Study on the Factors Affecting the Technological Innovation of Logistics Equipment Manufacturers from the Perspective of Supply Chain

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Abstract. As an emerging productive service industry, the character of logistics industry determines the technical innovation activities to consider whether it can improve the operational efficiency of upstream and downstream enterprises in the supply chain. From the perspective of supply chain based on technological innovation mechanism and technological innovation strategy theory, combined with the characteristics of logistics equipment, the conceptual model of the factors affecting the technological innovation of logistics equipment manufacturers is constructed from the aspects of market demand, environment, positive incentives, technological innovation strategies and characteristics of downstream logistics enterprises. Based on this, the corresponding hypotheses are put forward and verified also the intensity of each influencing factor on the technological innovation of logistics equipment manufacturers is analyzed.

1. Introduction
Collaborative innovation in supply chain has become an important way for enterprise technology innovation. Especially for logistics equipment with high inter-device connectivity and compatibility requirements, capital-intensive and energy-intensive equipment, logistics equipment manufacturers who have mastered key technologies, had innovative talents, and are at the core of the supply chain determined the advanced level of logistics equipment to a certain extent. For the research on the factors affecting the technological innovation of the equipment manufacturing industry, scholars at home and abroad have put forward their own opinions from the internal and external levels: At the internal level, Apergis (2012) [1] found that developed countries with advanced technologies have produced greater technology spillover effects and directly promoted the level of technological innovation; Demir (2012) [2] pointed out that in high-tech equipment manufacturing enterprises, the standardized strategic evaluation framework can help them improve their technological innovation capabilities, thus enhance their competitiveness; Xu Jianzhong and Qu Xiaoyu (2015) [3] constructed a model of the influencing factors of technological innovation in equipment manufacturing industry. The empirical evidence shows that the technological innovation willingness and technological innovation perception of enterprises have a positive impact on technological innovation. At the external level, Chongvilaivan (2012) [4] found that the high-tech capital investment promoted the
improvement of total factor productivity, thus had a positive impact on technological innovation by studying the factors affecting the technological innovation of equipment manufacturing in Singapore; Xu Fengwei (2011) [5] discovered that among the external factors for improving the technological innovation capability of the equipment manufacturing industry, the most important ones are government support, industry-university-research cooperation, and technology introduction.

Domestic and foreign scholars are less likely to study their technological innovations for logistics companies or logistics equipment manufacturers, and more are to study from a macro level. For example, Evangelista (2013) [6] took 153 third-party small and medium-sized logistics companies in Italy as an example to study the impact of information and communication technologies on their technological innovations. The results show that information and communication technology is more conducive to the integration of supply chain resources by third-party small and medium-sized logistics enterprises, thus promoting technological innovation; Zhang Hongbo (2013) [7] constructed a mechanism model for logistics enterprise technology innovation investment decision-making from the perspective of market demand and government regulation, and verified the enterprise's forecast of market demand scale, policy makers' preferences and government regulation had a positive impact on technological innovation for logistics enterprises activities.

Reviewing relevant literatures, most scholars take the entire equipment manufacturing industry as the research object and do not fully consider the equipment characteristics of the sub-sectors; The research on technological innovation in the logistics industry is relatively macroscopic, while the less is on logistics technology innovation activities from the front end of the supply chain. From the perspective of supply chain, this paper combines the characteristics of logistics equipment to construct a conceptual model of the factors affecting the technological innovation of logistics equipment manufacturers. Based on this, the assumptions of various influencing factors are proposed and verified, which is of great significance to improve technological innovation ability and meet customer needs.

2. Influencing factors analysis hypothesis and model construction

From the perspective of supply chain, based on the technology innovation mechanism and technology innovation strategy theory, and combined the characteristics of logistics equipment, this paper constructs a conceptual model of the factors affecting the technological innovation of logistics equipment manufacturers, and proposes the following assumptions:

2.1. Market demand

Market demand can trigger technological innovation in a way. Changes in market demand will enable logistics equipment manufacturers to adjust the way they combine production factors thereby to promote technological innovation.

Automated market demand: Due to the characteristics of distribution, e-commerce products have put forward higher requirements for express warehousing and sorting etc. Automated upgrading of existing logistics lines has become the consensus of the whole industry.

H1: The automation market demand has a significant impact on the technological innovation behavior of logistics equipment manufacturers

Green market demand: "Establishment of the 13th Five-Year Plan for Equipment Manufacturing Industry" proposes to fully implement green manufacturing and actively build a green equipment manufacturing system. The green market demand for logistics equipment is also growing.

