

Study on the Influence of Customer Concentration Degree on the Intelligent Transformation and Upgrading of Manufacturing Enterprises

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Abstract

Intelligent manufacturing is a global trend in the development of the manufacturing industry and a key direction for the transformation and upgrading of China's manufacturing sector. This paper explores the relationship between customer concentration and the intelligent transformation of manufacturing enterprises from the perspective of customer concentration, revealing the mechanisms through which innovation investment levels and innovation path dependence mediate the relationship between customer concentration and intelligent transformation in manufacturing. To this end, based on data from Chinese A-share manufacturing enterprises from 2013 to 2021, the study employs web crawling technology to collect "intelligent transformation" keywords from corporate annual reports, thereby characterizing the level of intelligent transformation in enterprises. The results indicate that customer concentration inhibits the intelligent transformation and upgrading of enterprises. Mechanism analysis shows that customer concentration primarily mitigates its inhibitory effect on intelligent transformation by promoting corporate innovation investment, while it exacerbates the inhibitory effect through innovation path dependence. Finally, the study proposes countermeasures and suggestions from three aspects: adjusting customer structure, enhancing innovation investment, and fostering an open and diversified mindset, providing theoretical guidance and insights for promoting the intelligent development of Chinese manufacturing enterprises.

Keywords

Customer Concentration; Intelligent Transformation; Innovation Path Dependence; Innovation Investment; Internal Control.

1. Introduction

In order to promote the high-end manufacturing process, the 20th Party Congress report clearly puts forward that the focus of economic development should be placed on the real economy, promote new industrialization, and strive to build a manufacturing power. In order to seek the strategic transformation from a "manufacturing power" to a "manufacturing power", China has taken intelligent manufacturing as a strategic support to promote the modernization of the manufacturing industry and to realize the transformation of old and new kinetic energy in China [1]. It is worth noting that, as an important part of China's industrial economy, the traditional manufacturing industry is facing many challenges such as diversification, globalization and personalized demand, which requires China's manufacturing industry to reflect the market demand in a timely manner, to meet the personalized needs of customers, and to improve its market competitiveness. Customers are the core of enterprises' access to external resources. In the process of intelligent transformation, obtaining feedback and demand information from customers plays a key role in determining the direction of transformation and optimizing products and services.

Customers, especially large customers, as important stakeholders in the supply chain, are not only related to the capital structure as well as production planning and operation of the enterprise, but also play an important role in activities such as intelligent transformation of the enterprise. Customer concentration is a portrayal of the characteristics of an enterprise's customer group, reflecting the extent of the enterprise's dependence on its customers. Existing literature research shows that, on the one hand, too much customer concentration may bring business management risk^[2], financing constraint risk^[3], etc., and on the other hand, customer concentration can achieve the benefits of reducing the enterprise transaction cost^[4] and enjoying the customer knowledge spillover^[5]. When the "enterprise-customer" relationship is deepening, the intelligent transformation of enterprises will also be affected by the two aspects of customer concentration, which will affect the choice of enterprise strategy. Based on this, this paper empirically examines the impact of customer concentration on the intelligent transformation of enterprises, using Chinese A-share listed companies in the manufacturing industry from 2013 to 2021 as the research sample.

2. Theoretical Analysis and Research Hypothesis

2.1. Influence of Customer Concentration on the Intelligent Transformation and Upgrading of Manufacturing Enterprises

High customer concentration promotes the intelligent transformation and upgrading of manufacturing enterprises. On the one hand, based on the perspective of resource-based theory, whether an enterprise can complete the transformation and upgrading depends to some extent on the elemental resources it owns^[6]. Customers are located in the downstream of the enterprise supply chain, which is the direct source of the enterprise's income, and a stable customer structure can provide high-quality resources for the enterprise. In the process of intelligent transformation, by strengthening customer relationship maintenance, enterprises can not only improve customer satisfaction and loyalty, but also enhance the willingness of supply chain partners to share knowledge and information^[7], so as to be able to break the limitations of their own resources, access to external resources, and co-creating scarce and inimitable resources, so that the enterprise can more efficiently understand and grasp the direction of the development of the current industry.

