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The Effect of Production Structure Roundaboutness on the Innovation Capability of High-Tech Enterprises—The Mediating Role of Technology Absorption Path

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Abstract: From the perspective of production structure sustainability, this study investigates the source of innovation power of high-tech enterprises. It proposes that the roundaboutness of production structure is the sustainable driving force for improving innovation capability in high-tech enterprises, and enterprises can improve their innovation capability by absorbing technology from three paths. The proposed model was tested based on the survey data from 315 enterprises in 10 robotics industrial parks in the Yangtze River Delta region of China. The results show that the roundaboutness of production structure has a positive influence on the innovation capability of high-tech enterprises, which is mediated by technology absorption paths (i.e., independent development in high-tech enterprises, technology acquisition in high-tech enterprises and government policy compliance in high-tech enterprises). Meanwhile, the enterprise has different technology absorption path at different position in production structure. The findings have important enlightenment for enterprises to improve market competitiveness, production efficiency and technological innovation capability, and provides a practical basis for better ways of leveraging market and capital and more effective government processes in industrial innovation.

Keywords: high-tech enterprise; production structure; innovation capability; technology absorption; roundaboutness

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1. Introduction

In the era of digital economy, the high-tech industry integrating high intelligence and high technological innovation has increasingly become the key factor enabling countries to improve their international competitiveness and achieving sustainable development [1–3]. As an important source of innovation in the new era of economic growth [4,5], high-tech industry needs to improve its technological innovation capability to increase the competitive advantage. Therefore, it is urgent to elucidate how to form sustainable innovation capability and innovation ecology among high-tech enterprises, and to identify the source of high-tech enterprises' innovation.

Improvement of technological innovation capability can be realized mainly in two paths: independent innovation based on research and development (R&D) investment or secondary innovation through technology introduction, absorption, and digestion [6]. Kim et al. [7] pointed out that external innovation has both complementary and substitution effects on the growth of local technological innovation, and the dominant effect depends on technology absorption capacity. In fact, with the increasing complexity of the technology environment and the intensification of competition, systematic division of labor and collaboration has become the mainstream paradigm of healthy industrial development [8]. In this case, there are many views on how enterprises can develop innovation

capability through technology absorption. Wu et al. [9] argued that technology import plays a crucial role in enhancing regional innovation capability. However, Weigelt [10] believes that enterprises rely more on technology acquisition, which may make enterprises form technology dependence and weaken the motivation of enterprises for independent learning and development. That is, technology acquisition may not be the best route to innovation [11]. Based on the results of a dynamic panel data model, Qi et al. [12] proposed that R&D input and industrial structure, not technology import, are the main sources of improved innovation capability. In addition, the research of Zhang et al. [13] differed from previous technological perspectives, indicated that policies have great potential to promote technological innovation of enterprises.

In sum, previous studies have explored multiple possible paths of the impact of technology absorption on innovation capability, but no consensus has been reached. More importantly, these studies do not directly start from the sustainable driving power of innovation capability improvement, and they lack a comparison of paths and effects. In addition, as far as microenterprises are concerned, it is not clear what key technologies can be acquired to facilitate efficient participation in intra-industry collaboration and how to access the required technology path in the open innovation mode. Therefore, the specific path and effect of technology absorption and its impact on innovation performance still need to be carefully explored.

Based on the argument of the roundaboutness of production structure, this paper discusses the source of the innovation power of high-tech enterprises and posits that the roundaboutness of production structure provides sustainable power for improving enterprises' innovation capability. The increase of the roundaboutness on enterprise's production structure improves the production process and system, enhances the completeness of production, and promotes the production efficiency, which will provide a sustainable driving force for enterprise innovation. Meanwhile, the roundaboutness of the production structure of enterprises affects the innovation capability of enterprises through three paths: independent development, technology acquisition, and government policy compliance. Based on the production sequence division (high (e.g., raw material), intermediate (e.g., manufacture), or low stage (e.g., retail)) in the Hayek triangle [14], this paper tests the different effects of the roundaboutness of production structure on the technology absorption power and path of high-tech enterprises in different production stages.

