Intelligent Transformation and Customer Concentration

Jinzhou Mao, School of Economics, Jilin University, Changchun, China
Yueyang Zhao, Centre for China Public Sector Economy Research and School of Economics, Jilin University, Changchun, China*
Siying Yang, Centre for China Public Sector Economy Research and School of Economics, Jilin University, Changchun, China
Rita Yi Man Li, Sustainable Real Estate Research Center, Department of Economics and Finance, Hong Kong Shue Yan University, Hong Kong
Jawad Abbas, Faculty of Management Sciences, University of Central Punjab, Pakistan

ABSTRACT

With the gradual integration of artificial intelligence and production processes, will the traditional business model of enterprises change? Based on the data of China’s manufacturing companies listed in Shanghai and Shenzhen A-shares from 2008 to 2021, we study the impact of enterprise intelligent transformation on customer concentration. Using text mining and machine learning tools, this study measures the degree of enterprise intelligent transformation and constructs an index based on the relevant words in annual reports. A multiphase DID model results show that enterprise intelligent transformation reduces customer concentration. A series of robustness tests and endogeneity tests validate this finding. This study shows that enterprise intelligent transformation improves information disclosure quality, strengthens innovation ability, and expands business boundaries, thus reducing customer concentration. Our findings provide empirical evidence to strengthen enterprise intelligent transformation further and maintain robust supply chain relationships.

KEYWORDS
Customer Concentration, Information Disclosure Quality, Technological Innovation Intelligent Transformation, Business Boundaries

INTRODUCTION

Establishing a good trade relationship with customers guarantees steady development of enterprises. In recent years, with increasingly fierce competition in the industry, enterprises’ dependence on customers has also increased correspondingly. Some companies rely on a small number of large clients for their sales performance (Campello and Gao, 2017). The research shows that reducing customer concentration positively affects enterprises’ operation and development. On the one hand, large customers can promote resource integration and information sharing among upstream and downstream
enterprises and enhance the informal financing ability of enterprises (Peng et al., 2019). On the other hand, as an external governance mechanism, well-established customers can prompt enterprises to pay more attention to customer needs and improve product quality (Krolikowski and Yuan, 2017). However, when the customer concentration is too high, enterprises will face huge business risks which affect business performance. The reason for this is that once a large customer falls into financial difficulties or there is a customer change, the sales revenue of an enterprise will decline rapidly and sharply (Song and Wang, 2019). What is more serious is that to maintain long-term and stable cooperative relationships with major customers, enterprises may strengthen investment in specific assets according to the needs of specific customers. This type of investment often leads to many sunk costs and opportunistic behaviours of large customers, thus putting enterprises at a disadvantage in the process of trade and significantly reducing their anti-risk ability (Dhaliwal et al., 2016).

With the intensification of market competition and the enhancement of risk prevention consciousness, enterprises should reduce potential risks and strengthen the business model’s robustness to maintain stable growth of performance. Moreover, the Chinese government strongly supports micro-enterprises in carrying out intelligent transformation and has introduced a series of policies to support the development of intelligent technology (Hou et al., 2021). Besides, Chinese manufacturing enterprises are transforming from traditional production mode to intelligent manufacturing and investing much intelligent infrastructure. Does the integration of intelligent technology and enterprise production impact enterprise supply chain management? To explore the above problems, we use the manufacturing listed companies’ data from 2008 to 2021 to study the impact of enterprise intelligent transformation on customer concentration and its action path.

Our major contribution is as follows: First, we provide new ideas and methods for measuring the degree of enterprise intelligent transformation. Using text mining and machine learning tools, we construct an index of the degree of intelligent transformation by searching the relevant words of enterprise intelligent transformation and calculating the frequency of their occurrence in annual reports. The index provides a valuable reference for subsequent research on enterprise intelligent transformation. Second, we expand the research boundaries of customer concentration. Customer relationship management has always been one of the most important research topics in marketing. However, few studies discuss the changing trend of corporate customer concentration based on the development of intelligent technology. We study the influence of enterprise intelligent transformation on customer concentration to enlighten enterprises on using the development opportunity brought by intelligent technology to reduce the overdependence on large customers and prevent business risks. Third, we have clarified the impact path of intelligent transformation on customer concentration. We discuss the impact of intelligent transformation on customer concentration from the perspectives of information disclosure quality, core competitiveness cultivation and business boundaries, providing new insight into the impact of intelligent transformation on customer concentration under different mechanisms.