On the other hand, according to the theory of market demand, the nature and size of the market serves as a driving factor for transformation and upgrading. When the customer concentration of an enterprise is high, it means that most of the enterprise's resources and efforts are concentrated on a few key customers. This helps enterprises to accurately collect and master customers' demands and reduce the cost of enterprise's cognition of customers' demands, so as to satisfy consumers' personalized demands in all aspects of design, production and sales. Therefore, the cooperation between enterprises and large customers establishes a good communication mechanism between the two sides of the transaction, provides more opportunities for intelligent transformation, and is conducive to the intelligent transformation and upgrading of enterprises.

High Customer Concentration Impedes Intelligent Transformation and Upgrading of Enterprises.

Based on the risk perspective. High customer concentration means that enterprises rely on several large customers, and large customers may require enterprises to reduce the product sales price, extend the payment term and provide more commercial credit with their strong position^[8], which compresses the profit space of the enterprise and increases the business risk of the enterprise^[9], and the enterprise lacks the motivation of upgrading the services or products, which is not conducive to the intelligent transformation of the enterprise. At the same time, enterprises worry about the loss of important customers, will hold more cash, it will

reduce the investment in research and development and innovation resources, is not conducive to the intelligent production of manufacturing industry^[10]. The increase of customer concentration will also make the enterprise to the main seller of the dedicated investment increase, so that the enterprise by the customer "knock" the risk of the corresponding increase, affecting the enterprise liquidity and debt financing costs, so as to squeeze the enterprise engaged in intelligent transformation of resources, inhibit the intelligent transformation of the enterprise^[8]. Therefore, high customer concentration has a negative impact on the efficiency of enterprise capital operation and external financing ability, which in turn restricts the process of enterprise intelligent transformation and upgrading.

In summary, customer concentration has a dual effect on enterprise intelligent transformation. Based on this, this study proposes the following opposing hypotheses to be further verified:

H1a: Under the condition of controlling other factors, customer concentration has a positive effect on enterprise intelligent transformation and upgrading.

H1b: Under the condition of controlling other factors, customer concentration has a negative effect on enterprise intelligent transformation and upgrading.

The mediating role of innovation investment level between customer concentration and firms' intelligent transformation and upgrading

The process of intelligent transformation often requires the use of advanced technologies and equipment, and the development and application of these technologies often require large amounts of innovation input. High customer concentration promotes firms' innovation investment to a certain extent, and in order to satisfy the specific needs of these customers or maintain long-term cooperative relationships, this will force firms to increase their R&D investment in order to provide customized products or services. At the same time, only when a stable and reliable customer relationship is formed between firms and their customers, major customers will be more willing to participate in joint investment, alleviating the huge technological risks and development cycle pressure borne by firms in the process of carrying out technological innovations, and thus increasing the willingness of these firms to carry out innovations.

H2: Enterprises with high customer concentration can promote intelligent transformation and upgrading by increasing innovation investment.

The mediating role of innovation path dependence between customer concentration and firms' intelligent transformation and upgrading

Innovation path dependence is a specific innovation mode and direction formed by a company in the process of innovation due to the influence of history, technology, market and other factors, which makes the company more inclined to develop along this path when innovating in the future. The existence of path dependence may cause the company to fall into an innovation dilemma, making it difficult to break through the limitations of existing technology.

When a firm has a high concentration of customers, it means that the firm's main source of revenue is dependent on a few large customers. In this case, the company may be more inclined to maintain a stable relationship with customers, investing a large number of relationship-specific investment to meet the needs of these large customers, the specialized investment is easy to induce the opportunistic behavior of customers, with a certain degree of situational lock-in and path dependence, the amount of investment reaches a certain level will make the enterprise by the customers to be trapped^[8], resulting in "R&D myopia", thus limiting its own innovation ability and innovation direction to some extent^[11]. These large customers may put forward specific technology or service demands to the company, and the company, in order to satisfy these demands, may choose to improve and optimize along the existing technological path instead of making disruptive innovations, thus hindering the intelligent transformation of the enterprise.