This study offers four important contributions. First, it reveals the internal driving force of technology absorption in high-tech enterprises from a perspective of production structure. This finding will expand the way that technological innovation diffusion is interpreted, fill the gap between theoretical exploration and practical interpretation, and provide decision support for high-tech industrial agglomeration to give full play to the advantages of cluster innovation diffusion and improve the performance of high-quality innovation diffusion. Second, by distinguishing the three paths of enterprise technology absorption, this study improves the interpretation of the micro-mechanism of technology diffusion and provides a reference for supply and adoption decision-making in the context of enterprise technology innovation. Third, the research results show that in order to promote performance and participate in cluster collaborative innovation, enterprises need to innovate in a way that benefits the production structure and its roundaboutness, and this finding sheds a new light on the regulation of technological innovation diffusion. Fourth, this study can provide a practical basis for better ways of leveraging market and capital and more effective government guidance in industrial innovation.

2. Literature Review

2.1. Innovation Diffusion and Technology Absorption

Innovation is the process of applying creativity to practice. From the perspective of process, the diffusion of technological innovation can be regarded as the process of improving the efficiency of production structure. Enterprise clustering is a mainstream way of improving regional economic development, and it plays an important role in optimizing re-

gional industrial structure and building a technological innovation platform [15]. Although the diffusion process model of technological innovation, which is based on enterprise clustering, is often used to improve the level of science and technology and regional economic competitiveness [16], the micro-mechanism of its operation is not clear. Some studies only conduct static analysis incorporating the market environment, policy environment and social environment, which are insufficient to ensure the effective diffusion of technological innovation [17]. Looking at the phenomenon of industrial agglomeration from the perspective of production structure, the specific industries gathered can be regarded as the micro production structure, and enterprises of different types constitute each part of the micro production structure.

From the currently popular network perspective, the industrial chain network of high-tech industrial cluster is composed of core enterprises, competitive enterprises, upstream and downstream enterprises, and so on. The network diffusion of technological innovation requires the ability of cooperation and matching among enterprises. Innovation resources, such as information, capital, and technology, will affect the efficiency of network diffusion and restrict the unity of industrial chain, value chain, and ecological chain. Studies have shown that different enterprises play different roles in technology diffusion and absorption. For example, Andergassen et al. [18], studying an economy composed of technologically heterogeneous companies, found that the larger the technology gap between companies, the less conducive the economy is to technology diffusion. The research results of Zhu et al. [19] confirmed that there are differences in the performance of different types of enterprises in terms of operation and innovation diffusion. In the context of industrial agglomeration, overall competitiveness can be improved only by giving full play to the industrial synergy among different enterprises. Although some scholars study synergy from the perspective of the industrial chain and supply chain, this idea puts more emphasis on the operational stability and efficiency of agglomeration areas, rather than dealing with output fluctuations and innovation. Meanwhile, although many studies have focused on the impact of the network relationship between enterprises on regional innovation and industrial agglomeration, the direction of innovation source and diffusion is still not clear. As the research of Li and Ju [20] identified, innovation process has the characteristics of openness, dynamic, nonlinearity, and fluctuation. Enterprises should play their adequate roles in the production structure to improve technology innovation capability.

Studying the absorption of technology from the perspective of production structure offers great promise, but work in this area is just beginning. Makkonen et al. [21] pointed out that the customer-dominant logic framework can provide a reasonable explanation for the behavior mechanisms that organizations adopt for technological innovation, as these mechanisms shape technology transformation activities by locking in the foundation, business relationships and key roles to determine the technology objectives. Wang et al. [22] interpreted the diffusion process of technological innovation in China and defined its stages by constructing an agent-based model. The results show that effective innovation occurs in the eastern region, while the central region needs policy stimulation to spread technological innovation. Although these studies involve the production structure, they lack in-depth analysis. This paper uses the production structure model proposed by Hayek to explore the micro-mechanism of innovation capability cultivation based on different technological paths in innovation diffusion.

2.2. Production Structure and Its Roundaboutness

The Austrian business cycle theory originated by Menger was gradually recognized in theoretical circles after Hayek's interpretation [23]. As one of the core concepts, production structure has been applied by more and more research institutes. Production structure describes the distribution structure of capital goods in each production process within the whole society. The research results of Singh [24] showed that on average, structural change is conducive to productivity growth. The more stages the production process goes through,

the more roundabout the production process is and the higher the production efficiency is [25]. The extension of the production process reflects the progress of technology [26].

When the roundaboutness of production increases, a new stage of production will appear, so the production structure will continue to expand vertically. A change in production structure thus entails a change in roundaboutness. The roundaboutness of production structure refers to the process of producing more advanced capital goods in order to produce consumer goods [14]. The goods circulating within the production structure are called capital goods. Capital goods farther from final consumer goods are considered superior, while those closer to the final consumer goods are considered inferior. Viewed statically, the production structure describes the structural relationship between the quantity and distribution of capital goods input at each stage of production. Viewed dynamically, the production structure describes the process by which the final consumer goods are traced through a circuitous production process [27]. As Bohm-Bawerk pointed out, the production of consumer goods is a process of continuous input and transformation of a series of capital goods in different production stages, and the more stages it goes through, the more complex it is and the more roundabout it is considered [28]. The more roundabout a whole production stage is, the higher the completeness of consumer goods production.

