Research Article

The Dynamics of Manufacturing Value Chain Climbing System under MPL Framework: Modeling and Simulation Based on Intelligent Transformation

Jiazi Zhou and Xin Wen

School of Management, Shenyang University of Technology, Shenyang 110870, China

Correspondence should be addressed to Xin Wen; wenxin@sut.edu.cn

Received 4 April 2022; Accepted 12 July 2022; Published 11 August 2022

Academic Editor: Juan L. G. Guirao

Copyright © 2022 Jiazi Zhou and Xin Wen. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Taking intelligent manufacturing pilot enterprises such as the verification sample, this paper uses system dynamics modeling and system simulation methods to analyze the influencing factors and climbing modes of their value chain climbing system under the intelligent transformation. The results show that (1) the value chain climbing system under the intelligent transformation is divided into the original chain climbing layer, cross-chain horizontal climbing layer, and new chain vertical climbing layer; (2) intelligence level, technological innovation level, market share, green development, and government investment all positively impact the value increase. Increased technological innovation level can effectively promote the rise of the value chain from the original chain climbing level to the cross-chain horizontal climbing level. The increase in market scale can effectively promote the rise of the value chain from the cross-chain horizontal climbing level to the new chain vertical climbing level. Green development has a significant impact when enterprises climb to the high end of the value chain; (3) with the deepening of intelligent transformation, the value chain system rises in an orderly, layer by layer manner.

1. Introduction

With the advent of artificial intelligence technology, the traditional manufacturing industry is changing aggressively. As the main development direction of China’s manufacturing industry, intelligent manufacturing has not only become a research hotspot to promote sustainable development of the manufacturing industry but also an important strategic plan to build an innovative country and promote the transformation and upgrading of the manufacturing industry [1]. Simultaneously, with external trade friction and the counterglobalization phenomenon, such as COVID-19 havoc, China’s manufacturing enterprises, which are at the bottom of the value chain, become more difficult. Although these manufacturing enterprises have not eliminated the problems of relying on resource advantages and lack of independent research and development, by promoting intelligent and high-quality economic development, manufacturing companies have gradually changed their development mode. According to the China Commercial Industry Research Institute, the output value of China’s intelligent manufacturing equipment will reach 2265 billion yuan in 2021. At the same time, “the intelligent manufacturing development plan of the 14th 5-year plan” clearly sets 2025 and 2035 as the two key stage objectives of intelligent manufacturing development. From “manufacturing enterprises above the Designated Size popularize digitization, key industry backbone enterprises initially realize intelligent transformation” to “manufacturing enterprises above the Designated Size fully popularize digitization, and the backbone enterprises basically realize intelligent transformation,” the state has given clear policy guidance for developing intelligent manufacturing in terms of path and goal. Therefore, the manufacturing industry takes artificial intelligence and digital development as technical means [2]. By reforming the
production process and improving production efficiency, it can obtain new competitive advantages and promote the high-end rise of the enterprise value chain. By clarifying the value chain climbing dynamic system of manufacturing enterprises under intelligent transformation, this paper provides an important theoretical basis for integrating intelligent resources of manufacturing enterprises, promoting high-end climbing of the manufacturing value chain, and accelerating the high-quality development of the Chinese economy.

At present, scholars’ research on the rise of value chain mainly focuses on the concept definition, influencing factors, and heterogeneity analysis. In terms of concept definition, the climb of the value chain was, first, divided into function upgrade and chain upgrade according to the "smile curve" theory. Later, scholars took the global manufacturing industry as the background and divided the global value chain into four modes: product upgrade, production process upgrade, industrial function upgrade, and chain upgrade [3]. Some scholars also believe that the rise of the value chain refers to enterprises transferring from low value-added production links to high value-added production links [4]. In terms of influence factors, scholars believe that technological innovation and the digital economy are significant for the rise of the value chain [5,6]. In terms of heterogeneity, scholars believe that different service source structures differently affect the rise of the value chain [7].