H3: Firms with high customer concentration may hinder firms' intelligent transformation and upgrading by increasing innovation path dependence.

The moderating effect of enterprise internal control level between customer concentration and enterprise intelligent transformation and upgrading

Compared with the enterprise's daily investment in tangible assets, innovation activities are characterized by long cycles and high risks, which leads to high agency and supervision costs. The high-quality implementation of internal control can improve the integrity of accounting information reporting^[12], so that investors or banks and other financial institutions accurately assess the future profitability of enterprises, thus effectively reducing external financing costs, alleviating financing pressure, and creating favorable conditions for enterprises to obtain more material resources for innovation activities. Meanwhile, in the dimension of human resources, a high-quality internal control system helps to improve the effectiveness of corporate governance, improve the incentive mechanism, cultivate the risk-taking spirit of executives^[13], and encourage employees to actively participate in innovative activities. Based on the above analysis, it is believed that a high-quality internal control system can regulate the mediating role of innovation inputs between customer concentration and intelligent transformation.

A sound and effective internal control system can ensure that the enterprise obtains customer information in a timely manner and understands the needs and changes of customers, thus providing the enterprise with a basis for decision-making regarding the choice of innovation paths. At the same time, internal control can effectively constrain management's behavior and prevent them from over-consuming limited resources on short-term performance-enhancing innovation decisions, so that the enterprise can focus more on long-term, promising innovation projects. Based on the above analysis, it is argued that high-quality internal control can moderate the mediating role of innovation path dependence between customer concentration and intelligent transformation.

H4: The higher the level of internal control, the stronger the impact of firms' customer concentration on intelligent transformation through innovation investment.

H5: The higher the level of internal control, the weaker the impact of firms' customer concentration through innovation path dependence on intelligent transformation.

3. Study Design

3.1. Sample Selection and Data Sources

In this paper, the data of A-share listed manufacturing enterprises in 2013~2021 is selected as the initial research sample, among which, the enterprise data comes from CSMA database, annual report of listed companies. And do further processing: ① exclude the company data named "ST, PT" in the current year; ② eliminate the company data with major business changes during the study period; ③ eliminate the company data with serious missing data. Meanwhile, in order to exclude the influence of extreme values, the continuous variables were also tailed according to the standard of 1%. In the end, this paper obtains the annual non-equilibrium panel observations of 1,707 companies.

3.2. Variable Selection

Level of Corporate Intelligent Transformation. Currently, most manufacturing enterprises are still in the initial stages of intelligent transformation, and the methods for measuring the degree of intelligent transformation remain imperfect. Drawing on the measurement approaches of Yu et al.^[14], Chen Qingjiang et al.^[15], and Li Wanhong et al.^[16], this study utilizes a database derived from corporate annual reports to conduct relevance mapping analysis. It identifies 29 keywords related to the intelligent transformation of manufacturing enterprises, including intelligent manufacturing, smart manufacturing, intelligent terminals, and intelligent

recognition. Based on this, the degree of intelligent transformation of a sample company in a given year is measured by the ratio of the total occurrences of intelligent transformation keywords in that company's annual report to the total occurrences of the same keywords across all companies in the same industry during the same year. The measurement formula is as follows:

$$\text{Intel_Trans}_{it} = q_{it} / \sum_t q_{it}$$

Among them, q_{it} represents the number of keywords in the annual report of the sample company, i denotes the sample company code, and t means the year. The larger the value of Intel _ Trans, the higher the degree of intelligent transformation of the company.