According to the Hayek triangle (see [14]), a change of production roundaboutness means an expansion of production structure [29]. Increased roundaboutness reflects a production process involving deepening division of labor and complexity of production. In fact, roundabout production is a hallmark of modern consumer goods production, and roundabout production can promote economic growth and sustainable development by accelerating technological progress [30]. Young [31] proposed using TIOR (total industry output requirement) to express the quantitative measurement of roundaboutness. However, most scholars study roundaboutness in view of specific problems of economic growth, while only a few uses the theory of production roundaboutness to analyze industrial economies [30,31] and very few conducts in-depth studies that combine the production roundaboutness theory and technological innovation. This paper hypothesizes that to some extent, the roundaboutness of production structure can provide high-tech enterprises with the internal power needed for the external diffusion of core technology, which is an important factor to be considered in the process of enterprise innovation strategy formulation.

3. Relevant Hypotheses

3.1. Roundaboutness

Independent development in high-tech enterprises means that enterprises rely on their own strength and resources to carry out original innovation and high-tech research. The roundaboutness of production structure in high-tech enterprises plays an important role in promoting the independent development of enterprise technology. The roundaboutness of production structure can accelerate the technological progress of enterprises, provide certain internal power for the absorption of technology within the organization, and realize an increase of economic benefits [32]. When the roundaboutness of the whole production structure promotes the further refinement of the division of labor in the value chain, and the enterprise's internal production complexity increases, and it need to carry out independent innovation to fit the changed structure. Under the influence of the roundaboutness of production structure, enterprises tend to obtain stable technological innovation output, and they have the motivation to carry out independent technological development. Therefore, this paper proposes the following hypothesis:

Hypothesis 1. *The roundaboutness of production structure in high-tech enterprises positively impacts their independent development.*

Technology acquisition refers to the enterprises adopt advanced technology, new products, or external experience to implement technology innovation. The roundaboutness of production structure plays an important role in promoting the technology acquisition

in high-tech enterprises [33]. When productivity is improved by increasing the roundaboutness of production structure, as the intermediate links increase, the completeness of the industry will gradually become saturated, and the complexity of the requirements for capital goods upstream and downstream of the enterprise will also change. Driven by the roundaboutness of production structure, enterprises will strengthen their technology acquisition because of the internal complexity of production and the complexity of external upstream and down-stream requirements for capital goods. Technology acquisition under human intervention will faster enterprises to improve their innovation capability under the effect of roundaboutness of production structure. Therefore, this paper proposes the following hypothesis:

Hypothesis 2. *The roundaboutness of production structure in high-tech enterprises positively impacts their technology acquisition.*

Some researchers have emphasized the potential of roundabout production to cause change in the industrial competition environment and to change the division of production and resource allocation [30]. Under the influence of the roundaboutness of production structure, a study by Huggins et al. [34] found that rapid development of the middle and lower reaches of the industry may make the innovation development of upstream enterprises more difficult while also increasing the enterprise's vulnerability in its middle and lower reaches, and at this time, enterprises will more comply with relevant government policies. Government policy compliance in high-tech enterprises refers to the process of enterprises following and obeying the industrial policy of the government, adjusting and changing their attitudes and behaviors, and recognizing and accepting the policy from motivation to behavior. Gabriele [35] stated that in the context of roundabout production, the defects of market resource allocation and division of labor mechanisms motivate government policy-making departments to guide enterprises to realize industrial upgrading through coordination of industrial policies. Enterprises need to comply with the direction of policies to adapt the changed production structure. Therefore, this paper proposes the following hypothesis:

Hypothesis 3. *The roundaboutness of production structure in high-tech enterprises positively impacts their government policy compliance.*

3.2. Innovation Capability

High-tech enterprise innovation capability is the core of national and regional competitiveness as well as the key to the survival and development of enterprises [36]. In order to support adjustments to economic structures and transform growth patterns, it is essential to improve enterprises' innovation capacity and rely on scientific and technological progress to accelerate traditional industries and open new ones [37]. Prior studies have shown that independent R&D in high-tech enterprises have significant effects on their productivity and innovation performance [38,39]. Through internal R&D investment, enterprises can not only realize the creation and accumulation of knowledge but also improve their technological foundation and innovation capability [40]. As a strategic resource, the independent development of enterprises can not only reflect the competitiveness of enterprise products, but also reflect the ability of enterprises to absorb capital. Independent development in high-tech enterprises is the source power of enterprises' development and core competitiveness that needs to be strengthened urgently. High-tech enterprises urgently need to improve their innovation strategy and enhance independent development to promote innovation capability [41]. Therefore, this paper proposes the following hypothesis:

Hypothesis 4. *The independent development in high-tech enterprises positively impacts their innovation capability.*

Technology acquisition in high-tech enterprises is also an important means to improve the performance of innovation [41]. Compared to internal R&D, technology acquisition can help enterprises make better use of existing resources, achieve economies of scale for innovation, and reduce R&D costs [42]. More importantly, the introduction of outer advanced technology can greatly improve the technical level in a short time and at a low cost. Technology is cumulative. Technology acquisition in high-tech enterprises can increase the depth and breadth of their technology and increase their technology base, which is conducive to the improvement of enterprises' innovation capability [43]. The introduction of new technology can increase the level of knowledge base, make up the disability of knowledge capital accumulation, and play a positive role in improving the innovation capability of enterprises; on the other hand, digestion and absorption of the introduced technology helps enterprises creatively convert the introduced technology into a more comprehensive and systematic new technology, creating opportunities for enterprises to imitate new technology, and further promote the improvement of enterprises' innovation capability [44]. Therefore, the following hypothesis is proposed in this paper:

Hypothesis 5. *The technology acquisition in high-tech enterprises positively impacts their innovation capability.*

Wei and Liu [45] found that government support can improve enterprise innovation performance. Governments can provide innovation support for enterprises through fiscal incentives, regulatory regulations, and related policies to achieve the goal of developing national innovation capability, improving productivity, and creating a suitable innovation environment [46]. Government often plays an important role as the provider of information and technology resources needed for the innovation process, and its mediating and guiding functions, such as policy guidance, financial support, and market induction, play an important role in the extent of enterprises' innovation performance in the cluster [47]. Major government fiscal incentives, such as special loans and tax credits, have a positive impact on enterprises' innovation performance [48]. As an important innovation-driven source subject, high-tech enterprises have received more and more key support from the government, and their enjoyment of a series of preferential policies will significantly encourage their R&D input and output, especially substantive innovation [49]. Therefore, this paper proposes the following hypothesis:

Hypothesis 6. *The government policy compliance in high-tech enterprises positively impacts their innovation capability.*

In summary, this paper proposes the research model as shown in Figure 1.

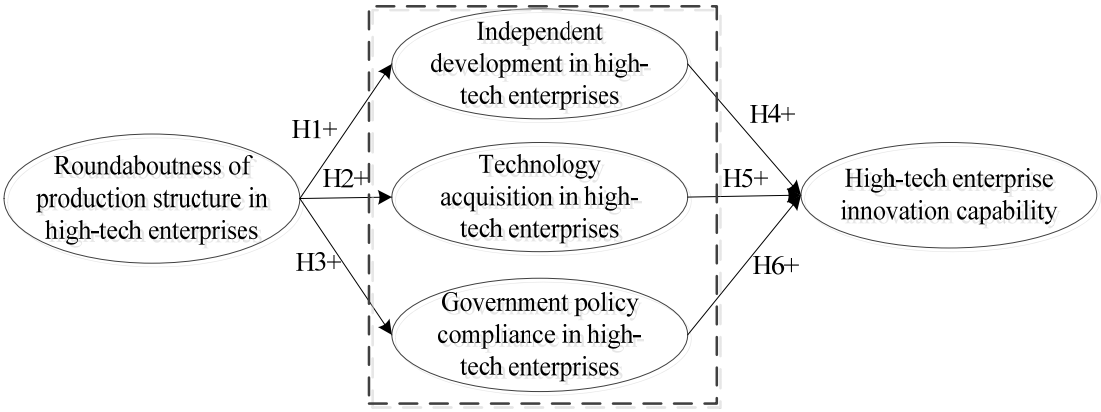

Figure 1. Research model and hypotheses.

