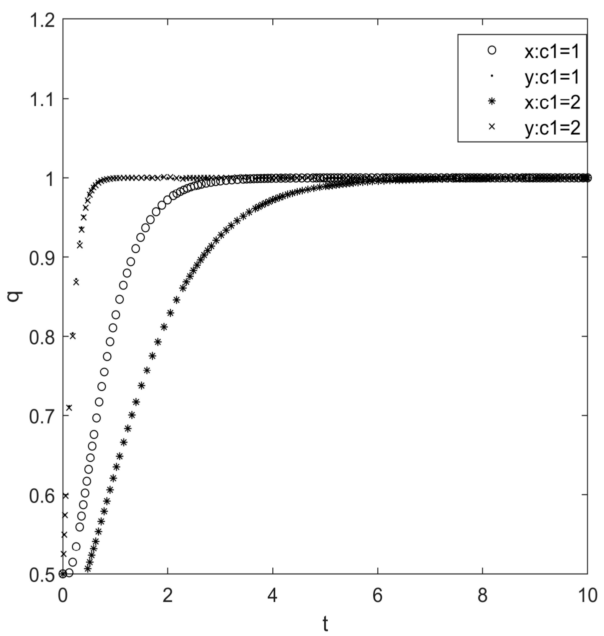



**Figure 11.** The influence of $c_1$ on the final evolution result.

(7) The impact of the regulatory cost of Enterprise A on the final evolution results.

Regulation is a means for Enterprise A to avoid greater losses, but regulation has costs. Therefore, under the condition of satisfying the Case 2 parameter inequality, we conducted a numerical simulation by resetting the $c_2 = 1$ and $c_2 = 2$ two cases, respectively, and the simulation results are shown in Figure 12. Thus, the smaller the supervision cost of Enterprise A, the more incentive that it must provide credit sales financing services to Enterprise B. If Enterprise B can consciously abide by its commitments and establish trust with Enterprise A, it can reduce the friction between the enterprises, negotiation costs, supervision costs, and other costs, improve the efficiency of cooperation between enterprises, and thus improve the evolutionary efficiency of both upstream and downstream enterprises in the supply chain. Moreover, as the number of collaborations between upstream and downstream enterprises of the supply chain increases, mutual trust is enhanced to a certain extent, thus reducing the cost of supervision. As Cojoianu et al. [81] said, trust plays a positive role in the supply chain, and trust and innovation are the prerequisites for higher performance in the supply chain.