Customer Concentration (CC_top5). Customer concentration reflects the degree of dependence of the enterprise on its main customers. The more concentrated the customers are, the more the enterprise relies on several large customers, and on the contrary, that the customers of the enterprise are more dispersed. Customer concentration is measured in many ways, most of which is based on the proportion of key customers' total sales. This paper uses the proportion of five customers sold in the last five years.

Investment in technological innovation (Cre). Intelligent technology innovation is the foundation of intelligent manufacturing. Only a good intelligent technology can provide basic guarantee for intelligent application and intelligent benefits, and the research and development and application of these technologies often require a large amount of innovation investment. This paper uses the proportion of R&D expenditure in the total operating income to express.

Innovation path dependence (Path). This paper uses the methods of Zhang Qinglei et al.^[17] and Yang Yujin et al.^[18]^[18], and selects the window period of 5 years based on the top 4 positions of IPC patent classification number. If the same IPC patent category does not appear in the previous 5 years in the patent data applied by the enterprise in the current year, the unpublished patent count of these classification numbers will be taken as an exploratory innovation. Then use 1 minus the ratio of the number of exploratory innovation patents to the total number of patents in the past five years to measure the path dependence orientation of the enterprise.

Internal control effectiveness (IC). To assess the effectiveness of internal control, this study adopts the research methodology of Ma Yongqiang and Lu Yuanyuan^[19], utilizing the "Dibo Internal Control Index" released by Dibo Company as the measurement standard. To mitigate the impact of heteroscedasticity, the aforementioned index was logarithmically transformed in this research.

According to relevant literature, the intelligent transformation and upgrading is not only affected by the collection of customers, but also affected by other factors of the enterprise itself, including: the enterprise development scale (Size), measured by the natural log of the total assets of the enterprise; the equity concentration (Top10), the shareholding ratio of the top ten shareholders; the return of assets (ROA), measured by the proportion of the net profit in the total assets of the enterprise; the operating cost rate (OCR) and the proportion of the operating cost in the operating income of the enterprise. In addition, in order to control the possible effects of enterprise factors and time trends, the industry effect (Industry) and the annual effect (Year) are controlled in the regression analysis.

Table 1. provides a description of the variables

Type of variable	Variable name	Variable symbol	Variable declaration
Dependent variable	Intelligent transformation and upgrading	Intel_Transit	The intelligent related keywords in the annual report have the word frequency
Independent variable	Customer concentration	CC_top5	Nearly five years ago, five sellers sales ratio
Mediation variables	Innovation investment	Cre	R & D expenditure / total operating income
	Innovation path dependence	Path	1- (Number of patents for exploratory innovation in the past 5 years/Total number of patents)
Regulated variable	internal controls	IC	Ln(Dibo internal control index)
Controlled variable	enterprise size	Size	Ln(Total assets)
	Equity concentration	Top10	The shareholding ratio of the top ten shareholders
	Operating cost rate	OCR	Operating costs / operating income
	return on assets	ROA	The proportion of enterprise net profit in enterprise total assets
	financial leverage	LEV	Total liabilities / total assets

3.3. Model Design

In order to discuss whether customer concentration improves the intelligent transformation level of manufacturing industry, the following benchmark regression model is constructed:

$$Intel_Transit = \alpha_0 + \alpha_1 CC_top5 + \alpha_2 Control_{it} + \sum Industry_j + \sum Year_t + \epsilon_{it} \tag{1}$$

Intel_Trans represents the degree of intelligent transformation, CC_top5 represents the customer concentration of the enterprise, Control_{it} is the control variable, Industry_j and Yearly are the fixed effect of industry and year respectively, and ε it is the random interference item.