**HYPOTHESIS**

**Intelligent Transformation and Customer Concentration**

With the increasing integration of enterprises and technical resources such as artificial intelligence, big data, and cloud computing, the internal structure of enterprises is more robust, so they have stronger strength to cooperate with high-quality customers. On the one hand, intelligent transformation makes it easier for enterprises to obtain external investors’ recognition (Liu et al., 2020), thus generating a good market image and attracting larger customers’ willingness to cooperate. On the other hand, intelligent transformation can optimize the traditional organizational model and promote the emergence of more interactive and dimensional value-creation models (Liu and Yu, 2021). Currently, enterprises obtain more performance growth points, thus reducing the dependence on the original large customers.
With customers’ dynamic and diversified needs, the manufacturing industry is undergoing a major transformation from product-led to service-led (Coreynen et al., 2018), and intelligent transformation accelerates this process. Through industrial Internet platforms, industrial e-commerce platforms, mobile Internet equipment, 3D printing tools and other intelligent facilities, enterprises strengthen the connection with the downstream suppliers, timely grasp the information of all parties, and meet the diversified needs of customers. Moreover, intelligent development requires enterprises to invest corresponding intelligent resources. Intelligent technology can help enterprises implement “intelligent manufacturing + industrial Internet”, open the information barriers between different departments, enhance information flow within the enterprise, reduce resource redundancy and waste (Niu et al., 2021). At this time, intelligent transformation makes enterprises more capable of responding to environmental changes, and enterprises can flexibly adjust their business strategies according to changes in the market environment, thus reducing the possibility of being restricted by customers. Therefore, intelligent transformation improves the viability of enterprises in volatile market environments and helps enterprises carry out flexible trade methods with customers to meet the needs of many customers. All these aspects lead to more opportunities for enterprises to cooperate with potential customers, thereby reducing the proportion of trade with original customers. We propose hypothesis 1.

**H1:** Enterprise intelligent transformation significantly reduces customer concentration.

**Intelligent Transformation, Information Disclosure Quality and Customer Concentration**

Intelligence is a high degree of integration of information technology and digitalization. Enterprise intelligent transformation makes production and operation processes increasingly transparent and improves the quality of enterprise information disclosure (Torres and Sidorova, 2019). Blockchain technology enables data to maintain logical links so that accounting records cannot be tampered with, effectively preventing information fraud, improving the authenticity and integrity of information disclosure. Intelligent transformation can also improve the depth and breadth of auditors’ access to enterprise internal data and improve audit efficiency, thus avoiding management misconduct, including hiding true information (Yang and Wu, 2021; Yang et al., 2023). In terms of enterprise external governance, intelligent transformation attracts more analysts’ attention in the capital market so that analysts’ reports are more authentic, thus improving the transparency of enterprise information. In addition, intelligent technology’s high universality and permeability can help stakeholders grasp corporate information more comprehensively and improve the quality and efficiency of internal control (Qiu, 2021). Frequent interaction between investors and management is conducive to strengthening the external supervision mechanism of enterprises, enhancing the degree of information transparency, and restraining information manipulation. In conclusion, intelligent transformation can significantly improve information disclosure quality.

The improvement of enterprise information disclosure reduces customer concentration. First, enterprises with high-quality information disclosure tend to release positive financial signals, indicating the company’s stable operating condition (Xia and Wang, 2021; Xu et al., 2023), attracting high-quality customers to conduct trade cooperation with enterprises. Second, improving information disclosure quality gives enterprises more advantages in trade negotiations with external customers. Third, improving the quality of information disclosure reduces internal management costs, giving enterprises more profit space and a price advantage. In this case, the enterprise’s market competitiveness is effectively improved to gain more customers’ favor. These aspects allow companies to work with potential customers, which may reduce their dependence on large customers. Therefore, we propose:

**H2:** Enterprise intelligent transformation has an inhibitory effect on customer concentration by increasing information disclosure quality.
Intelligent Transformation, Innovation Capacity and Customer Concentration

In the process of intelligent transformation, the large-scale application of data elements and intelligent technology plays a vital role in the rational use of traditional resources of enterprises. Specifically, intelligent development can optimize process management or enhance a company’s market positioning, thereby improving operational efficiency, including automation, business process improvement, and cost savings (Song et al., 2022). At the same time, replacing the original simple manufacturing with intelligent manufacturing will not only replace conventional equipment and general manual labor, but also increase the demand for highly skilled labor such as R&D personnel and management personnel (Balsmeier and Woerter, 2019; Lei et al., 2023). An efficient organization model and high-quality human capital will be integrated into the product development and management process, resulting in a direct technology diffusion effect and improving the independent innovation ability of enterprises.

When the strength of technological innovation is gradually enhanced, enterprises can provide differentiated technological products and services (Wang et al., 2022). In this context, products with high-technology content can meet the needs of different types of customers (Mahmoud et al., 2018), thus providing opportunities for cooperation with more customers. In addition, the role of companies with strong core competitiveness in the supply chain has become increasingly prominent, resulting in a strong brand effect, so the original customer resources have been consolidated and developed. Finally, intensified technological innovation enables enterprises to hold a favourable position in trade negotiations (Autor et al., 2020). Firms may actively reduce their reliance on large clients to mitigate liquidity risk. We propose hypothesis 3.

H3: Enterprise intelligent transformation has an inhibitory effect on customer concentration by strengthening innovation capacity.

Intelligent Transformation, Business Boundaries and Customer Concentration

The application of intelligent technologies such as artificial intelligence, cloud computing, blockchain and the Internet of Things has laid a technological foundation for enterprises to expand their business scale. Through the comprehensive and systematic use of intelligent technology and data elements, enterprises can build intelligent application systems, thus promoting the breadth and depth of business development (Lei et al., 2021). Intelligent technology enables data elements and traditional resources to improve enterprise resource reorganization ability and utilization efficiency (Nasiri et al., 2020) so that enterprises can expand business boundaries by combining existing resources. In addition, applying intelligent technology can also provide enterprises with more convenient execution paths and improve employees’ work enthusiasm and management efficiency (Zhang and Guo, 2022), reducing the cost of developing new businesses. Therefore, intelligence is conducive to enterprises expanding business boundaries.

With the continuous expansion of business boundaries, enterprises have more contact with different types of customers. The proportion of the performance of the original business has been reduced, resulting in the reduction of the sales of the original vital customers. In addition, expanding business boundaries gives enterprises more channels to find potential trading partners (Ljubownikow and Ang, 2020), thus reducing their dependence on original customer groups. Therefore, we propose:

H4: Enterprise intelligent transformation reduces customer concentration by expanding business boundaries.

DATA AND MODEL

Sample Selection

We use Chinese manufacturing listed companies from 2008 to 2021 as research samples. Due to the partial change of Chinese accounting standards in 2007, we take 2008 as the starting point. Among
them, the financial data of the enterprises come from the CSMAR and WIND databases. The annual reports of listed companies come from the official websites of the Shenzhen Stock Exchange and Shanghai Stock Exchange. We process the data as follows: remove ST, ST* and delisted samples and remove the samples with missing major variables.

**Variables**

*Customer Concentration (Customer)*

The internal structure characteristics of customers may be closely related to the production and operation of the enterprise. This is because the performance of the enterprise may be restricted by the major customers who account for a high proportion of the total business. Referring to the study of Zhu et al. (2021), we measure customer concentration by the sum of the sales proportion of the top five customers of an enterprise ($Customer$)\(^1\).