4. Data Collection and Analysis

4.1. Data Collection

To test the hypotheses proposed in this study, a questionnaire survey was used to collect data. The researchers surveyed 400 enterprises in 10 robotics industrial parks (40 firms per park) in China's Yangtze River Delta region. Considering that this study involves product judgment and technology evaluation, only marketing department executives who had worked in the enterprise for more than one year were randomly selected to fill in the questionnaire. The survey lasted 40 days from the beginning of March to the middle of April in 2020, 400 questionnaires were issued, and 315 valid questionnaires were recovered. A grouping T-test of the first 50 and the last 50 questionnaires showed that there was no significant nonresponse bias in the data, and Harman's single factor test showed that there was no significant homology bias. Table 1 summarizes the sample characteristics.

Table 1. Sample characteristics.

Characteristic (N = 315)		Frequency	Percentage
Gender of marketing executives	Male	175	55.56%
	Female	140	44.44%
Operation time of enterprises	One to three years	151	47.94%
	Four to six years	87	27.63%
	More than six years	77	24.44%
The number of employees	0–10	36	11.43%
	11–20	150	47.62%
	21–30	99	31.43%
	30–50	30	9.52%

4.2. Questionnaire Design

The survey questionnaire consists of three parts. The first part is the explanation, which not only expounds the research purpose but also concretely explains the meaning of the production structure and draws the schematic diagram of the Hayek triangle to explain the three stages (high, intermediate, and low). The second part is the scale of variables involved in this study, all of which are measured on a five-point Likert scale. To measure the roundaboutness of production structure in high-tech enterprises, two items were modified from Acemoglu and Autor [30]. Independent development in high-tech enterprises measurement items were adapted from Han and Feng [50], the items of technology acquisition in high-tech enterprises were adapted from Wang et al. [51], and the government policy compliance in high-tech enterprises items were adapted from Tyler and Blader [52]. The measurement for the dependent variable, high-tech enterprise innovation capability, items was adapted from Huang [53] (See Table 2). Since in this study the robotics industry is regarded as a complete industrial chain and a single production structure, enterprises were asked to evaluate their positions in regard to the three stages of production structure in a subjective way; 106 enterprises identified themselves as being in the high stage, 106 in the intermediate stage, and 103 in the low stage.

Table 2. Variable measures, items, and factor loading.

Variable	Item	Mean	Standard Deviation	Factor Loading
Roundaboutness of production structure in high-tech enterprises	1. The length of the production chain between products/services provided and consumer goods has changed greatly	3.70	0.852	0.764
	2. There are significant changes in the technology inherent in the products/services provided	3.67	0.887	0.751

Table 2. *Cont.*

Variable	Item	Mean	Standard Deviation	Factor Loading
Independent development in high-tech enterprises	1. Our enterprise relies on setting up research and development institutes to develop new technology	3.67	0.814	0.773
	2. Our enterprise relies on our excellent people to develop new technology	3.68	0.876	0.796
	3. Our enterprise relies on free equipment to develop new technologies	3.69	0.820	0.732
	4. Our enterprise is willing to invest resources to develop new technology	3.63	0.850	0.793
Technology acquisition in high-tech enterprises	1. Our enterprise realizes technology updates through purchase	3.69	0.884	0.805
	2. Our enterprise uses the purchase of technology to meet the requirements of development	3.75	0.877	0.776
	3. Our enterprise has a good technology acquisition project implementation ability	3.72	0.877	0.761
	4. Our enterprise can control the cost and scale of technology acquisition projects	3.71	0.921	0.792
Government policy compliance in high-tech enterprises	1. Our enterprise absorbs technology according to park policy orientation	3.54	0.925	0.822
	2. Our enterprise absorbs technology in accordance with the direction of technology policy guidance	3.53	0.876	0.801
	3. Our enterprise earnestly implements the park's science and technology development guidance policy	3.53	0.950	0.807
	4. Our enterprise absorbs technology according to the layout of park and government planning	3.52	0.901	0.816
High-tech enterprise innovation capability	1. Our enterprise introduces new products/services very quickly	3.64	0.934	0.820
	2. The technical service scheme of our enterprise is very novel	3.57	0.921	0.812
	3. Our enterprise is able to open up new markets	3.57	0.921	0.810
	4. Our enterprise innovation output is considerable	3.50	0.925	0.774

Notes: (1). The calculated load values were significant at the 0.001 level; (2). Index of the confirmatory factor model are Chi-Square (180.567)/df (125) = 1.445, $p < 0.01$, CFI = 0.982, TLI = 0.978, IFI = 0/82, GFI =0/37 and RMSEA = 0.038.