On this basis, in order to verify the intermediary effect between innovation path dependence and intelligent innovation ability in customer concentration degree and intelligent transformation, this paper borrows the research method of Wen Zhonglin^[20] three-step regression method, and establishes the model as follows:

$$Path = \alpha_0 + \alpha_1 Scidown + \alpha_2 Scidown + \alpha_3 Control_{it} + \sum Industry_j + \sum Year_t + \epsilon_{it} \tag{2}$$

$$Intel_Transit = \alpha_0 + \alpha_1 CC_top5 + \alpha_2 Path_{it} + \alpha_3 Control_{it} + \sum Industry_j + \sum Year_t + \epsilon_{it} \tag{3}$$

$$Cre = \alpha_0 + \alpha_1 Scidown + \alpha_2 Scidown + \alpha_3 Control_{it} + \sum Industry_j + \sum Year_t + \epsilon_{it} \tag{4}$$

$$Intel_Transit = \alpha_0 + \alpha_1 CC_top5 + \alpha_2 Cre_{it} + \alpha_3 Control_{it} + \sum Industry_j + \sum Year_t + \epsilon_{it} \tag{5}$$

4. Analysis of the Empirical Results

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics of all variables in this study. The mean value of corporate intelligent transformation is 1.27, with a variance of 2.475, indicating that the level of intelligent transformation in China's industries still needs further improvement. In terms of the measurement of customer concentration, the mean value of corporate customer concentration is 0.294, with a maximum value of 0.896, suggesting that customer concentration is a common phenomenon in practice. Exploring its impact on corporate intelligent transformation and upgrading holds practical significance.

Table 2. Descriptive Statistics

Variable	Mean	SD	Min	Max
Intel_transit	1.278	2.476	0.000	17.500
CC_top5	0.294	0.197	0.000	0.896
top10	0.542	0.186	0.000	0.879
size	22.178	1.176	20.036	25.675
roa	0.037	0.064	-0.261	0.195
ocr	0.713	0.167	0.188	0.990
lev	0.398	0.189	0.058	0.864

In the baseline regression examining the impact of customer concentration on corporate intelligent transformation, potential time trends were taken into account. Through the Hausman test, a fixed-effects regression analysis was further adopted in the baseline regression to eliminate possible heteroscedasticity, serial correlation, and other issues. Control variables were gradually added, and the regression results are shown in Table 3.

First, based on the regression results from columns (1) to (3), it can be observed that the regression coefficients of customer concentration are significantly negative. This remains valid after incorporating industry fixed effects and time fixed effects. Furthermore, after adding a series of control variables for firm characteristics, the results remain significantly negative at the 1% level. This indicates that excessively high customer concentration significantly inhibits a firm's intelligent transformation, supporting the conclusion of H1b.

Table 3. Results of the mediation effect test

	Intel_Trans	Intel_Trans	Intel_Trans	Intel_Trans
CC_top5	-1.212*** (-11.37)	-0.718*** (-7.47)	-1.15*** (-10.56)	-0.485** (-4.89)
TOP10			1.037*** (9.01)	0.293** (2.60)
Size			0.103*** (5.13)	0.133*** (7.55)
ROA			1.615** (4.38)	0.346 (1.09)
Ocr			0.738*** (5.15)	-1.01*** (-6.44)
Lev			-0.322*** (-2.68)	-0.344*** (-3.40)
_cons	1.634*** (43.25)	2.886*** (20.96)	-1.690 (-4.03)	-0.737 (1.83)
Year/Industry	No	Yes	No	Yes
R ²	0.009	0.310	0.022	0.319