*Intelligent Transformation (Intelligence)*

With the embedding of intelligent technology in manufacturing production and operation, organizational structure, management mode, etc., enterprise intelligent transformation is gradually advancing. For the degree of intelligent transformation, previous literature measures it from the perspective of robot penetration rate (Acemoglu and Restrepo, 2020), industrial robot usage (Yang et al., 2020) and so on. However, most of these methods are suitable for measuring the intelligence level at the regional or industry level. Following Xu et al. (2022) and Yang et al. (2023), we comprehensively measure the degree of intelligent transformation from five aspects: macro policy, enabling technology, paradigm characteristic, radiation field and key equipment. Specifically, based on machine learning technology, we look for relevant words from corporate annual reports to measure the above five aspects\(^2\). We then calculate the word frequencies for these five aspects. Finally, we logarithmically process the number of these words to obtain the indicator that measures enterprise intelligent transformation.

*Control Variables*

We also add some control variables that may affect enterprise intelligence transformation in the estimation process, including (1) enterprise size ($Asset$), which is measured by the logarithm of the total assets; (2) age ($Lnage$), which is measured by the logarithm of the establishment age; (3) performance ($Roa$), which is measured by the ratio of net profit to operating income; (4) asset-liability ratio ($Lev$), which is measured by the ratio of total liabilities to total assets; (5) cashflow ($Cashflow$), which is measured by the ratio of cash and cash equivalents to total assets; (6) ownership ($Nation$), SOE is defined as 1 and others as 0; (7) concentration ($Top10$), the shareholding ratio of the top ten shareholders; (8) board size ($Board$), the logarithm of the number of board members.

**Model Design**

To test the marginal effect of intelligent transformation on customer concentration, the following model is constructed:

$$Customer_{i,t} = \rho_0 + \rho_1Intelligence_{i,t} + \rho_2X_{i,t} + u_t + \gamma_j + g_k + \varepsilon_{i,t}$$  \hspace{1cm} (1)

Among them, $Customer$ represents customer concentration. $Intelligence$ represents enterprise intelligent transformation. $X$ is a collection of control variables. $u$, $\gamma$ and $g$ represents the year, industry, and province fixed effects, respectively. $\varepsilon$ represents the residual.
Descriptive Statistics

Table 1 reports descriptive statistics for the main variables. Among them, the mean value of *Customer* is 34.170, and the standard deviation is 31.910, indicating that the customer concentration of manufacturing enterprises generally has a significant difference. The mean value of *Intelligence* is 2.862, the median value is 2.944, and the maximum value is 5.953, indicating that most manufacturing enterprises have carried out different degrees of intelligent transformation.

EMPIRICAL ANALYSIS

Baseline Regression

Table 2 reports the results of the impact of enterprise intelligent transformation on customer concentration. In Column (1), the coefficient of *Intelligence* is negative (p<0.01), which confirms the conclusion that enterprise intelligent transformation reduces customer concentration. In Column (2), enterprise-level control variables are added; In Column (3), the province fixed effect is added, showing that intelligent transformation reduces enterprise customer concentration. Our empirical results confirm hypothesis 1.

The development of emerging intelligent technology is gradually changing the traditional business model, which impacts enterprise customer relationship management. Zhang and Zhang (2023) explored the impact of enterprise digital transformation on customer concentration and found that digital transformation would inhibit customer concentration. Our conclusion enriches the impact of emerging technology development on enterprise customer relationship management from the perspective of intelligent transformation. In the process of gradually promoting intelligent transformation, the internal organization structure and business characteristics change significantly, which promotes the optimization of the production process, weakening the dependence on large customers. Intelligent transformation is conducive to helping enterprises form a more robust trade relationship.

Endogeneity Problem

There may be endogeneity between enterprise intelligent transformation and customer concentration. First, a growing number of studies confirm the importance of customer relationship management to enterprise innovation and the application of new technologies (Krolikowski and Yuan, 2017). Companies with lower customer concentration have more robust cash flows and higher risk-bearing

<table>
<thead>
<tr>
<th>Table 1. Descriptive statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Customer</td>
</tr>
<tr>
<td>Intelligence</td>
</tr>
<tr>
<td>Lnage</td>
</tr>
<tr>
<td>Roa</td>
</tr>
<tr>
<td>Lev</td>
</tr>
<tr>
<td>Cashflow</td>
</tr>
<tr>
<td>Nation</td>
</tr>
<tr>
<td>Top10</td>
</tr>
<tr>
<td>Board</td>
</tr>
</tbody>
</table>
capacity (Cao et al., 2021). Such companies tend to be more competitive, more aware of the great potential of smart technology and more inclined to invest in smart technology. Therefore, there may be reverse causation between the two. Second, different types of manufacturing companies have different needs for smart technology, which may lead to biased results. Third, missing variables may cause endogeneity problems. We weaken endogeneity in the following ways.