H2: Green market demand has a significant impact on the technological innovation behavior of logistics equipment manufacturers

Standardized market demand: In 2015, the National Standards Commission Service Association issued the “Medium and Long-term Development Plan for Logistics Standardization (2015-2020)”. The implementation of the plan has expanded the logistics standardized market.

H3: Standardized market demand has a significant impact on the technological innovation behavior of logistics equipment manufacturers
Specialized market demand: Cai Jin (2017) [8] pointed out that the characteristics of supply chain optimization structure and efficiency improvement require the logistics equipment industry to achieve specialization from the perspective of supply chain.

H4: Specialized market demand has a significant impact on the technological innovation behavior of logistics equipment manufacturers.

Internet market demand: "The State Council's guidance on actively promoting "Internet +" action" pointed out that the organic combination of "Internet +" and logistics equipment can improve the automation, intelligence level and operational efficiency of logistics operations, and reduce logistics costs. It is bound to expand the internet market demand for logistics equipment.

H5: Internet market demand has a significant impact on the technological innovation behavior of logistics equipment manufacturers.

Systematic market demand: The market demand for logistics equipment is further enhanced, and one-stop logistics services are proposed. This requires logistics equipment manufacturers to adopt advanced logistics equipment integration systems to provide integrated supply chain solutions.

H6: Systematic market demand has a significant impact on the technological innovation behavior of logistics equipment manufacturers.

2.2. environmental factor

The technological innovation activities of logistics equipment manufacturers are greatly influenced by the external environment, and the interaction with external organizations has become an important driving force for promoting their technological innovation. This article summarizes the environmental factors into the following two aspects:

Government policy: Zheng Qiongjie (2015) [9] pointed out that under the market environment and financial constraints, government subsidies and tax refunds can alleviate the problem of insufficient funds for SMEs, thereby promote technological innovation activities of SMEs.

H7: Government policies have a significant impact on the technological innovation behavior of logistics equipment manufacturers.

Enterprise competition: Xu Jianzhong and Qu Xiaoyu (2015) [10] studied the factors affecting the efficiency of technological innovation in China's equipment manufacturing industry and found that corporate competition has a significant role in promoting the efficiency of environmental technology innovation.

H8: Enterprise competition has a significant impact on the technological innovation behavior of logistics equipment manufacturers.

2.3. Technological innovation strategy

According to the strategic theory of technological innovation, this paper believes that the improvement of independent research and imitation innovation capabilities and the willingness of industry, university and research cooperation of logistics equipment manufacturers can influence their technological innovation, so the following three assumptions are proposed.

The improvement of independent research and development capabilities. Li Guangwei et al. (2011) [11] analyzed the relationship between technology introduction, independent R&D and innovation performance of large and medium-sized industrial enterprises, and found that the impact of independent R&D on technological innovation is the most significant.

H9: The improvement of independent research and development capabilities has a significant impact on the technological innovation behavior of logistics equipment manufacturers.

The improvement of imitating the ability: By imitating innovation, companies can reduce the cost of technological innovation. American scholars have studied the cost of 48 independent innovation products and simulated innovations in the four industries as chemical, pharmaceutical, electronics and mechanical in the Northeast and found the average cost of imitating innovation is 65% of independent innovation.
H10: The imitation of innovation ability has a significant impact on the technological innovation behavior of logistics equipment manufacturers.

Willingness to cooperate with industry, university and research institute: Hui Qing (2010) [12] took the industry-university-research cooperation enterprise as an example to study the relationship between industry-university-research cooperation innovation network, knowledge integration and technology innovation, and found that there is a significant positive correlation between the industry-university-research cooperation innovation network and technology innovation.

H11: The willingness of industry, university and research cooperation has a significant impact on the technological innovation behavior of logistics equipment manufacturers

2.4. Positive incentive
According to the theory of technological innovation mechanism, the incentive mechanism is divided into positive incentive and reverse incentive. For the reverse incentive factors are reflected in the previous section, this section will focus on the impact of positive incentives on corporate technological innovation behavior.

The need for survival and development of enterprises: Zhang Huirong (2014) [13] found that the interaction between technological innovation activities and various elements has a significant positive effect on the development of SMEs.

H12: The need for the survival and development of enterprises has a significant impact on the technological innovation behavior of logistics equipment manufacturers

Improvement of corporate reputation vision: Prescott and Louis (2010) [14] pointed out that companies often carry out technological innovation activities because of their social reputation; Zhao Yuyu and Feng Wei (2010) [15] found that corporate reputation is conducive to accessing human resources and customer resources and have positive impact on innovation performance.