4.2. Regression Analysis

4.2.1. Direct Effect

In the benchmark regression to verify the impact of customer concentration on the intelligent transformation of enterprises, taking into account the possible time trend, through the Hausman test in the benchmark regression to further use fixed effects regression analysis to eliminate possible heteroskedasticity and serial correlation, etc., and gradually add control variables, the regression results are shown in Table 4. Firstly, the regression results from column (1) to column (3) show that the regression coefficients of customer concentration are all significantly negative, which still holds after adding industry fixed effects and time fixed effects, based on which, by adding the series of control variables of enterprise characteristics, the result is still significantly negative at 1% level, indicating that high customer concentration of an enterprise can significantly inhibit the intelligent transformation of the enterprise. Secondly, for the results of the control variables in the benchmark regression model, the increase of enterprise scale and return on total assets can help the intelligent transformation and upgrading of enterprises, in which enterprises with larger scale and higher return on total assets have stronger management ability and risk-bearing ability, and have a stronger “shock absorption” effect on the risks transmitted by major customers. Role. The increase in financial leverage and operating cost ratio adversely affects the intelligent transformation of enterprises, probably because if the financial leverage of an enterprise is too high, it may lead to greater pressure on debt servicing, which increases the uncertainty of the enterprise's operation and thus restricts its investment in the intelligent transformation. Operating cost ratio reflects the management efficiency and profitability of an enterprise. In the process of smart transformation, a high operating cost ratio may lead to greater operating pressure.

Therefore, there is a negative correlation between customer concentration and intelligent transformation and upgrading, and higher customer concentration will hinder the intelligent transformation of enterprises, and the conclusion supports H1b.

Table 4. Influence results of customer concentration on intelligent transformation

	Intel_Trans	Intel_Trans	Intel_Trans	Intel_Trans
CC_top5	-1.212*** (-11.37)	-.718*** (-7.47)	-1.15*** (-10.56)	-0.485** (-4.89)
TOP10			1.037*** (9.01)	0.293** (2.60)
Size			0.103*** (5.13)	0.133*** (7.55)
ROA			1.615** (4.38)	0.346 (1.09)
Ocr			0.738*** (5.15)	-1.01*** (-6.44)
Lev			-0.322*** (-2.68)	-0.344*** (-3.40)
_cons	1.634*** (43.25)	2.886*** (20.96)	-1.69 (-4.03)	-0.737 (1.83)
Year/Industry	No	Yes	No	Yes
R ²	0.009	0.310	0.022	0.319

4.2.2. Mediation Effect Analysis

Column (1) is a regression model that does not include the mediator innovation input and innovation path dependence (i. e., consistent with the benchmark regression model in Table 4). In column (2), the innovation input is the intermediary factor. At this time, the coefficient of the customer business concentration degree (CC_top5) is 0.264, which is significantly positive at the 5% level, indicating that the customer concentration degree is positively correlated with the intermediary factor. Column (3), when the independent variable and intermediary factor combined regression, the coefficient of intermediary factor is 0.036, at 1% level and intelligent transformation (Intel _ Trans), at this time CC_top5 still significant but regression coefficient decreased, this shows that innovation investment cover effect, support "customer concentration-innovation-intelligent transformation" channels. In addition, the Bootstrap method was used to test the accuracy of mediation effect, when the mediation effect value is 0.009 confidence interval is [0.00,0.001], which does not include 0 in the 95% confidence interval, which again proved H2.

In column (4), the innovation path dependence (Path) is the intermediary factor. At this time, the coefficient of the customer business concentration (CC_top5) is 0.029, which is significantly positive at the 1% level, which indicates that the customer concentration is positively correlated with the intermediary factor. In column (5), when the mediator innovation path dependence (Path) returns combined with customer concentration (CC_top5), the Path coefficient is -0.176 and negatively correlated with intelligent transformation (Intel _ Trans) at the 5% level, when CC_top5 is still significant. This shows that innovation path dependence (Path) has some intermediary effect on intelligent transformation (Intel_Trans), and supports the role channel of "customer concentration- -innovation path dependence- -intelligent transformation". Moreover, the Bootstrap test showed that the mediation effect value is -0.005 confidence interval of [-0.006, -0.003], excluding 0, indicating a significant mediation effect, and this test method again proved H3.