**PSM-DID**

First, we weaken the endogeneity problem by constructing a multiphase DID model. Specifically, we use the median of enterprise intelligent transformation in the same industry in the same year as the basis; those greater than the median are identified as highly intelligent enterprises, and those lower than the median are identified as low intelligent enterprises. Then, we set the enterprises that have always been at the low intelligence level as the control group and those that have changed from the low intelligence level to the high intelligence level during the sample period as the experimental group.

![Table 2. The impact of enterprise intelligent transformation on customer concentration](image)
group. We also delete the experimental group with a period of less than 2 years to ensure that the experimental group has a sufficient observation period. The model we construct is as follows:

\[ \text{Customer}_{i,t} = \beta_0 + \beta_1 \text{Treat} \times \text{Post}_{i,t} + \beta_2 X_{i,t} + \delta_i + \gamma_j + \varepsilon_{i,t} \]  

(2)

*Treat* is defined as if the enterprise is the experimental group, *Treat* is 1; otherwise, *Treat* is 0. *Post* is the time dummy variable, 1 if the enterprise is at a high level of intelligence in the current and subsequent years and 0 otherwise. We construct the interaction terms of *Treat* and *Post*, whose estimated coefficients reflect the impact of enterprise intelligent transformation on customer concentration. \( \delta \) represents firm fixed effects.

We perform DID estimation based on Model (2), and the results are shown in Regression (1) in Table 3. The coefficient of the interaction term *Treat* and *Post* is negative (p<0.01). The results show that intelligent transformation inhibits customer concentration, which is consistent with the results shown in Table 2. In addition, we also select the control group matching the experimental group based on the PSM method of nearest neighbour matching (1:1) and then estimate Model (2) based on the matched samples. Regression (2) in Table 3 is the estimated result of the PSM-DID model, which confirms the conclusion that enterprise intelligent transformation reduces customer concentration.

**Instrumental Variable Method**

Referring to the practice of Fan et al. (2013), we adopt the number of coastal ports in each province as the instrumental variable (*Seaport*) of enterprise intelligence transformation. On the one hand, compared with inland provinces, international trade in coastal provinces is more convenient, and it is easier for local enterprises to introduce advanced intelligent technologies. In addition, the economies

| Table 3. Regression results of the endogeneity test |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                | (1)             | (2)             | (3)             | (4)             | (5)             |
|                                | DID            | PSM-DID         | IV              |                 |                 |
| Customer                       | Treat×Post     | Seaport         | Intelligence    | Controls and Constant | Firm FE | Province FE | Industry / Year FE | LM test | F test | N | R2_a |
|                                | -1.266***      | -1.159***       | 0.113***        | Yes              | Yes              | Yes            | No            | Yes            | Yes | Yes | 20868 | 0.117 |
|                                | (-4.79)        | (-3.05)         | (12.07)         | Yes              | Yes              | Yes            | No            | Yes            | Yes | Yes | 7042  | 0.095 |
|                                |                |                 |                | Yes              | No               | Yes            | Yes           | Yes            |     |     | 22776 | 0.346 |
|                                |                |                 |                |                  | No               | Yes            | Yes           | Yes            | 144.431***   | 145.180 (16.38) |
|                                |                |                 |                |                  |                  |                |               |                |     |     | 22776 | 0.145 |
|                                |                |                 |                |                  |                  |                |               |                |     |     | 22776 | 0.131 |

Note: * p < 0.1, ** p < 0.05, *** p < 0.01.
of the coastal provinces are relatively more developed, and the demand for intelligent technologies is also stronger. Therefore, Seaport meets the correlation requirements. On the other hand, the number of coastal ports in the region may reflect international trade, and it is difficult to influence the customer concentration of local enterprises, making Seaport meet the exclusivity requirements. The results are shown in Columns (3) - (5) in Table 3. In Regression (3), the coefficient of Seaport is positive, and the correlation of the instrumental variable is satisfied. In Column (4), the coefficient of Seaport is not significant; the results show that Seaport satisfies the exclusivity requirement. In addition, the LM and F tests reject the hypothesis of insufficient identification of the instrumental and weak instrumental variables, respectively. In summary, using the number of coastal ports as the instrumental variable is reasonable. In Column (5), the coefficient of Intelligence is negative (p<0.05), which also confirms the conclusion that enterprise intelligent transformation reduces customer concentration.