4.3. Reliability and Validity Test

To ensure the validity and reliability of measurement, AMOS 21.0 was used to construct a five-factor confirmatory factor model. As shown in Table 3, the parameters of the constructed factor model all conform to the recommended range of Hair et al. [54], indicating that the data fit is good. At the level of measurement items, the standardized factor load of each question is greater than the required threshold value of 0.5, indicating that each measurement item has sufficient reliability and validity. Meanwhile, the combined reliability of variables is greater than 0.7, AVE is greater than 0.5, and the square root of AVE is greater than the correlation coefficient corresponding to row and column. The results show that the measurement items have sufficient reliability and discriminant validity at the variable level.

Table 3. Correlation coefficient and reliability and validity.

Variable	CR	AVE	1	2	3	4	5
1. Roundaboutness of production structure in high-tech enterprises	0.729	0.574	0.757				
2. Independent development in high-tech enterprises	0.857	0.599	0.657	0.774			
3. Technology acquisition in high-tech enterprises	0.864	0.614	0.593	0.622	0.784		
4. Government policy compliance in high-tech enterprises	0.885	0.659	0.446	0.519	0.531	0.812	
5. High-tech enterprise innovation capability	0.880	0.647	0.518	0.643	0.682	0.685	0.804

Notes: (1). CR = composite reliability; (2). AVE = average variance extracted; (3). below the diagonal is the correlation coefficient between variables, above the diagonal is the square root of AVE.

4.4. Structural Equation Model

To test the hypotheses proposed in this study, AMOS 21.0 was used to build a structural equation model. The model fit, standardized correlation coefficient and significance are shown in Figure 2. The results show that the roundaboutness of production structure in high-tech enterprises has a significant positive impact on their independent development

($\beta = 0.790,\ p < 0.01$), technology acquisition ($\beta = 0.744,\ p < 0.001$), and government policy compliance ($\beta = 0.606,\ p < 0.001$), supporting hypotheses H1, H2, and H3. Meanwhile, high-tech enterprise innovation capability is positively driven by its independent development ($\gamma = 0.236,\ p < 0.001$), technology acquisition ($\gamma = 0.335,\ p < 0.001$) and government policy compliance ($\gamma = 0.401,\ p < 0.001$), which supports hypotheses H4, H5 and H6.

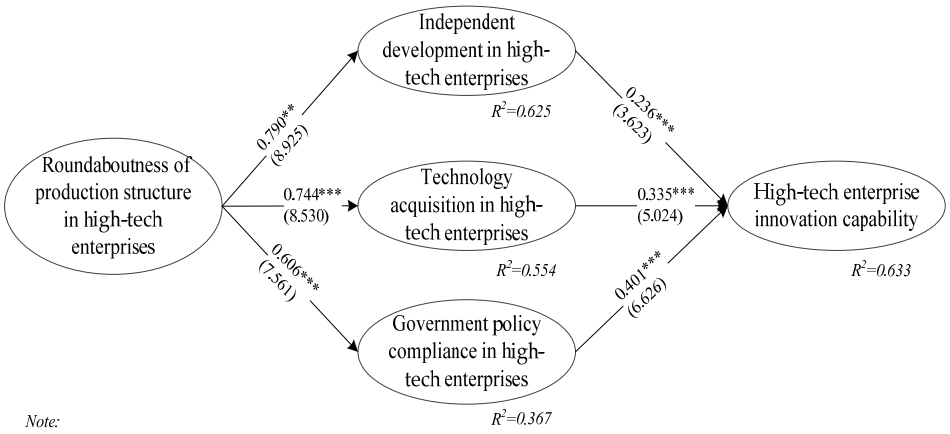

Figure 2. Results of the structural equation model.

To further explore the mediation utility of the three paths, we followed the requirements of Baron and Kenny [55] and conducted the mediation utility test using the PROCESS macro for SPSS 18.0. As shown in Table 4, the indirect effect interval corresponding to lines 2, 3 and 4 does not include zero, and three intermediary variables are added one at a time. The standardized regression coefficient between independent variable and dependent variable decreases significantly but is still significant. It shows that three variables partially mediate the relationship between the independent and dependent variables. However, when the three mediating variables are added into the model at the same time (see X+M→Y column), the relationship between independent variables and dependent variables is no longer significant. This result indicates that the three mediating variables jointly fully mediate the relationship between roundaboutness and innovation capability.

Table 4. Mediating effect test results.