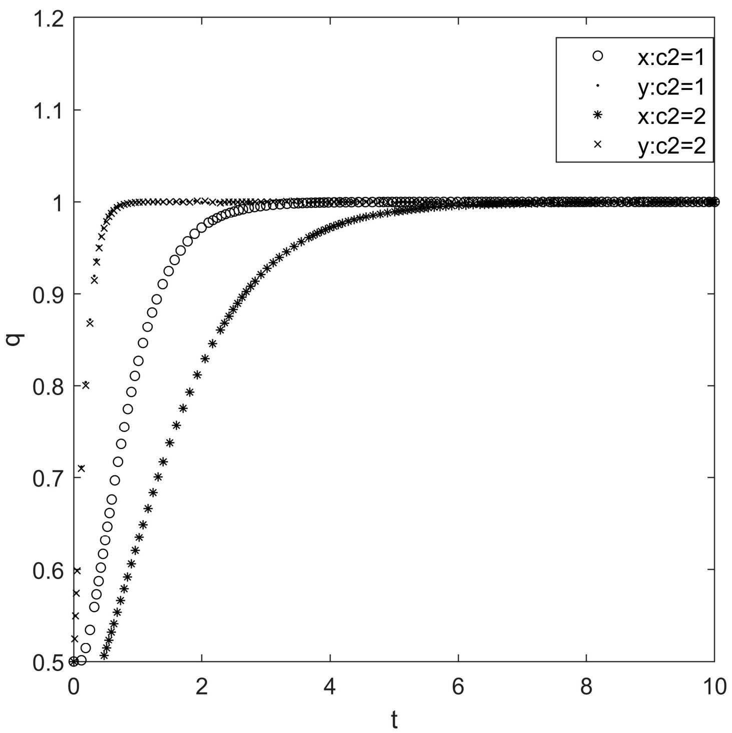



**Figure 12.** The influence of $c_2$ on the final evolution result.

## 6. Conclusions and Policy Implications

### *6.1. Conclusions*

In order to alleviate the financing dilemma of enterprises' GTI, this paper introduces credit sales into the game model to verify if they can provide financing direction and how to design a credit sales mechanism to promote supply chain enterprises to achieve sustainable GTI. Through the game analysis and simulation, this paper draws the following conclusions: (1) Credit sales are a financing method that benefits supply chain enterprises' GTI. For enterprises that accept financing services, credit sales relieve their financial pressure and increase the willingness to implement GTI. The shared profits brought by GTI also enhance upstream enterprises' economic benefits and the entire supply chain's competitiveness. As the income from GTI and credit sales increases, upstream enterprises are more willing to provide credit sales, and downstream enterprises are more likely to implement GTI. Although the widespread use of credit sales may lead to an excessive extension of payment periods and, consequently, deteriorate the profitability of companies, the advantages may outweigh this including, among others, the reduction of transaction costs, and could be a financial alternative to the banking system and an additional tool to improve business activities. In sum, credit sales and GTI are the optimal strategies that can benefit the development of the supply chain while satisfying the requirements of their interests. (2) The shared benefits from GTI increase upstream enterprises' enthusiasm to provide credit sales. The shared benefits of GTI increase the profits of enterprises providing credit sales by offsetting their supervision cost. Under the dual blessing of shared and sales profits, enterprises will tend to provide credit sales. The bundling of GTI and credit sales by downstream enterprises will prompt upstream enterprises to provide credit sales services. (3) The government's green subsidies or incentives stimulate the GTI of enterprises enjoying credit sales services. For enterprises receiving credit sales, the green subsidies or incentives provide funds for GTI and thus increase the probability of GTI. The downstream enterprises' GTI indirectly increases upstream enterprises' willingness to provide credit sales. Therefore, the government's support for GTI positively affects supply chain enterprises' goals.

### *6.2. Policy Implications*

Based on the conclusions, this paper puts forward the following suggestions: (1) Credit sales create profits for supply chain companies. Upstream enterprises should change their concepts and regard credit sales as a tool to promote sales and obtain green income, rather than a risk. To obtain credit sales, downstream enterprises should actively develop GTI and allocate appropriate green income to upstream enterprises. Thus, a sustainable GTI supply chain is formed under the joint action of trust, fairness, and profit. (2) The government should increase subsidies and incentives for supply chain enterprises. On the one hand, the government should provide incentives and subsidies for enterprises that carry out GTI to encourage green transformation and enhance their confidence in GTI. On the other hand, the government also provides incentives and subsidies to enterprises that offer credit sales, increasing the willingness and proportion to provide credit sales. The joint promotion of upstream and downstream enterprises can form a positive synergistic effect and prompt the supply chain to form a virtuous circle of credit sales and GTI. (3) Improve financing-related laws and regulations to provide legal protection for supply chain collaboration. Bad debts are the main risk for upstream enterprises that provide credit sales, and the resulting supervision cost is a key factor affecting enterprises' credit sales provision. Perfect and effective supervision and traceability laws provide a safety backing, which can effectively improve the financing capacity of supply chain GTI.

### *6.3. Limitations and Future Research Directions*

This paper studies supply chain enterprises' interaction with GTI from the perspective of credit sales. The conclusions provide a reference for solving the financing dilemma of enterprises' GTI. This study still has potential space for exploration in expanding financing channels to promote enterprises' GTI. (1) This paper adopts the method of the dynamic game to examine the strategic game of upstream and downstream enterprises in credit sales and GTI, but fails to verify it with empirical data. It is suggested that future research studies the relationship between supply chain credit sales and GTI based on long-term panel data. (2) This study found a positive interactive relationship between credit sales and GTI and did not delve into the composition of credit sales services. Future research could focus on the optimal state of the trust period and the proportion of accounts payable in the credit sales service to provide the optimal economic decision-making basis for supply chain enterprises.