Where developed countries have put forward strategic measures such as “Industry 4.0” and “Advanced Manufacturing Development Country,” China has also presented “Made in China 2025” focusing on the development direction of the manufacturing industry. Meanwhile, General Secretary Xi Jinping has emphasized that intelligent development has become the main direction of manufacturing transformation. The researchers, in further exploring the regional intelligence level, found a significant positive influence on the status of the global value chain and the effect of intelligent rise on the global value chain industry, the heterogeneity of the region, and policy [8], the digital economy to the effect competition effect, structure effect, and space effect toward the transition of the manufacturing value chain [9]. From the perspective of the value chain, manufacturing enterprises comprehensively promote the intelligent transformation and upgrade path of “strong chain, complementary chain, and extended chain” [10]. However, artificial intelligence also plays an important role in optimizing the industrial structure of a country and enhancing the global value chain competitiveness [11].

Previously, scholars have expounded on intelligent development and value chain from different perspectives. Intelligent development can promote the climb of the value chain and enhance competitive advantages. However, little attention is paid to the internal dynamic system of value chain climbing under intelligence, and there is not enough theoretical research on the internal function of the value chain climbing for reference. Therefore, this study uses a multilevel analysis framework to sort out the internal dynamic system of the manufacturing value chain climbing under intelligence. In essence, the framework is to study the evolution of the system from three levels, divide the evolution process of the value chain climbing system by stages, and study its path, influencing factors, and system evolution. In this paper, the value chain climbing dynamic system of the manufacturing industry under intelligent transformation is divided into a three-level model, then makes dynamic analysis of the model to provide a new idea and perspective for studying value chain climbing.

2. Theoretical Basis

2.1. Research on Intelligent Transformation and Value Chain Climbing. Intelligent transformation is an organic combination of new artificial intelligence technologies and corporate manufacturing processes. Intelligent manufacturing enables a product’s life cycle. It also enables machines to have self-sensing, self-decision-making, self-execution, and other intelligent capabilities, to realize the substitution of artificial intelligence for human and brain power [12]. At present, domestic and foreign scholars’ research on intelligent transformation mainly focuses on influencing factors [13–15], transformation path [16–18], and transformation process [19, 20]. Transformation factors mainly focus on digitalization capability, intelligent platform, intelligent management system, intelligent technology, intelligent interaction capability, etc. The transformation path comprises product intellectualization, service intellectualization, industrial chain intellectualization, and business model intellectualization. Each stage of the intelligent process has a large span, and all take the birth and application of new technology as the inflection point of development. As research deepens, scholars are also developing their knowledge of the impact of technology and the economy [21]. This paper, therefore, has a practical significance in studying manufacturing from the point of view of intelligent transformation.

The value chain was first put forward by an American scholar named Porter. The enterprise value creation process is mainly composed of basic activities (production, marketing, transportation, after-sales service, etc.) and supporting activities (raw material supply, technology, human resources, finance, etc.). These activities are interlinked in the process of enterprise value creation, constituting the behavior chain of enterprise value creation—value chain. At present, scholars’ research on value chains mostly focuses on the measurement of global value chain location [22] and the division of value chain [23]. With the widespread recognition of the “smile curve,” the high-end climb of the value chain has also become a research hotspot. From the perspective of the smile curve, the climb of the value chain usually refers to the climb from a low value-added link to a high value-added link.

The new round of industrial revolution with big data, artificial intelligence, and cloud computing as technological reforms has provided significant opportunities and challenges for the organization mode, transformation direction, and location breakthrough of the manufacturing industry [24]. The “Internet Plus” has played a positive role in promoting the climb of the value chain. The spatial spillover
effect also encourages the development of manufacturing sectors in the surrounding regions [25, 26]. The digital economy has also promoted the rise of the value chain of China’s small and medium-sized enterprises through four stages: initial connection, all-round development, level jump, and high-level participation [27]. Existing studies have explained and discussed the positive impact of intelligent transformation on the rise of the value chain. At the same time, scholars also summarized and studied the influence of innovation-driven, green technological innovation, digital transformation, consumption upgrading, and other factors on the climb of the value chain [28, 29]. However, in the existing research, there are few studies on the dynamic evolution of the climbing system of the manufacturing value chain under intelligent transformation. In today’s manufacturing industry, with great technological change and economic development, how the internal driving force of the value chain climbing system evolves under the intelligent transformation has become the main problem discussed in this study.