**Robustness Test**

We also use the following methods to test the robustness of the conclusion that enterprise intelligent transformation reduces customer concentration.

First, we use the alternative indicator to measure enterprise intelligent transformation. We divide the word frequency of intelligent transformation-related words by the total annual report words as a surrogate variable for intelligent transformation ($Rate_{Intelligence}$) and then conduct a quantitative test based on Model (1). In Column (1) of Table 4, the coefficient of $Rate_{Intelligence}$ is significantly negative, which is consistent with the baseline regression results.

Second, we measure customer concentration using the proportion of sales from the company’s first largest customer ($Customer_{top1}$). The estimated results are shown in Column (2) of Table 4. The regression coefficient of Intelligence shows that enterprise intelligence transformation inhibits customer concentration.

Third, we add control variables. To control the influence of some factors at the provincial level over time on the empirical results, we add the province and year interaction fixed effects based on Model (1). In Regression (3) of Table 4, the coefficient of Intelligence is negative (p<0.01), which again proves the above conclusion.

Fourth, we change the time window. A global outbreak of COVID-19 broke out in late 2019. Due to the epidemic’s impact, the production process, customer relationship management and enterprise intelligence transformation in most regions have been affected to varying degrees. To avoid bias caused by this event on the empirical results, we use the data from 2008 to 2018 to conduct a regression on Model (1). In Column (4) of Table 4, the regression coefficient of Intelligence is negative (p<0.01), which also verifies the conclusion that enterprise intelligent transformation reduces customer concentration.

**Mechanisms**

We further study the impact path of enterprise intelligent transformation on customer concentration. According to the above theories, intelligent transformation can help enterprises improve information disclosure quality, strengthen innovation ability and expand business boundaries, thus affecting customer concentration. We construct Models (3) and (4) to verify how enterprise intelligent transformation affects customer concentration:

\[
Path_{i,t} = \psi_0 + \psi_1 Intelligence_{i,t} + \psi_2 X_{i,t} + u_i + \gamma_j + g_k + \varepsilon_{i,t}, \quad (3)
\]

\[
Customer_{i,t} = \alpha_0 + \alpha_1 Intelligence_{i,t} + \alpha_2 Path_{i,t} + \alpha_3 X_{i,t} + u_i + \gamma_j + g_k + \varepsilon_{i,t}, \quad (4)
\]
For Models (3) and (4), *Path* represents information disclosure quality (*Quality*), innovation ability (*Patent*) and business boundaries (*Diversified*), respectively.

We use the corporate information disclosure index published by Shanghai and Shenzhen A-share exchanges to measure corporate information disclosure quality (Zhao and Mao, 2023). The index ranges from 1 to 4; the higher the value is, the higher the reliability of the information published by the enterprise. To weaken the influence of heteroscedasticity, we take the index logarithmically to measure information disclosure quality (*Quality*). Innovation ability (*Patent*) is measured as ln(1+the number of invention patent applications of enterprises). This is because invention patents have higher technical content and economic value (Zhang et al., 2018; Liu et al., 2023). For the business category (*Diversified*), we use the number of business types of the enterprise plus one and then take a logarithm to measure (Li et al., 2019).

The regression results of Models (3) and (4) are shown in Table 5. In Regression (1), the coefficient of *Intelligence* is positive (p<0.01); the results show that enterprise intelligent transformation improves information disclosure quality. In Regression (2), the coefficient of *Quality* is negative (p<0.05); the results show that the improvement of information disclosure quality has a restraining effect on customer concentration. These two sets of results validate the impact path of intelligent transformation to reduce customer concentration by improving information disclosure quality. With the gradual advancement of intelligent transformation, strengthening human-machine interaction is conducive to improving the transparency of business processes, thus reducing the degree of information asymmetry. The weakening of information asymmetry is helpful for enterprises to find potential customers, thus reducing customer concentration and weakening enterprises’ dependence on large customers. Hypothesis 2 is tested.