**Author Contributions:** Conceptualization, Z.W.; Methodology, Z.W.; Investigation, Z.W. and L.T.; Resources, L.W.; Data curation, L.T. and C.L.; Writing—original draft, Z.W.; Writing—review & editing, C.L.; Supervision, L.W. and C.L.; Project administration, L.W. and C.L.; Funding acquisition, L.W. All authors have read and agreed to the published version of the manuscript.

**Funding:** The research is supported by National Social Science Fund of China (22AJY013).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data that support the findings of the current research are available from the corresponding author on reasonable request.

**Conflicts of Interest:** The authors declare no conflict of interests.

## References

1. Ahmad, M.; Wu, Y. Combined role of green productivity growth, economic globalization, and eco-innovation in achieving ecological sustainability for OECD economies. *J. Environ. Manag.* **2022**, *302*, 113980. [CrossRef] [PubMed]
2. Zhang, H.; Shao, Y.; Han, X.; Chang, H. A road towards ecological development in China: The nexus between green investment, natural resources, green technology innovation, and economic growth. *Resour. Policy* **2022**, *77*, 102746. [CrossRef]
3. Jin, P.; Peng, C.; Song, M. Macroeconomic uncertainty, high-level innovation, and urban green development performance in China. *China Econ. Rev.* **2019**, *55*, 1–18. [CrossRef]
4. Li, X.; Dai, J.; He, J.; Li, J.; Huang, Y.; Liu, X.; Shen, Q. Mechanism of enterprise green innovation behavior considering coevolution theory. *Int. J. Env. Res. Public Health* **2022**, *19*, 10453. [CrossRef]
5. Singh, S.K.; Del Giudice, M.; Chiappetta Jabbour, C.J.; Latan, H.; Sohal, A.S. Stakeholder pressure, green innovation, and performance in small and medium-sized enterprises: The role of green dynamic capabilities. *Bus. Strateg. Environ.* **2022**, *31*, 500–514. [CrossRef]
6. Chien, F.; Kamran, H.W.; Nawaz, M.A.; Thach, N.N.; Long, P.D.; Baloch, Z.A. Assessing the prioritization of barriers toward green innovation: Small and medium enterprises Nexus. *Environ. Dev. Sustain.* **2022**, *24*, 1897–1927. [CrossRef]
7. Du, J.; Ali, K.; Alnori, F.; Ullah, S. The nexus of financial development, technological innovation, institutional quality, and environmental quality: Evidence from OECD economies. *Environ. Sci. Pollut. Res.* **2022**, *29*, 58179–58200.
8. Ashton, W.S.; Panero, M.A.; Cruz, C.I.; Marta, M.H. Financing resource efficiency and cleaner production in Central America. *Clean Technol. Environ.* **2018**, *20*, 53–63. [CrossRef]
9. Wang, X.; Wang, Y. Research on the green innovation promoted by green credit policies. *J. Manag. Word* **2021**, *37*, 173–188.
10. Feng, T.; Zhao, J.; Zhou, H. Does environmental regulation improve the quantity and quality of green innovation: Evidence from the target responsibility system of environmental protection. *China Ind. Econ.* **2021**, *2*, 136–154.
11. Wang, Q.; Su, M. A preliminary assessment of the impact of COVID-19 on environment—A case study of China. *Sci. Total Environ.* **2020**, *728*, 138915. [CrossRef] [PubMed]