2.2. MPL Theory Research. MPL multilayer analysis method is a popular analysis method for social technology transformation in recent years. It originated from the research of innovation, absorbed the views of evolutionary economics, technological sociology, and other schools, and emphasized the importance of collaborative evolution to transformation. The value chain climbing system has multiple cooperating levels and internal factors. At the same time, the driving force behind the rise of the value chain is the result of the common actions of several factors and levels. It is a gradual increasing process from the microlevel to the macrolevel and then to the microlevel. Therefore, this paper uses the multilevel perspective analysis framework as the analysis basis of the evolution of the value chain climbing dynamic system. MPL distributes the complex dynamic processes interacting at all levels, such as relevant elements or innovation resources, into the same analytical framework. It is mainly based on the joint action of macroenvironment, miso technology, and microinnovation, and the premise of nonlinear evolution. Scholars use MPL to analyze the sharing economy as a sustainable development economy and new free capital [30] and the research on the path of industrial upgrading under the sharing economy [31]. Therefore, this study attempts to analyze the complex system of the value chain climbing under intelligence through a multilevel framework and deeply analyze the dynamic mechanism and dynamic model of the value chain climbing system.

2.3. Construction of the Value Chain Climbing System Model. With the further promotion of Intelligent Manufacturing in China, “standard first” has become the technical basis for the manufacturing industry to realize intelligent manufacturing. The "National Guide for the Construction of Intelligent Manufacturing Standard System (2018 Edition)” describes the standardization of intelligent manufacturing in three dimensions: life cycle, system-level, and intelligent features. According to the research objectives of this paper, intelligent features are selected for reference. At the same time, in the intelligent transformation process, under the influence of fierce external competition and limited internal resources, the value chain of manufacturing enterprises climbs high-end to obtain a lasting competitive advantage and value-added. Therefore, based on the multilevel analysis framework, this paper divides the value chain climbing system into value dimension and intelligent feature dimension and constructs the dynamic system model of the value chain climbing. As shown in Figure 1, the value chain climbing dynamic system model consists of three levels. The first level is original chain climbing; the power source is an innovative technology and digital resources. The second level is cross-chain horizontal climbing, and the power source is the interconnection of market information. The third level is the vertical climbing of new a chain, and the power source is the sustainable development inside and outside the system.

2.3.1. Innovation Resource Leading. In the manufacturing value chain climbing system, to achieve the high-end climbing of the value chain under the external competitive pressure and limited internal resources, traditional manufacturing enterprises generally start from the R&D link, increase R&D investment, overcome the technical barrier, and achieve a technological innovation breakthrough. At this time, enterprises obtain the value creation of the R&D link through new technology. Under intelligent transformation, resource elements of manufacturing enterprises will reach the digital level under the guidance of intelligent technology, and when the intelligent technology develops to a certain extent, the equipment of enterprises and even between enterprises will realize interconnection or information exchange [32].

Under the guidance of intelligent interaction and intelligent resources, enterprises achieve new value creation through downstream service marketing. Service marketing links directly face customers. Through intelligent means, such as big data and network links, enterprises adopt new marketing models or increase the diversification of services to achieve value creation in marketing service links. At this time, the enterprise climbs from the production and manufacturing link with low added value to the R&D and design or marketing service link with high added value, realizing the original chain climb of the first level of the value chain climb system. For manufacturing enterprises at this level, the R&D of new technologies is still in the creation period. Whether they climb to the R&D and design link or service marketing link, they have created new value creation and climbed based on the original value chain.

2.3.2. Market Sharing Promotion. By further applying technology in the market, other companies in the industry will also research and develop new technologies to realize value-added, and the original competitive advantage of the company will gradually weaken [33]. In order to obtain a sustainable competitive advantage in the market, the enterprise will increase the market share of products by
improving production efficiency and obtain data feedback on products in the market. It also guarantees information acquisition in research and design and marketing services. At this time, intelligent manufacturing technology has moved from the interconnection level to the collaborative sharing level [34]. At the same time, the company value realizes new value creation. By applying technology to the market, companies can obtain new competitive advantages. New technology improves production efficiency to promote the production and manufacturing links to break through the low added value of the original value chain and climb to the new high added value. Finally, it reaches the cross-chain horizontal climb of the second layer of the value chain.