Table 5. Results of the mediation effect test

	(1)Intel_Trans	(2)Cre	(3)Intel_Trans	(4)Path	(5)Intel_Trans
CC_top5	-0.485** (-4.89)	0.264** (1.95)	-0.494*** (-4.95)	0.029*** (2.86)	-0.450*** (-4.84)
TOP10	-0.293** (2.60)	-0.119 (-0.78)	0.298*** (2.65)	0.123*** (10.85)	0.315*** (-4.84)
Size	0.133*** (7.55)	-0.115*** (-4.78)	0.137*** (7.79)	0.007*** (3.90)	0.134*** (2.78)
ROA	0.346 (1.09)	-12.320*** (-28.40)	0.327** (2.42)	0.231** (7.19)	0.387 (1.21)
OCR	-1.01*** (-6.44)	-11.435*** (-53.33)	-0.600*** (-3.47)	-0.028* (-1.79)	-1.018*** (-6.47)
Lev	0.344*** (-3.40)	-1.11*** (-8.05)	-0.304*** (-3.00)	-0.396*** (-3.87)	-0.351*** (-3.46)
Cre			0.036*** (5.75)		
Path					-0.176** (-2.06)
_cons	-0.737 (1.83)	13.686*** (24.95)	0.243 (0.59)	0.643*** (15.86)	0.850 (2.09)
Year/Industry	Yes	Yes	Yes	Yes	Yes
R ²	0.319	0.420	0.320	0.320	0.319

Table 6. Summary of the results of the Bootstrap mediation effect test

	Gross effect	a	b	Intermediary effect value	a*b (Boot SE)	a*b (95% BootCI)	c'	conclusion
Concentration => innovation input => intelligence	-0.485***	0.246**	0.036***	0.009	0.000	0.000 ~ 0.001	-0.494***	Cover effect
Concentration => path dependence => intelligence	-0.485***	.029***	-0.176**	-0.005	0.000	-0.006 ~ -0.003	-0.450***	Part of the intermediary

4.2.3. Mediation Analysis with Regulation

The results of Table 7 show that when the value of the internal control level is small, moderate and large, the mediation effect of innovation input gradually increases, indicating that the internal control level can positively regulate the mediation effect of innovation input, but whether the regulation effect is significant needs to be judged according to the significance of the difference value. The data results showed that the residual value was positive, and the 95% confidence interval did not include 0 (the confidence interval is 0.001~0.014), which had a significant mediation effect of regulation. For low internal control level, the positive effect of customer concentration on innovation investment is not significant (b =0.004, CI = [-0.001,0.01]; p> 0.1); but for moderate and high internal control level, the positive effect of customer concentration is significant on innovation path dependence, and the significance is respectively (b=. 006, CI= [0.000,0.014]) and (b=0.007, CI= [0.000,0.018]).

When the internal control level value is small, moderate, larger, the innovation path dependence mediation effect gradually reduced, shows that the internal control level can negatively adjust the mediation of innovation path dependence, for internal control level is low, moderate and high, customer concentration of positive influence of innovation path dependence is significant, significance is respectively (b= -. 005, CI= [-0.078, -0.02]) (b= -0.055, CI= [0.000,0.009]) and (b= -0.059, CI= [0.000,0.013]).

Table 7. Indirect effects at different levels of internal control

Mediation variables	Level	Horizontal value	Effect	BootSE	BootLLCI	BootULCI
Cre	-1SD	6.313	0.004	0.003	-0.002	0.013
	Mean	6.467	0.006	0.003	0	0.014
	+1SD	6.621	0.007	0.003	0	0.018
Path	-1SD	6.367	-0.05	0.017	-0.078	-0.02
	Mean	6.475	-0.055	0.012	-0.075	-0.034
	+1SD	6.582	-0.059	0.016	-0.09	-0.033

Note: BootLLCI refers to the lower limit of 95% interval for Bootstrap sampling, and BootULCI refers to the upper limit of 95% interval for Bootstrap sampling.

Tabel 8. Adjust the intermediary index

Regulated variable	Mediation variables	Index	BootSE	BootLLCI	BootULCI
IC	Cre	0.010	0.014	-0.015	0.042
	path	-0.041	0.108	-0.276	0.141

4.3. Robustness Test

1) Replacement of the Explained Variable Measure mMethod

Drawing on the study of Tang Yuejun et al. [20], the Herfindahl-Hirschman Index (HHI) for suppliers and the proportion of purchases from the largest supplier (TCTTR) are used as explanatory variables for robustness testing.