12. Srivastava, J.; Sampath, A.; Gopalakrishnan, B. Is ESG the key to unlock debt financing during the COVID-19 pandemic? International evidence. *Financ. Res. Lett.* **2022**, *49*, 103125. [CrossRef] [PubMed]
13. Wang, Q.; Zhang, F. What does the China's economic recovery after COVID-19 pandemic mean for the economic growth and energy consumption of other countries. *J. Clean. Prod.* **2021**, *295*, 126265. [CrossRef] [PubMed]
14. Li, J.; Sarkis, J. Product eco-design practice in green supply chain management: A China-global examination of research. *Nankai Bus. Rev. Int.* **2022**, *13*, 124–153. [CrossRef]
15. Xiang, X.; Liu, C.; Yang, M. Who is financing corporate green innovation. *Int. Rev. Econ. Financ.* **2022**, *78*, 321–337. [CrossRef]
16. Waniak-Michalak, H.; Michalak, J.; Gheribi, E. Financial performance of loan and guarantee funds in Poland. How business elements influence it? *Account. Manag. Inform. Syst.* **2018**, *17*, 566–590. [CrossRef]
17. Ghisetti, C.; Montresor, S. On the adoption of circular economy practices by small and medium-size enterprises (SMEs): Does "financing-as-usual" still matter. *J. Evol. Econ.* **2020**, *30*, 559–586. [CrossRef]
18. Cecere, G.; Corrocher, N.; Mancusi, M.L. Financial constraints and public funding of eco-innovation: Empirical evidence from European SMEs. *Small Bus. Econ.* **2020**, *54*, 285–302. [CrossRef]
19. Tan, Y.; Wang, Y. Environment regulation, financing constraints and heavy-polluting enterprises' investment path selection in greening innovation. *Collect. Essays Financ. Econ.* **2020**, *264*, 75.
20. Chen, W.; Zhu, Y.; He, Z.; Yang, Y. The effect of local government debt on green innovation: Evidence from Chinese listed companies. *Pac.-Basin. Financ. J.* **2022**, *73*, 101760. [CrossRef]
21. Irfan, M.; Razzaq, A.; Sharif, A.; Yang, X. Influence mechanism between green finance and green innovation: Exploring regional policy intervention effects in China. *Technol. Forecast. Soc.* **2020**, *182*, 121882. [CrossRef]
22. Mahat, T.J.; Bláha, L.; Uprety, B.; Bittner, M. Climate finance and green growth: Reconsidering climate-related institutions, investments, and priorities in Nepal. *Environ. Sci. Eur.* **2019**, *31*, 46. [CrossRef]
23. Jin, H.; Yu, L.; Xu, Y. Green industrial policy and green technology innovation in the manufacturing industry. *China Popul. Resour. Environ.* **2022**, *32*, 136–146.
24. Liu, P.; Chu, P. Renewables finance and investment: How to improve industry with private capital in China. *J. Mod. Power Syst. Clean Energy* **2019**, *7*, 1385–1398. [CrossRef]
25. Barykin, S.E.; Sergeev, S.M.; Mottaeva, A.B.; Plaza, E.D.L.P.; Baydukova, N.V.; Gubenko, A.V. Evaluating energy financing considerations and sustainable energy innovation with the role of financial development and energy development. *Environ. Sci. Pollut. Res.* **2022**. [CrossRef]
26. Li, Z.; Liao, Z.; Huang, Z. Green loan and subsidy for promoting clean production innovation. *J. Clean. Prod.* **2018**, *187*, 421–431. [CrossRef]