2.3.3. System Sustainability. With the gradual accumulation of information technology, companies spread technology across all value chain links. At this time, companies realize the integration of intelligent equipment into intelligent production units, intelligent production lines, digital workshops, intelligent factories, and even intelligent manufacturing systems [35]. Intelligent production equipment not only improves efficiency but also transmits production data to the R&D end. At the same time, the marketing service link also feeds back the customer’s data to the R&D end. The R&D end further applies the new technology to the production and service ends through the technical improvement of information and data processing to realize the information flow within the value chain. At this time, the new value network form of the value chain is launched. The manufacturing industry will also integrate the value chain among companies through new industrial forms. At this time, each value chain link breaks through the original value-added mode, realizes value co-creation, and achieves the overall rise of the value chain. Finally, it reaches the vertical rise of the new chain at the third level.

3. System Dynamics Analysis of the Value Chain Climbing

3.1. Practical Analysis of the Model. System dynamics is an applied discipline based on computer simulation technology, quantitative research system, and system feedback theory. It quotes and studies complex systems [36]. The causal relationship, system feedback, and other features contained in system dynamics are suitable for analyzing the dynamic relationship within the intelligent value chain climbing system studied in this paper. It is specifically manifested in the following aspects:

(1) Many factors influence the dynamic system of the value chain climbing under intelligence, and the relationship between the factors is complex [37]. The system dynamics method can abstract the interactive relationship between the various levels of the climbing system and marginalize the various influencing factors combined with the structured thinking method so that the problems at all levels of the climbing dynamic system of the value chain under intelligence can be comprehensively analyzed.

(2) The dynamic evolution mechanism of intelligent transformation on value chain climbing applies to system dynamics. System dynamics mainly include system feedback research, causality analysis, dynamic mechanism analysis, etc. It is more in line with the internal and external dynamic mechanism of the value chain climbing system. The framework model of system dynamics, through causality diagram, system flow diagram, and simulation analysis, can simulate and analyze the internal structure, internal power, and evolution law of the value chain climbing system. This can better analyze the dynamic mechanism of the value chain climbing system under the intelligent transformation.
3.2. Analysis of Influencing Factors. Based on the manufacturing characteristics of the manufacturing industry, this paper divides the value chain climbing dynamic system into the original chain climbing subsystem, cross-chain horizontal climbing subsystem, and new chain vertical climbing subsystem from the perspective of multilevel analysis. In the original chain climbing subsystem of the first level, based on the intelligent characteristics, to realize the digitization of resource elements and the interconnection of intelligent technology, manufacturing companies mainly carry out transformation and upgrading driven by technological innovation and intelligence, realizing new value creation. Through the research results of scholars like Jian [38,39], this paper sorts out influencing factors such as the number of intelligent talents, intelligent technology, and scientific researchers. The elements in the original chain climbing subsystem enable the value chain climbing system to break through the original organizational boundary and realize new value co-creation. At this time, the intelligent transformation obtains collaborative sharing of information based on the first level; the cross-chain horizontal climbing subsystem in the second level includes expanding manufacturing scale and emerging competitive advantages. Therefore, this study selects the influencing factors such as the asset scale and output value of manufacturing unit enterprises. In the new chain vertical climbing subsystem of the third layer, with the further development of intelligent transformation, an intelligent manufacturing system is created, and new business forms are produced among enterprises. At this time, the indicators of sustainable green development and relevant government support are selected as well as the influencing factors such as government policy support and industrial energy consumption. Table 1 shows the specific influencing factors.

3.3. System Dynamics Causality Diagram. Based on previous structural analysis and index selection of the value chain climbing system, combined with the principles of data availability and operational feasibility, the dynamic cause and effect diagram of the value chain climbing system under intelligent transformation is constructed using Vensim software (Figure 2).