H13: The vision to enhance corporate reputation has a significant impact on the technological innovation behavior of logistics equipment manufacturers

Vision for improving technical capabilities: The key for an enterprise to gain an advantage in market competition depends on technological capabilities and must be achieved through technological innovation.

H14: The vision to improve technical capabilities has a significant impact on the technological innovation behavior of logistics equipment manufacturers

2.5. Downstream logistics enterprise characteristics
Facing a more open innovation market, cooperation, exchanges and synergies among supply chain companies deepen, and the participation of downstream users is inevitable. Therefore, from the perspective of supply chain coordination, the user characteristics factors affecting the technological innovation of logistics equipment manufacturers are proposed.

Technological R&D capabilities of downstream logistics companies: For upstream supply chain enterprises, engaging in technological innovation activities not only depends on their own technology R&D capabilities, but also requires downstream enterprises to have technological R&D capabilities.

H15: The technological R&D capabilities of downstream logistics companies have a significant impact on the technological innovation behavior of logistics equipment manufacturers

The willingness of downstream logistics enterprises to exchange technology: For upstream enterprises in the supply chain, under the high technology of downstream users, the two technologies complement each other, thus promote the development of new products. Not only upstream enterprises can expand the market, but also downstream customers can obtain high satisfaction.

H16: The willingness of downstream logistics companies to exchange technology has a significant impact on the technological innovation behavior of logistics equipment manufacturers

Equipment experience needs of downstream logistics enterprises: Li Jingsheng and Wang Xiaoyun (2017) [16] pointed out that the need for users to improve and innovate products (the information
resource dimension of user participation) has a positive effect on the technological innovation activities of enterprises.

H17: Equipment experience requirements of downstream logistics companies has a significant impact on the technological innovation behavior of logistics equipment manufacturers.

Equipment use satisfaction of downstream logistics companies: Technological innovation and customer satisfaction are continuous co-evolution processes, and customer satisfaction is the fundamental driving force for technological innovation.

H18: The satisfaction of equipment use of downstream logistics companies has a significant impact on the technological innovation behavior of logistics equipment manufacturers.

Based on the above analysis of market demand, environment, positive incentives, technological innovation strategy selection and downstream logistics enterprise characteristics, a conceptual model of the factors affecting the technological innovation of logistics equipment manufacturers is constructed, as shown in Figure 1.

![Conceptual model of factors affecting technological innovation of logistics equipment manufacturers](image)

Figure 1. Conceptual model of factors affecting technological innovation of logistics equipment manufacturers

3. Empirical analysis

3.1. Questionnaire design, distribution and recycling

According to the conceptual model above, this paper takes market demand, environment, positive incentives, technological innovation strategies and downstream logistics enterprise characteristics as potential variables. The hypothetical variables (18 items) were used as observation variables and the final questionnaire was formed by the Likert 5-point scoring method. The questionnaire is divided into two parts: the first part is the basic situation of the logistics equipment manufacturer; the second part is the factors that affects the technological innovation of the logistics equipment manufacturer.

The questionnaire was distributed in the form of field research and electronic questionnaires. A total of 190 questionnaires were distributed and 185 were collected. After eliminating 7 copies of incomplete and unanswered, the final number of questionnaires was 178, of which the effective questionnaire rate was 96.2%. The sample distribution is shown in Table 1.
Table 1. Sample data distribution table

| Characteristic          | Class                  | Number of questionnaires | percentage(%) |
|-------------------------|------------------------|--------------------------|---------------|
| Registered capital      | 3 million and below    | 68                       | 38.20         |
|                         | 3 million to 20 million| 97                       | 54.49         |
|                         | 20 million to 40 million| 13                      | 7.31          |
|                         | 400 million and above  | 0                        | 0             |
| Personnel position      | manager                | 62                       | 34.83         |
|                         | Technical staff        | 44                       | 24.72         |
|                         | salesperson            | 35                       | 19.66         |
|                         | Frontline staff        | 27                       | 15.17         |
|                         | other                  | 10                       | 5.62          |
| Equipment type          | Warehousing equipment  | 118                      | 20.52         |
|                         | Loading and unloading equipment | 96                   | 16.70         |
|                         | Container equipment    | 87                       | 15.13         |
|                         | Transportation Equipment| 87                   | 15.13         |
|                         | Packaging Equipment    | 72                       | 12.52         |
|                         | Distribution processing equipment | 51              | 8.87          |
|                         | Information collection and processing equipment | 39       | 6.78          |
|                         | other                  | 25                       | 4.35          |