27. Sriyono, S.; Biduri, S.; Proyogi, B. Acceleration of performance recovery and competitiveness through non-banking financing in SMEs based on green economy: Impact of COVID-19 pandemic. *J. Entrep. Manag.* **2021**, *10*, 27. [CrossRef]
28. Ning, Y.; Cherian, J.; Sial, M.S.; Álvarez-Otero, S.; Comite, U.; Ziaud-Din, M. Green bond as a new determinant of sustainable green financing, energy efficiency investment, and economic growth: A global perspective. *Environ. Sci. Pollut. Res.* **2022**. [CrossRef]
29. Chen, Y.; Chen, Z.; Peng, J. How does emission right-based lending contribute to sustainable production and green financing? A modelling study. *Environ. Dev. Sustain.* **2021**, *23*, 13945–13972. [CrossRef]
30. Liu, W.; Sun, Y.; Yüksel, S.; Dinçer, H. Consensus-based multidimensional due diligence of fintech-enhanced green energy investment projects. *Financ. Innov.* **2021**, *7*, 72. [CrossRef]
31. Feng, S.; Chong, Y.; Li, G.; Zhang, S. Digital finance and innovation inequality: Evidence from green technological innovation in China. *Environ. Sci. Pollut. Res.* **2022**, *29*, 87884–87900. [CrossRef] [PubMed]
32. Lin, B.; Ma, R. How does digital finance influence green technology innovation in China? Evidence from the financing constraints perspective. *J. Environ. Manag.* **2022**, *320*, 115833. [CrossRef] [PubMed]
33. Li, X.; Chang, T.; Albu, L.L. Does digital finance promote the green innovation of China's listed companies. *Energy Econ.* **2022**, *114*, 106254. [CrossRef]
34. Yu, C.; Wu, X.; Zhang, D.; Chen, S.; Zhao, J. Demand for green finance: Resolving financing constraints on green innovation in China. *Energ. Policy* **2021**, *153*, 112255. [CrossRef]
35. Li, Y.; Chen, T. Blockchain empowers supply chain: Challenge, implementation path and prospect. *Nankai Bus. Rev. Int.* **2021**, *24*, 192–203, 212.
36. Dong, Z.; Tan, Y.; Wang, L.; Zheng, J.; Hu, S. Green supply chain management and clean technology innovation: An empirical analysis of multinational enterprises in China. *J. Clean. Prod.* **2021**, *310*, 127377. [CrossRef]
37. Roh, T.; Noh, J.; Oh, Y.; Park, K. Structural relationships of a firm's green strategies for environmental performance: The roles of green supply chain management and green marketing innovation. *J. Clean. Prod.* **2022**, *356*, 131877. [CrossRef]
38. Yu, H.; Kang, C. Research on financing mechanism of SEM based on supply chain finance. *Nankai Econ. Stud.* **2017**, *7*, 141–152.
39. Lashgari, M.; Taleizadeh, A.A.; Ahmadi, A. Partial up-stream advanced payment and partial down-stream delayed payment in a three-level supply chain. *Ann. Oper. Res.* **2016**, *238*, 329–354. [CrossRef]
40. Demica. *A Study on the Growth of Supply Chain Finance, as Evidenced by SCF Dedicated Job Titles at Top European Bank*; Demica: London, UK, 2014.
41. PIRI. *2015–2020 China Supply Chain Financial Market Foresight and Investment Strategy Planning Analysis Report*; Prospective Industry Research Institute: Beijing, China, 2015.