3.4. Analysis of the Main Feedback Loop of the Value Chain Climbing System. The stock-flow diagram of the value chain climbing system under intelligence is established based on the system causal loop diagram. All feedback loops in the model can be obtained using Vensim software. The causal loop diagram of the value chain climbing system involves many feedback loops. This paper only analyzes the five main feedback loops that affect the value chain climbing.

(1) R&D investment →+ Number of invention patents authorize →+ Technological innovation →+ Original chain climbing level →+ Value chain climbing level

(2) Infrastructure →+ Intelligent efficiency →+ Intelligence level →+ Original chain climbing level →+ Value chain climbing level

(3) Market share →+ Market size →+ Cross-chain horizontal climbing level →+ Value chain climbing level

(4) Industrial energy consumption →+ Industrial solid waste discharge →+ Environmental pollution degree →+ Industrial pollution control investment →+ Green development →+ New chain vertical climbing level →+ Value chain climbing level

(5) Government investment →+ New chain vertical climbing level →+ Value chain climbing level

3.5. System Dynamics Stock-Flow Diagram. The stock-flow diagram of system dynamics is constructed based on the cause-and-effect diagram (Figure 3).

According to the system dynamics model constructed by Jian Xiaobin and Gu bin, the main equations in the model are as follows:

Original chain climbing value increment = INTEG (Intelligence level * weight + Technological innovation level * weight, Initial value).

Cross-chain horizontal climbing value increment = INTEG (Market size, Initial value).

New chain vertical climbing value increment = INTEG (Green development * weight + Government investment * weight, Initial value).

Value chain climbing value increment = INTEG (Original chain climbing value increment + Cross-chain horizontal climbing value increment + New chain vertical climbing value increment, Initial value).

Intelligence level = LN (Intelligent efficiency * weight + Intelligent talent * weight + Intelligent technology service * weight + Intelligent economic benefit * weight).

Technological innovation level = Number of invention patents authorize * (25-New product development cycle).

Market size = Market share + Business income/10.

Green development = 0.5 * Industrial pollution control investment.

Government investment = Government policy support * weight + Government financial support * weight.

4. Data Source and Validity Test

4.1. Data Source. According to the research direction, this paper takes the listed companies in the "2018 Intelligent Manufacturing Pilot Demonstration Project" published by the Ministry of Industry and Information Technology as the research objective. The "Intelligent Manufacturing Development Plan" shows that the development of intelligent manufacturing in China has achieved phased results through the joint development of national and local departments.
The market satisfaction rate of intelligent manufacturing equipment has exceeded 50%, the productivity of pilot demonstration projects has increased by 45% on average, and the product development cycle has reduced by 35% [40]. In addition, process-intelligent manufacturing and mass personalized customization have emerged. At the same time, as a representative digital technology, intelligent manufacturing changes the technological paradigm and industrial pattern leads and gives birth to a series of new products, new models, and new business forms, and has become the core driving force to promote the transformation of China’s manufacturing industry. In addition, the data of listed companies are regularly open, available, and relatively complete. Therefore, taking intelligent manufacturing enterprises as representatives to explore the value-added situation of the value chain climbing is conducive to
revealing the climbing law of the manufacturing value chain under intelligent transformation and grasping the basic situation of China’s manufacturing industry transformation and development [41].

After determining the research object, this paper combs the list of intelligent manufacturing listed enterprises according to the intelligent manufacturing sector in Tong Huashun and Sohu Securities, excluding enterprises that have suffered losses for two consecutive years and may face delisting risk. On this basis, the relevant data of intelligent manufacturing enterprises are being searched according to the company’s official website, the website of the State Intellectual Property Office, and the annual reports of listed companies of Shenzhen Stock Exchange and Shanghai Stock Exchange. The enterprises that could not be collected, had incomplete information, and had too little business volume are eliminated. Finally, this paper retains 15 enterprises. Among the 15 manufacturing enterprises, 8 are registered in first-tier cities, including Beijing, Shanghai, Guangzhou, and Shenzhen; their intelligent businesses cover automobiles, steel, ship, etc. The research takes the intelligent projects constructed by 15 manufacturing enterprises as the object, and the time range of obtaining data is from 2017 to 2020.