3.2. Questionnaire test

3.2.1. Reliability test. In this paper, the Cronbach α is used to test the reliability of the five potential variables and the whole questionnaire. It is found that in the characteristics of downstream logistics enterprises, when the factors of “equipment experience of downstream logistics enterprises” and “satisfaction of equipment use of downstream logistics enterprises” are deleted, the Cronbach α of the latent variable is improved, so the following result is obtained. See Table 2 for details:

Table 2. Potential variable Cronbach α coefficient

| Potential variable name                   | Observe the number of variable items | Cronbach α coefficient |
|------------------------------------------|--------------------------------------|------------------------|
| Questionnaire                            | 16                                   | 0.781                  |
| Market demand                            | 6                                    | 0.735                  |
| envirnmental factor                      | 2                                    | 0.723                  |
| Positive incentive                       | 3                                    | 0.724                  |
| Technological innovation strategy choice  | 3                                    | 0.727                  |
| User characteristic factor               | 2                                    | 0.911                  |

The Cronbach α falls at 0.7-0.9 indicates that the reliability of the questionnaire is better. It can be seen from Table 2 that the Cronbach α of the questionnaire and the five latent variables are above 0.7, which means that the questionnaire data has a high reliability and can be accepted.

3.2.2. Validity test. After the questionnaire passed the reliability test, this paper used exploratory factor analysis to analyze the validity of 16 observed variables. It was found that the Kaiser-Meyer-Olkin (KMO) value was 0.695, which was above 0.5, so it was suitable to do exploratory factor analysis. The specific results are shown in Table 3 and Table 4:
Table 3. Principal component extraction and factor loading of observed variables

| Observation variable                          | element 1 | element 2 | element 3 | element 4 | element 5 |
|----------------------------------------------|-----------|-----------|-----------|-----------|-----------|
| Systematic demand                           | 0.804     |           |           |           |           |
| Standardization needs                       | 0.774     |           |           |           |           |
| Professional needs                          | 0.696     |           |           |           |           |
| Internet demand                              | 0.627     |           |           |           |           |
| Green demand                                 |           |           |           |           |           |
| Automation requirements                     |           |           |           |           |           |
| Industry, university and research cooperation willingness | 0.813 |           |           |           |           |
| Independent innovation ability              | 0.786     |           |           |           |           |
| Imitate the ability to innovate              | 0.678     |           |           |           |           |
| Downstream logistics enterprise research     |           |           |           |           |           |
| and development capabilities                |           |           |           |           |           |
| Willingness of downstream logistics enterprises to exchange technology |           |           |           |           |           |
| Improve corporate reputation vision          |           |           |           |           |           |
| Vision for improving technical capabilities  |           |           |           |           |           |
| Enterprise survival and development needs   |           |           |           |           |           |
| government policy                           |           |           |           |           |           |
| Inter-enterprise competition                |           |           |           |           |           |

Table 4. Observed variables explain the total variance

| element | Initial eigenvalue | Rotation square sum loading |
|---------|--------------------|----------------------------|
|         | total              | % of variance | Cumulative % | total | % of variance | Cumulative % |
| 1       | 3.849              | 24.058        | 24.058       | 2.655 | 16.593        | 16.593       |
| 2       | 2.467              | 15.42         | 39.479       | 2.114 | 13.213        | 29.806       |
| 3       | 1.768              | 11.047        | 50.526       | 2.065 | 12.904        | 42.711       |
| 4       | 1.294              | 8.088         | 58.614       | 1.995 | 12.466        | 55.177       |
| 5       | 1.053              | 6.579         | 65.192       | 1.602 | 10.015        | 65.192       |
| 6       | 0.895              | 5.595         | 70.787       |       |               |              |
| 7       | 0.845              | 5.282         | 76.069       |       |               |              |
| 8       | 0.692              | 4.328         | 80.397       |       |               |              |
| 9       | 0.651              | 4.069         | 84.466       |       |               |              |
| 10      | 0.51               | 3.191         | 87.657       |       |               |              |
| 11      | 0.487              | 3.043         | 90.7         |       |               |              |
| 12      | 0.432              | 2.697         | 93.397       |       |               |              |
| 13      | 0.341              | 2.13          | 95.527       |       |               |              |
| 14      | 0.299              | 1.871         | 97.398       |       |               |              |
| 15      | 0.272              | 1.702         | 99.099       |       |               |              |
| 16      | 0.144              | 0.901         | 100          |       |               |              |

(Extraction method: principal component analysis method)

Table 3 and Table 4 show that, except for “automation demand” and “green demand”, the factor load of all other factors is above 0.5, which means that these two factors are invalid; And the total variance of the 5 principal components extracted is 65.192%. This indicates that the 5 main
components of market demand, environmental factors, positive incentives, technological innovation strategy selection and downstream logistics enterprise characteristics can reflect 65.192% of the information, so the exploratory factor analysis is effective, that is, the data of the observed variables are valid.