42. Li, Y.; Wei, Y.; Yao, Q.; Li, M. Research on the construction of supply chain management for undergraduate programs at Chinese Applied Universities. *Discrete Dyn. Nat. Soc.* **2021**, *2021*, 6690213. [CrossRef]
43. Lai, Z.; Lou, G.; Zhang, T.; Fan, T. Financing and coordination strategies for a manufacturer with limited operating and green innovation capital: Bank credit financing versus supplier green investment. *Ann. Oper. Res.* **2021**. [CrossRef]
44. Taleizadeh, A.A.; Tavassoli, S.; Bhattacharya, A. Inventory ordering policies for mixed sale of products under inspection policy, multiple prepayment, partial trade credit, payments linked to order quantity and full backordering. *Ann. Oper. Res.* **2020**, *287*, 403–437. [CrossRef]
45. Chen, R.; Ghoul, S.E.; Guedhami, O.; Kwok, C.C.Y.; Nash, R. International evidence on state ownership and trade credit: Opportunities and motivations. *J. Int. Bus. Stud.* **2021**, *52*, 1121–1158. [CrossRef]
46. Murro, P.; Peruzzi, V. Relationship lending and the use of trade credit: The role of relational capital and private information. *Small Bus. Econ.* **2022**, *59*, 327–360. [CrossRef]
47. Diabat, A.; Taleizadeh, A.A.; Lashgari, M. A lot sizing model with partial downstream delayed payment, partial upstream advance payment, and partial backordering for deteriorating items. *J. Manuf. Syst.* **2017**, *45*, 322–342. [CrossRef]
48. Mu, X.; Kang, K.; Zhang, J. Dual-channel supply chain coordination considering credit sales competition. *Appl. Math. Comput.* **2022**, *434*, 127420. [CrossRef]
49. Wu, C.; Xu, C.; Zhao, Q.; Lin, S. Research on financing strategy of low-carbon supply chain based on cost-sharing contract. *Environ. Sci. Pollut. Res.* **2022**, *29*, 48358–48375. [CrossRef]
50. Marchia, B.; Jaber, M.Y. Credit-dependent demand in a vendor-buyer model with a two-level delay-in-payments contract under a consignment-stock policy agreement. *Appl. Math. Model.* **2021**, *99*, 585–605. [CrossRef]
51. Ahmed, W.; Moazzam, M.; Sarkar, B.; Rehman, S.U. Synergic effect of reworking for imperfect quality items with the integration of multi-period delay-in-payment and partial backordering in global supply chains. *Engineering* **2021**, *7*, 260–271. [CrossRef]
52. Duary, A.; Das, S.; Arif, M.G.; Abualnaja, K.M.; Khan, M.A.; Zakarya, M.; Shaikh, A.A. Advance and delay in payments with the price-discount inventory model for deteriorating items under capacity constraint and partially backlogged shortages. *Alex. Eng. J.* **2022**, *61*, 1735–1745. [CrossRef]
53. Aljazzar, S.M.; Gurtu, A.; Jaber, M.Y. Delay-in-payments—A strategy to reduce carbon emissions from supply chains. *J. Clean. Prod.* **2018**, *170*, 636–644. [CrossRef]
54. Yang, Z.; Lin, Y. The effects of supply chain collaboration on green innovation performance: An interpretive structural modeling analysis. *Sustain. Prod. Consump.* **2020**, *23*, 1–10. [CrossRef]