HHI is calculated as the sum of the squares of the proportions of purchases from the top five suppliers relative to total purchases. The specific calculation formula is as follows:

$$HHI = \sum_{i=1}^N \left(X_i / X \right)^2 = \sum_{i=1}^S S_i^2$$

2) Control estimation method

In order to exclude the influence of the estimation method on the regression results, Table 3 is used as the benchmark regression model, using the random effect maximum likelihood estimation (MLE) and mixed effect model respectively. From the regression results, the estimated coefficients of the seller integration are negative and significant at the 5% level, only the comparison of the benchmark regression results. Therefore, the selection of estimation method does not change the symbolic direction and significance of the estimation coefficient of seller concentration, and the conclusion that customer concentration has a negative impact on the intelligent transformation level of manufacturing industry has a strong robustness.

3) Endogenous problem

Considering that the influence of customer concentration on the intelligent transformation of the enterprise may have a lag, in order to control the possible endogenous problems of the empirical research, this paper uses the customer concentration of the lag phase as the explanatory variable to test the research hypothesis, and alleviates the endogenous problems. The results show that the research conclusion is reliable.

Table 9. The robustness test

	Replace variables		MLE	Lagged by one period
	Intel_Trans	Intel_Trans	Intel_Trans	Intel_Trans
HHI	-0.872*** (-2.90)			
TCTTR		-0.479*** (-2.64)		
CC_top5			-0.531***	
L.CC_top5				-0.300*** (-3.05)
Control	Yes	Yes	Yes	Yes
_cons	-1.428*** (-3.06)	-1.383*** (-2.95)	0.927 (1.37)	-0.969** (-2.54)
Year/Industry	Yes	Yes	Yes	Yes
R ²	0.314	0.314		0.331

5. Conclusion and Recommendations

The manufacturing sector is the primary force driving the implementation of intelligent transformation and upgrading in China, playing a decisive role in the high-quality development of the country's manufacturing industry. The findings of this study are as follows: (1) Customer concentration inhibits the intelligent transformation and upgrading of manufacturing enterprises. (2) Customer concentration primarily alleviates its inhibitory effect on intelligent transformation by promoting corporate innovation investment; additionally, it exacerbates the inhibitory effect on intelligent transformation through innovation path dependence. (3) The level of internal control plays a moderating role in the process through which customer concentration affects innovation investment and innovation path dependence. Enhancing internal control can positively moderate the positive effect of customer concentration on innovation investment. At the same time, internal control can also effectively and negatively moderate the potential adverse effects of customer concentration on innovation path dependence.

In light of the above conclusions, this study proposes the following recommendations:

First, enterprises should rationally adjust their customer structure, balancing the risks and benefits brought by customer concentration. By expanding customer development, implementing hierarchical customer management, and optimizing products and services, they can maintain customer concentration at a reasonable level to promote intelligent transformation.

Second, enterprises should increase their investment in innovation. The progress of intelligent manufacturing depends on technological innovation in intelligence. Currently, the progress of intelligent manufacturing in Chinese enterprises is relatively lagging, and the related investment is low. Therefore, it is essential to encourage manufacturing enterprises to establish a strategic awareness of innovation, integrate innovative concepts into all departments and business processes, and increase funding and personnel investment in innovation. This will lay a solid foundation for accelerating the intelligent transformation of the manufacturing industry.

Third, enterprises should maintain an open and diversified mindset, avoiding excessive reliance on existing markets and customers, and actively seek new business opportunities and markets. Through market research, competitive product analysis, and customer interviews, they can understand new market demands and trends, thereby formulating innovation strategies that better align with market needs and break away from existing thinking patterns and path dependence.

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