Variable	X→Y	X+M1→Y	X+M2→Y	X+M3→Y	BootLLCI	BootULCI	X+M→Y
1. Roundaboutness of production structure in high-tech enterprises (X)	0.415 ***	0.170 **	0.174 **	0.229 ***			0.032 ns
2. Independent development in high-tech enterprises (M1)		0.473 ***			0.1646	0.3388	0.228 ***
3. Technology acquisition in high-tech enterprises (M2)			0.513 ***		0.1662	0.3344	0.296 ***
4. Government policy compliance in high-tech enterprises (M3)				0.519 ***	0.1187	0.2734	0.349 ***
R^2	0.173	0.332	0.378	0.407			0.527

Notes: (1). The independent variable is roundaboutness of production structure in high-tech enterprises (X) and the dependent variable is high-tech enterprise innovation capability (Y); (2). BootLLCI and BootULCI represent the upper and lower bounds of bootstrap1000 indirect effects, respectively; (3). *** $p < 0.001$, ** $p < 0.01$, ns means not significant.

To explore the technology absorption power and the differential effect of absorption path caused by the roundaboutness of enterprises' production structure in different production stages, AMOS 21.0 was used for grouping analysis. The results of the grouping model show that there is no significant difference among measurement models

($\Delta\chi^2(15.252)/(\Delta df(26) = 0.587, p > 0.10)$), but there is an overall difference in path coefficient ($\Delta\chi^2(71.198)/(\Delta df(12) = 5.933, p < 0.01)$), which can be analyzed by grouping. The grouping analysis results, shown in Table 5, reveal the following. (1) There is no difference in the impact of the roundaboutness of production structure in high-tech enterprises on their independent development in each production stage. (2) The effect of roundaboutness of production structure in high-tech enterprises on their technology acquisition shows an asymmetric inverted U shape. (3) In terms of the impact intensity of the roundaboutness of production structure in high-tech enterprises on their government policy compliance, enterprises in the high and intermediate stages are significantly stronger than those in the low stage. (4) There is no significant difference in the intensity of the impact of independent development in high-tech enterprises on their innovation capability at different production stages, and the contribution is not significant at the intermediate and low stages. (5) Technology acquisition in high-tech enterprises have a significant positive effect on their innovation capability at the intermediate stage but not at the high or low stages. (6) The government policy compliance in high-tech enterprises of low stage have a significant positive impact on its innovation capability, while has no significant effect on the high-tech enterprise of high and intermediate stages.

Table 5. Path analysis at different stages during production.

Path	① High Stage	② Intermediate Stage	③ Low Stage	Groups ①–② Compared ($\Delta\chi^2/\Delta df1$)	Groups ①–③ Compared ($\Delta\chi^2/\Delta df1$)	Groups ②–③ Compared ($\Delta\chi^2/\Delta df1$)
Roundaboutness of production structure in high-tech enterprises →independent development in high-tech enterprises	0.824 ***	1.110 ***	0.611 ***	1.086 ns	−1.032 ns	−1.786 ns
Roundaboutness of production structure in high-tech enterprises →technology acquisition in high-tech enterprises	0.871 ***	1.349 ***	0.503 **	1.494 ns	−1.712 ns	−2.600 **
Roundaboutness of production structure in high-tech enterprises →government policy compliance in high-tech enterprises	0.852 ***	1.235 ***	0.021 ns	1.276 ns	−3.558 ***	−3.625 ***
Independent development in high-tech enterprises →high-tech enterprise innovation capability	0.472 ***	0.237 ns	0.204 ns	−1.324 ns	−1.543 ns	−0.171 ns
Technology acquisition in high-tech enterprises →high-tech enterprise innovation capability	0.172 ns	0.697 ***	0.161 ns	3.654 ***	−0.060 ns	−2.777 **
Government policy compliance in high-tech enterprises →high-tech enterprise innovation capability	0.191 ns	0.082 ns	0.800 ***	−0.787 ns	4.205 ***	5.041 ***

Notes: *** $p < 0.001$, ** $p < 0.01$, ns means not significant.

5. Discussion

5.1. Key Findings

This paper investigates the innovation power source of high-tech enterprises from the perspective of the roundaboutness of production structure in high-tech enterprises. The results show that the innovation capability of enterprises is driven by roundaboutness in enterprises' production structure, and technology absorption is carried out in three paths: independent development, technology acquisition, and government policy compliance. These three paths completely mediate the relationship between the roundaboutness of production structure in high-tech enterprises and their innovation capability.