55. Kong, J.; Zhou, Y.; Lai, H.; Zhang, F.; Zhou, Z. Analysis of credit sale risk of emerging market product. *Proc. Comput. Sci.* **2016**, *91*, 362–371. [CrossRef]
56. Zhang, J.; Wu, M. Cooperation mechanism in blockchain by evolutionary game theory. *Complexity* **2021**, *2021*, 1258730. [CrossRef]
57. Xu, L.; Ma, Y.; Wang, X. Study on environmental policy selection for green technology innovation based evolutionary game: Government behavior vs. public participation. *Chin. J. Manag. Sci.* **2022**, *30*, 30–42.
58. Li, X.; Li, Y. On green market segmentation under subsidy regulation. *Supply Chain Manag.* **2017**, *22*, 284–294. [CrossRef]
59. Kang, K.; Zhao, Y.; Zhang, J.; Chen, Q. Evolutionary game theoretic analysis on low-carbon strategy for supply chain enterprises. *J. Clean. Prod.* **2019**, *230*, 981–994. [CrossRef]
60. Sun, H.; Wan, Y.; Zhang, L.; Zhou, Z. Evolutionary game of the green investment in a two-echelon supply chain under a government subsidy mechanism. *J. Clean. Prod.* **2019**, *235*, 1315–1326. [CrossRef]
61. Zhao, S.; Jiang, Y.; Wang, S. Innovation stages, knowledge spillover, and green economy development: Moderating role of absorptive capacity and environmental regulation. *Environ. Sci. Pollut. Res.* **2019**, *26*, 25312–25325. [CrossRef]
62. Wang, J.; Lan, Y.; Zhao, R.; Xing, T. The optimal payment policy for a firm: Cash sale versus credit sale. *Soft Comput.* **2018**, *22*, 5843–5860. [CrossRef]
63. Dong, G.; Liang, L.; Wei, L.; Xie, J.; Yang, G. Optimization model of trade credit and asset-based securitization financing in carbon emission reduction supply chain. *Ann. Oper. Res.* **2021**. [CrossRef]
64. Yang, X.; Liao, S.; Li, R. The evolution of new ventures' behavioral strategies and the role played by governments in the green entrepreneurship context: An evolutionary game theory perspective. *Environ. Sci. Pollut. Res.* **2021**, *28*, 31479–31496. [CrossRef] [PubMed]
65. Li, G.; Wang, X.; Su, S.; Su, Y. How green technological innovation ability influences enterprise competitiveness. *Technol. Soc.* **2019**, *59*, 101136. [CrossRef]
66. Sun, Z.; Zhang, W. Do government regulations prevent greenwashing? An evolutionary game analysis of heterogeneous enterprises. *J. Clean. Prod.* **2019**, *231*, 1489–1502. [CrossRef]
67. Zhang, S.; Yu, Y.; Zhu, Q.; Qiu, C.; Tian, A. Green innovation mode under carbon tax and innovation subsidy: An evolutionary game analysis for portfolio policies. *Sustainability* **2020**, *12*, 1385. [CrossRef]
68. Cui, H.; Wang, R.; Wang, H. An evolutionary analysis of green finance sustainability based on multi-agent game. *J. Clean. Prod.* **2020**, *269*, 121799. [CrossRef]
69. Liu, L.; Peng, Q. Evolutionary game analysis of enterprise green innovation and green financing in platform supply chain. *Sustainability* **2022**, *14*, 7807. [CrossRef]
70. Zhou, K.; Wang, Q.; Tang, J. Evolutionary game and simulation analysis of enterprise's green technology innovation under green credit policy: Evidence from China. *Technol. Anal. Strateg. Manag.* **2022**, 1–20. [CrossRef]
71. Zhang, L.; Xue, L.; Zhou, Y. How do low-carbon policies promote green diffusion among alliance-based firms in China? An evolutionary-game model of complex networks. *J. Clean. Prod.* **2019**, *210*, 518–529. [CrossRef]
72. Chen, H.; Wang, J.; Miao, Y. Evolutionary game analysis on the selection of green and low carbon innovation between manufacturing enterprises. *Alex. Eng. J.* **2021**, *60*, 2139–2147. [CrossRef]
73. Li, M.; Gao, X. Implementation of enterprises' green technology innovation under market-based environmental regulation: An evolutionary game approach. *J. Environ. Manag.* **2022**, *308*, 114570. [CrossRef] [PubMed]
74. Wang, Q.; Qu, J.; Wang, B.; Wang, P.; Yang, T. Green technology innovation development in China in 1990–2015. *Sci. Total. Environ.* **2019**, *696*, 134008. [CrossRef]
75. Hussain, J.; Pan, Y.; Ali, G.; Yue, X. Pricing behavior of monopoly market with the implementation of green technology decision under emission reduction subsidy policy. *Sci. Total. Environ.* **2020**, *709*, 136110. [CrossRef] [PubMed]
76. Zhang, X.; Yousaf, H.M.A.U. Green supply chain coordination considering government intervention, green investment, and customer green preferences in the petroleum industry. *J. Clean. Prod.* **2020**, *246*, 118984. [CrossRef]
77. Xie, X.; Huo, J.; Zou, H. Green process innovation, green product innovation, and corporate financial performance: A content analysis method. *J. Bus. Res.* **2019**, *101*, 697–706. [CrossRef]
78. Xie, M.; Wang, J.; Liu, D. Environment regulation, technological innovation and corporate performance. *Nankai Bus. Rev.* **2014**, *17*, 106–113.
79. Wang, L.; Chen, G. A game analysis on the technology innovation of chain-style industrial cluster. *Chin. J. Manag. Sci.* **2016**, *24*, 151–158.
80. Meng, Q.; Hou, C.; Lu, B. Firms' innovation and the risk of default. *J. World Econ.* **2019**, *42*, 169–192.
81. Cojoianu, T.F.; Clark, G.L.; Hoepner, A.G.F.; Paitka, V.; Wójcik, D. Fin vs. tech: Are trust and knowledge creation key ingredients in fintech start-up emergence and financing. *Small Bus. Econ.* **2021**, *57*, 1715–1731. [CrossRef]