4.2. Validity Test. The simulation experiment is carried out based on the model construction. The simulation time is 10 years, the step size is 1 year, and the unit is dimensionless. The validity and scientificity of the model are tested by comparing the simulation data with the actual data. The research takes the amount of enterprise R&D investment closely related to the rise of the value chain as the index, the simulation value is the enterprise R&D investment in the model, and the actual value is the annual average value of the R&D investment index in the annual reports of 15 enterprises. The fitting degree of the model is verified by the real data from 2017 to 2020. Table 2 presents the test results. All numerical errors are within 10%. The model better fits the climbing process of the value chain and passes the effectiveness test.

5. Dynamic Simulation Analysis

5.1. Trend Simulation. First, it analyzes the change trend of the rising level of the value chain. As seen in Figure 4, the rising level of the value chain increases slightly and slowly from 2017 to 2021. This stage is the first stage of intelligent transformation. From 2021 to 2024, the rising level of the value chain shows a rapid growth period. This stage is the second stage of intelligent transformation. The rising level of the value chain increased explosively year by year from 2024 to 2026. This stage is the third stage of intelligent transformation. At the same time, simulation data shows that from 2024, the value chain level will increase significantly for each level of the enterprise in the value chain climbing system. If it reaches the highest level, it can reach the peak value of the value rising level.

The factors affecting the rise of the value chain are further simulated and analyzed. Figure 5 shows the simulation results. All factors have a positive effect on the value chain climbing system. In the first stage of intelligent transformation, there is no obvious difference in the influence of all factors on the value chain climbing system. With the further development of enterprises, in the second stage of intelligent transformation, technological innovation, green development, and market size significantly impact the rise of the value chain. In the third stage of the value chain climbing, green development and market size have the most significant positive impact on the value chain climbing system. Therefore, different stages of intelligent development have different factors that influence the rise of the value chain.
realize the climb from the original climbing layer to the cross-chain horizontal climbing layer in 2023, the second stage of intelligent transformation. Figure 6(b) shows the analysis of the change in technological innovation level in the climbing layer of the original chain and the cross-chain vertical climbing layer. Although the technological innovation level has increased by 80% (current3 in Figure 6(b)), the company still cannot cross from the climbing layer of the original chain to the vertical climbing layer of the new chain, nor can it climb from the cross-chain horizontal climbing layer to the new chain vertical climbing layer in the simulation time.

Figure 7 shows the changes in the vertical climbing level and the cross-chain horizontal climbing level of the new chain when the market size increases by 20%, 40%, and 60% under the condition that other factors remain unchanged. As shown in the figure, when the market size increases by 20% (current1 in Figure 7), the company cannot climb from the cross-chain horizontal climbing layer to the new chain vertical climbing layer during the simulation period. When the market size increases by 40% (current2 in Figure 7), the cross-chain horizontal climbing layer of enterprises in the final stage of intelligent transformation will be infinitely close to the vertical climbing layer of the new chain. When the market size increases by 60% (current3 in Figure 7), the company will climb from the cross-chain horizontal layer to the new chain vertical layer in 2022, the second stage of intelligent transformation.

Figure 8(a) shows the changes at all levels of the value chain climbing system with other factors unchanged, and the green development level increased by 80%. According to the sensitivity analysis of green development, when its level increases to 80%, the company cannot climb to the cross-chain horizontal climbing layer and the new chain vertical climbing layer in the original chain climbing layer (current3 in Figure 8(a)) and the enterprise cannot climb from the cross-chain horizontal climbing layer to the new chain vertical climbing layer. Figure 8(b) shows the changes at all levels of the value chain climbing system when other factors remain unchanged, and the green development level decreases by 20%, 40%, and 60%. The analysis shows that reducing the level of green development will lead to value chain decline. At the same time, if the level of green development reduces to 60% (current3 in Figure 8(b)), the company value chain will fall from the vertical climbing layer of the new chain to the horizontal climbing layer of the cross-chain.