3.3. Hypothetical verification
Based on the reliability and validity analysis of the questionnaire, this paper excludes four factors: “equipment experience demand of downstream logistics enterprises”, “satisfaction of equipment use of downstream logistics enterprises”, “automation demand” and “green demand”. In order to further verify the rationality of the hypothesis, the conceptual model of Fig. 1 is loaded into the AMOS structural equation model, finally the fitting degree of the model and the path coefficient of each variable are obtained (see Table 5 and Table 6).

Table 5. Model fitting degree analysis results

| Fitting index | $\chi^2 / df$ | CFI | GFI | AGFI | PGFI |
|---------------|---------------|-----|-----|------|------|
| model         | 1.813         | 0.934 | 0.915 | 0.909 | 0.567 |

Table 6. Variable path coefficient and P value

| Variable name | Path coefficient | P value | test result | Variable name | Path coefficient | P value | test result |
|---------------|------------------|---------|-------------|---------------|------------------|---------|-------------|
| H3            | 0.81             | <0.001  | Significant | H10           | 0.64             | <0.001  | Significant |
| H4            | 0.67             | <0.001  | Significant | H11           | 0.81             | <0.001  | Significant |
| H5            | 0.52             | <0.001  | Significant | H12           | 0.68             | <0.001  | Significant |
| H6            | 0.74             | <0.001  | Significant | H13           | 0.65             | <0.001  | Significant |
| H7            | 0.66             | <0.001  | Significant | H14           | 0.71             | <0.001  | Significant |
| H8            | 0.86             | <0.001  | Significant | H15           | 0.93             | <0.001  | Significant |
| H9            | 0.67             | <0.001  | Significant | H16           | 0.9              | <0.001  | Significant |

As can be seen from Table 5, the $\chi^2 / df$ is under 2, the CFI, GFI, and AGFI are all above 0.9, and the PGFI is above 0.5, indicating that the overall model fits well. The path coefficients in Table 6 shows that 15 influencing factors have a positive impact on the technological innovation of logistics equipment manufacturers. Among all, the technology R&D capabilities, technology exchange willingness, inter-firm competition, industry-university-research cooperation and standardized requirements of logistics enterprises have more significant influence on logistics equipment manufacturers. The reason may be: the formulation and introduction of the Medium and Long-term Development Plan for Logistics Standardization (2015-2020) expands the market demand for standardized logistics facilities and equipment, enabling logistics equipment manufacturers to focus their technological innovation on R&D and design standardization facilities. The impact of competitors in the same industry and foreign logistics equipment manufacturers on the logistics equipment market has stimulated the technological innovation behavior of domestic logistics equipment manufacturers to a large extent, and has become a key factor affecting the technological innovation of logistics equipment manufacturers; The uncertainty of the technological innovation environment is increasing, with the collaborative innovation of supply chain technology become the mainstream of enterprise technology innovation. The improvement of technology R&D capabilities and the willingness of technology exchange of downstream logistics enterprises can promote the technological innovation activities of logistics equipment manufacturers up to a point.
4. Conclusions
This paper constructs a conceptual model of the factors affecting the technological innovation of logistics equipment manufacturers from the aspects of market demand, environment, positive incentives, technological innovation strategies and characteristics of downstream logistics enterprises. Based on this, the corresponding hypotheses are proposed and verified. Research indicates: 1) The impact of competition among enterprises on the technological innovation of logistics equipment manufacturers is more significant. A reasonable and orderly competitive environment is a prerequisite for equipment manufacturers to survive and develop, and is a key factor to promote the technological innovation of logistics equipment manufacturers. 2) Standardization needs have a significant impact on boosting technological innovation activities sustainably. Technological innovation comes from market demand. For domestic small and medium-sized logistics equipment manufacturers, they must seize the opportunity, take the standardization of logistics equipment as the starting point, accelerate the promotion of technological innovation activities, thus expand market share. 3) As a core enterprise in the supply chain, logistics equipment manufacturers should strengthen technology exchange willingness with downstream logistics companies, provide funding, talents and technical support for them, stimulate technological R&D potential, and establish a good communication and coordination mechanism to promote a supply chain. This paper provides a useful reference for logistics equipment manufacturers to improve their technological innovation capabilities to some degree. In the future, the dimension of the research will be further expanded, in which common variables such as enterprise-scale technological innovation capital investment and talent input will be added in.

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