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Research on the High-Quality Development of Innovation in Private Manufacturing Industry Based on Game Theory

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Abstract

Promoting high-quality development and innovation-driven growth in the manufacturing industry is crucial for enhancing the efficiency of traditional manufacturing and achieving economic transformation. This paper discusses the current development status and innovation strategies of private traditional manufacturing in three parts, establishing a game model to reveal the game status between exploratory innovation and exploitative innovation in manufacturing enterprises. Finally, it offers suggestions for the smooth and efficient realization of high-quality development in the private manufacturing sector.

Keywords: Private manufacturing; Innovation-driven; Game theory

Since the 19th National Congress introduced the concept of "high quality," high-quality development has become key to addressing the current economic pressures and overcoming development challenges in China. Since the reform and opening up, the private manufacturing sector has made significant contributions to taxation, GDP, technological innovation, and employment. This paper starts from the current status of private manufacturing development and analyzes innovation strategies from a game

theory perspective, aiming to promote high-quality development in the private manufacturing sector.

1. Current Status of Private Manufacturing and High-Quality Development

1.1 Current Status of Private Manufacturing

1.1.1 Low Product Added Value

Developed countries emphasize high-value-added technologies and sales processes, improving resource consumption structures and implementing intensive growth. Currently, China's manufacturing industry remains at the low end of the value chain, developing under a resource-intensive consumption model. Many private enterprises invest insufficiently in product design and technology research and development, making them easily replaceable by similar products in the market. To reshape the poor economic development status of private manufacturing, it is essential to increase the added value of manufacturing, overcome the low-end value chain dilemma, and create a high-quality phase primarily focused on resource concentration.

1.1.2 Weak Independent Innovation Capability

Although since 2013, China's equipment manufacturing industry has made significant breakthroughs, positioning itself as a leading global manufacturing power, there remains a high degree of external reliance on key technologies, with weak independent research and development capabilities. Manufacturing enterprises rely on foreign investment for brand and technology standards, which limits their actual profit margins. Therefore, it is necessary for the government to draft industry support policies, and enterprises should learn from exemplary models, independently innovate, shift their mindset, develop long-term plans, and collectively promote the transformation from "Made in China" to "Intelligent Manufacturing in China."

1.2 High-Quality Development in the Context of Manufacturing

The high-quality development of manufacturing requires the complementary relationship between research and development and innovation. Enterprises must continuously invest in R&D, master core technologies, and enhance the technological content and added value of their products to adapt to market demand changes and upgrades. Environmental protection and sustainable development are key components of high-quality manufacturing development. Private manufacturing should actively adopt clean energy, optimize production processes, reduce waste emissions, and achieve environmentally friendly production. Talent cultivation and attraction are equally crucial for the high-quality development of the manufacturing sector. A high-quality talent pool is the foundation for driving technological and managerial innovation. Therefore, enterprises should increase their investment in human resources, attract and retain talent through education, training, and incentive mechanisms, and create a continuous innovation momentum.

2. Game Model of Innovation in Private Manufacturing

2.1 Game Theory and Nash Equilibrium

Game theory, also known as strategic decision theory, is a branch of modern mathematics that focuses on the strategic interactions between rational decision-makers in situations of conflict and cooperation. Within the framework of game theory, individual or collective participants make decisions under a defined set of rules to maximize their own interests or utility. Each participant must consider the possible strategies of others and their potential impact on their own outcomes. Nash equilibrium is a specific case in game theory that describes a state in which each individual believes they have made the optimal choice. In this state, no single individual can achieve a better outcome by changing their strategy unilaterally.

2.2 Exploratory Innovation vs. Exploitative Innovation

Innovation investments can be categorized differently depending on the period. Investments during the exploratory phase are referred to as exploratory innovation, while investments during the development phase are called exploitative innovation. The distinction lies in the fact that exploratory innovation is based on new knowledge and skills and involves exploring unknown areas, while exploitative innovation utilizes existing knowledge and technology for innovation. Furthermore, the long duration and continuity of exploratory innovation imply that it undergoes a prolonged phase from input to resource output to production application, while exploitative innovation requires less investment and is less time-consuming. In terms of profitability and investment risk, exploratory innovation seeks opportunities to enter new markets based on new knowledge, creating advantages and achieving high profits; however, due to its long cycle and uncertain outcomes, it carries higher investment risks. In contrast, exploitative innovation directly utilizes existing knowledge and technology in production, resulting in more predictable outcomes and lower risks.

2.3 Game Model of Innovation in Traditional Manufacturing

The following explores the game model of innovation methods in private manufacturing enterprises. When two manufacturing companies engage in exploitative innovation-utilizing existing knowledge and technology production for innovation-there may be differences in the timing of their innovation successes; however, this timing difference does not result in a monopolistic market by the first successful innovator. Since exploitative innovation generally has a short duration and is simply a utilization of existing resources, the two companies remain homogeneous, still facing price pressure from customers or suppliers. Therefore, manufacturing companies

cannot gain monopolistic power during the exploitative innovation phase. Here, we assume the economic profits of both manufacturing companies are (0, 0).

When both manufacturing companies engage in exploratory innovation, they each achieve monopolistic advantages. This is due to the fact that both companies produce new technologies, methods, and knowledge, resulting in unique products not yet seen in the market, further expanding their competitive advantages. Compared to customers or suppliers, they gain bargaining power. Through exploratory innovation, the industry reaches a situation of bilateral monopoly, and we assume the profits for both manufacturing companies are (10, 10).

If one company engages in exploratory innovation while the other engages in exploitative innovation, the longer time frame of exploratory innovation and numerous unpredictable factors may lead to the exploratory innovator's product being outperformed by the exploitative innovator's product before achieving successful innovation. Consequently, the exploratory innovating company may be eliminated from the market, while the exploitative innovating company succeeds. Here, we assume the exploratory innovating company incurs a loss of -10, leading to profits of (10, -10) for the two manufacturing companies.

3. Conclusion

Thus, through an analysis of the current development status of private traditional manufacturing and the game dynamics between exploratory and exploitative innovation, it is evident that for private manufacturing to achieve high-quality development, it must focus on exploratory innovation, continuously developing new technologies, products, and services to meet new customer and market demands, aiming for an effective transition from "manufacturing" to "intelligent manufacturing."

References

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