5.2. Sensitivity Analysis. According to the above analysis, intelligence level, technological innovation level, market size, green development, and government investment all play a positive role in promoting the rise of the value chain. Among them, technological innovation level, green development, and market size always have a significant impact on the rise of the value chain in the intelligent transformation. Therefore, the sensitivity analysis of the internal changes of the value chain climbing system for technological innovation level, green development, and market scale is carried out below. Figure 6(a) shows the changes in the original chain climbing level and cross-chain horizontal climbing level when the technological innovation level increases by 40%, 60%, and 80% under the condition that other factors remain unchanged. As shown in the figure, when the technological innovation level increases by 40% (current1 in Figure 6(a)), the company cannot climb from the original climbing level to the cross-chain horizontal climbing level during the simulation period. When the technological innovation level increases by 80% (current3 in Figure 6(a)), the company will

5.3. Simulation Analysis. According to the simulation trend results, first, under the intelligent transformation of manufacturing enterprises, intelligent development, technological innovation level, market size, green development, and government investment all positively impact the rise of the value chain. In the early stage of development, various factors have little impact on the rise of the value chain; it is more obvious in the later stage of development. At the same time, with the continuous extension of intelligent transformation, in the information age of technological change.
Through sensitivity analysis, this paper analyzes the rise of each layer of the value chain system from three main factors: (1) under the condition that other factors remain unchanged, the substantial improvement of the level of technological innovation can promote the original chain climbing to cross-chain horizontal climbing. At the same time, the more the level of technological innovation is improved, the faster the leap in the level can be realized. This shows that if enterprises want to realize the initial climbing of the value chain, they can realize it only through technological investment. The more technological investment, the faster the value chain can be realized. However, investment in technological innovation cannot realize the vertical climb from the original chain climbing to the new chain climbing, which shows that enterprises cannot achieve the high-level climb only through the promotion of technological innovation. This may be because technological innovation will reach maturity at a certain stage of intelligent development, and all enterprises in the market have certain technological resources. The added value of technology is not enough to drive the rise of the entire value. (2) When other factors remain unchanged, the effective improvement of market scale will promote enterprises to climb from the cross-chain horizontal climbing layer to the new chain vertical climbing layer. When the market scale increases slightly, the high-end climbing of the enterprise value chain can be realized. It shows that the market scale has played a significant role in promoting the high-end climbing of the value chain. In the process of intelligent transformation, improving market scale not only improves the customer group of enterprises but also analyzes customer information that can extract important data and provide effective feedback to all links of the value chain to improve product quality and refine production. Data transmission of all links can also give feedback to the customer group to improve satisfaction. (3) As for green development, while other factors remain unchanged, only improving its level cannot effectively promote the rise of the value chain. At the same time, reducing the level of green development will inhibit the rise of the value chain, which shows that the in the later stage of intelligent transformation, green development is an important factor for the rise of high-

and intelligent development, market size and green development have played a prominent role in the rise of the enterprise value chain. Second, in the early stage of intelligent transformation and development, companies pay more attention to their technological innovation and intelligent development levels. With the continuous improvement of technological level, companies need to pay attention to the scale of products in the market and sustainable development if they want to achieve further value chain rise. Finally, in the intelligent transformation process, the value chain system rises in an orderly, layer by layer manner. At the initial stage of intelligent transformation, all levels of the value chain system are at a low level and continue to rise slowly for a period. With the intelligent transformation as a new strategy, the innovation accumulation and development may be slow and risky at the initial stage of the transformation, and the intelligent products may be small in the market and unable to reach a certain customer group, hindering the effective transmission of information. In the middle and late transformation, on the one hand, the technical level is relatively mature. However, the market size gradually opens, and intelligent technology and effective information are effectively integrated and shared in all value chain links. At this time, all levels of the value chain system realize value-added, and the higher the level of the value chain system, the greater the value-added.
end enterprises. Although it cannot effectively promote the rise of the value chain, if the enterprise is already at the high end of the value chain system and only pays attention to technological innovation and market scale while ignoring green development, it will also be unable to achieve the rise of the value chain in further development.