In terms of production stages and technology absorption paths, the effect power and path are different in different production stages. First, the roundaboutness of production structure in high-tech enterprises have a significant impact on their independent development in each production stage. Comparing to the impact at the high stage and low stage, the impact of the intermediate stage is the largest, which shows that it is the most difficult to develop technology at the manufacturing end. Second, the effect of the roundaboutness of production structure in high-tech enterprises on their technology acquisition shows an asymmetric inverted U shape. Compared with the intermediate stage, the low stage has less impact on technology acquisition in high-tech enterprises. This indicates that it is harder for an enterprise to acquire technology when it is in the stage closer to the consumer. Third, the roundaboutness of production structure in high-tech enterprises in the high and intermediate stages have a significant impact on their government policy compliance. The impact of the intermediate stage is the largest, which implies that it is the most difficult for manufacturing enterprises to comply with government policy at the intermediate stage. Fourth, in terms of the high-tech enterprise innovation capability, enterprises in the high stage should develop technology independently; enterprises in the intermediate stage should introduce technology, and enterprises in the low stage should comply with government policies to maximize the innovation capability of enterprises.

5.2. Implications

Based on the intermediary utility of the technology absorption path, this study explores the impact of production structure roundaboutness on the innovation capability of high-tech enterprises, which provides some practical insight for their development.

Firstly, this study suggests that high-tech enterprises should attach great importance to the roundaboutness of production structure and recognize that it is an important driving force for the improvement of high-tech enterprise innovation capability. More importantly, high-tech enterprises should actively adapt and improve their production structures to realize their rationalization. Thus, while high-tech enterprises enhance their innovation capability through independent development, technology acquisition and government policy compliance, they should consider the roundaboutness of production structure and choose to absorb and spread technology along the direction of production structure.

Secondly, this study suggests that high-tech enterprises improve the ability of independent development and technology acquisition to form core technology. For example, the industrial park can actively carry out exchanges and cooperation between enterprises, update technology, increase knowledge levels, and increase investment in research and development. In addition, high-tech enterprises should take the initiative to go out and establish extensive cooperative alliances, build open cooperative innovation networks, and clarify the internal logic of different types of cooperative relationships affecting enterprise performance. Meanwhile, high-tech enterprises should actively absorb advanced technology, innovative products and experience, and carry out appropriate introduction and effective utilization in combination with their own development status, so as to enhance their innovation capability.

Thirdly, high-tech enterprises should evaluate their own development status and actively take advantage of favorable government policies that may promote the improvement of their innovation capability. High-tech enterprises should actively capitalize the relevant industrial and innovation policies released by the government. On the other hand, the government can macro-control the rational allocation of technological innovation resources of high-tech enterprises and effectively guide enterprises to innovate their technology by issuing a series of government incentive policies, such as government direct subsidy, government procurement, industrial science and technology policies, and the formulation of relevant laws and regulations.

Finally, considering the influence of the different absorption paths of technological innovation capability and the different stages of production, enterprises should have a clearer understanding of their own internal resources and external environment. This

implies that in order to promote innovation capability, enterprises at the high stage should strengthen their independent development, enterprises at the intermediate stage should strengthen technology acquisition, and enterprises at the low stage should strengthen government policy compliance. Meanwhile, enterprises in all stages of production should strengthen their cooperation to promote the transformation of technology absorption into practical benefits.

6. Conclusions, Limitations and Future Research Agenda

From the perspective of the roundaboutness of production structure in high-tech enterprises, this study explores the source of high-tech enterprises' innovation power. Unlike previous work that adopted a knowledge management perspective, this paper uses its new point of view to explore what paths best enable high-tech enterprises to absorb technology. Based on the different stages of production structure, it compares the effects of different absorption paths. The results indicate that the roundaboutness of production structure in high-tech enterprises have a positive effect on their independent development, technology acquisition, and government policy compliance. The roundaboutness of production structure in high-tech enterprises have a complete intermediary effect on the high-tech enterprise innovation capability through the three paths. Furthermore, the effects of the technology absorption paths vary by production stages. These results enrich the research related to technological innovation and provide insight to high-tech enterprises' innovation.

There are four main limitations of this paper. First, this paper only investigated 315 enterprises in 10 robotics industrial parks in the Yangtze River Delta region of China. The samples are relatively limited, and it is difficult to exclude regional or field bias caused by sample concentration, which affects all of the research results. In future, these research results can be further verified in high-tech industries in other countries or regions. Second, the data source of this paper focuses on the high-tech enterprises in the robot industrial park. The research conclusions can be tested in other high-tech industries. Third, this study adopts the questionnaire survey method, and the research results could be subjective. Statistical data can be used to re-examine the model proposed in this study. Fourth, this paper adopts the perspective of the roundaboutness of production structure in high-tech enterprises, and more specific research can be carried out from multiple perspectives in future. For example, to examine the source of the innovation power of high-tech enterprises from the perspective of division of labor or factor endowment.

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