6. Discussion and Conclusion

Intelligent manufacturing as a new development direction in the manufacturing industry has produced subversive changes in industrial structure, market demand, and lifestyle. This research breaks through the traditional “smile curve” value chain research perspective, takes the intelligent transformation as the background, analyzes the value chain climbing system through the characteristics of intelligent development, and uses the system dynamics simulation analysis method to study the influencing factors and internal climbing logic of the value chain climbing system. The main research conclusions are as follows: (1) In the context of intelligent transformation, this paper breaks through the traditional value chain research methods based on the multilevel analysis framework. The value chain climbing system is divided into three subsystems: the original chain climbing, cross-chain horizontal climbing, and new chain vertical climbing. (2) Among the five factors affecting the value chain climbing, intelligence level, technological innovation level, market size, green development, and government investment, the influence of various factors in the early stage of value chain climbing is not different. Market size and green development greatly influence the value chain climbing in the later stage. (3) The sensitivity simulation results show that in the value chain climbing system, increased technological innovation will be stored in the value chain from the first layer to the second layer, increased market size will promote the value chain from the second layer to the third layer, and reduced green development will inhibit the rise of the value chain.

Through dynamic system simulation analysis, this paper presents different value chain climbing strategies according to the development of enterprises in different manufacturing industries. (1) Traditional manufacturing companies, such as textile companies and metal processing companies, often have not yet undergone intelligent transformation or are still in the early stage of intelligent transformation. The scarcity of intelligent resources or the lack of intelligent technology makes it difficult to carry out intelligent transformation. At the same time, due to the competition in the industry and the scarcity of resources, traditional enterprises want to achieve a high-end rise in the value chain under the development of intelligent transformation, and continuous technical investment is required. The key point is obtaining independent core technology through cooperation with universities and scientific research institutes. However, core technology cannot be acquired overnight. It may require long-term accumulation and high investment, and the time span is also long. It is often difficult for some companies to maintain long-term investments in technology. At this time, the relevant encouragement of the government is needed to help companies better achieve technological breakthroughs and achieve intelligent transformation through policy or financial support. The development of innovative technology can drive the value increase of other links in the value chain to achieve the high-end rise of the value chain. (2) Advanced manufacturing enterprises, such as biological manufacturing companies and nanomanufacturing companies, which are different from traditional enterprises, often have more advanced technical equipment and management means. Under intelligent transformation, these companies often have certain technical advantages. However, with the diffusion of technology, the needs of market users also gradually increase. At this time, it is difficult to achieve the rise of the value chain only by improving the level of technological innovation. Therefore, companies should expand the market size, collect market customer information, process effective information with intelligent technology, and give feedback to the production and R&D ends to realize value-added and promote the high-end rise of the value chain with targeted R&D and productivity improvement. (3) Strategic emerging manufacturing companies, such as semiconductor companies, lithium battery companies, and mobile phone companies, often have government support and are concentrated in economically developed regions. With mature technology and a certain market scale, these enterprises will take the cost
of polluting the environment to achieve the high-end rise of the value chain under the development of intelligent transformation. Therefore, these enterprises should pay attention to green sustainable development. If they continue to invest in other factors and ignore green development, it may hinder intelligent transformation and company development. To obtain sustainable competitive advantage and value-added, companies must promote the higher-level rise of the value chain with an effective combination of green development and other factors.

This paper takes the value chain climbing dynamic system under intelligent transformation as the research object, uses the system dynamics analysis method, takes the listed companies as the research object, constructs the value chain climbing dynamic system model from the MPL perspective, and analyzes the influence of relevant factors on the value chain climbing dynamic system in the process of intelligent transformation through simulation. It provides a new idea for the research of the value chain climbing under the intelligent transformation of the manufacturing industry. This paper still has some limitations in analyzing the influence factors on the value chain climbing dynamic system research. Research only gives the effect of influence factors on the subsystems of the value chain climbing system; however, the specific investment of influence factors that can promote the climbing of the subsystems within the value chain-climbing dynamic is unclear. Therefore, future research can deeply analyze the impact of input factors on the increase between subsystems to further enrich the research content of the value chain climbing.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This study was supported by Liaoning Social Science Planning Fund Project (L19BJY037).

References

[20] B. Karimi and M. Bashiri, “Designing a Multi-commodity multimodal splittable supply chain network by logistic hubs