In Regression (3), the coefficient of *Intelligence* is positive (p<0.01); the result show that enterprise intelligent transformation promotes innovation capacity. This is consistent with the conclusion of Yang et al. (2022). Regression (4) shows the influence of enterprise intelligent transformation and technological innovation on customer concentration; The coefficient of *Patent* is negative (p<0.01), indicating that technological innovation is conducive to reducing customer concentration. Combined with Regressions (3) and (4), it can be concluded that enterprise intelligent transformation improves R&D strength, thereby reducing customer concentration, which confirms Hypothesis 3.

<table>
<thead>
<tr>
<th>Table 4. Regression results of robustness test</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Replace explanatory variable</td>
</tr>
<tr>
<td>Customer</td>
</tr>
<tr>
<td>Rate_ Intelligence</td>
</tr>
<tr>
<td>Intelligence</td>
</tr>
<tr>
<td>Controls and Constant</td>
</tr>
<tr>
<td>Province / Industry / Year FE</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>R2_a</td>
</tr>
</tbody>
</table>

Note: * p < 0.1, ** p < 0.05, *** p < 0.01.
Regression (5) examines the impact of enterprise intelligent transformation on business boundaries. The coefficient of *Intelligence* is positive (p<0.01); the results show that enterprise intelligent transformation expands business boundaries. Regression (6) examines the impact of intelligent transformation and business boundaries on customer concentration. The coefficient of *Diversified* is negative (p<0.01), indicating that expanding business boundaries is conducive to reducing customer concentration. The above two sets of results show that intelligent transformation increases business boundaries, thereby reducing customer concentration. Hypothesis 3 has also been tested.

In addition, Sobel tests are all negative (p<0.01), which also confirms the existence of the above three action mechanisms. Based on the above analysis, we believe that enterprise intelligent transformation improves information disclosure quality, enhances technological innovation and expands business boundaries, thus reducing customer concentration.

**CONCLUSION AND SUGGESTIONS**

Taking A-share manufacturing listed companies as samples, we use text analysis and machine learning to construct the indicator of enterprise intelligent transformation and study the influence of intelligent transformation on customer concentration. We find that enterprise intelligent transformation significantly reduces customer concentration. The influence mechanism study shows that enterprise intelligent transformation improves information disclosure quality, stimulates innovation ability, and expands business boundaries, thus reducing customer concentration.

We obtain the following policy implications. At present, influenced by the Russia-Ukraine conflict and geopolitical factors, the global economic situation is increasingly uncertain. In this macro background, enterprise risk resistance and crisis prevention ability are crucial to their development. While actively promoting intelligent change, enterprises should establish diversified trade routes.
and supply chain channels to prevent the major impact caused by adverse events. At the same time, when enterprises establish trade relationships with major customers, they should reasonably plan the production process, improve the liquidity of products and the substitutability of trade objects, and further disperse risks. Moreover, with the deepening integration of intelligent technology and production processes, enterprises should optimize supply chain management and create core competitive products to enhance the right to speak in the trade process.

ACKNOWLEDGMENT

We acknowledge financial support from “The National Social Science Foundation of China” [Grant Number: 22CJL033].
REFERENCES


ENDNOTES

1  We multiply customer concentration by 100.
2  Macro policy includes words: Made in China 2025, Internet +, Industry 4.0; Enabling technology includes words: Internet of Things, 3D printing, virtual reality, pattern recognition, neural networks, artificial intelligence, biometrics, cloud services, cloud technology, cloud computing, cloud platform, data center, data storage, big data, mass data, data mining, Internet, data analysis, mobile Internet; Paradigm characteristic includes words: information management, information application, automation, information, integration, virtualization, digitization, networking, intelligence; Radiation field includes words: intelligent terminal, green manufacturing, intelligent logistics, intelligent service, civil-military integration, smart grid, high-end equipment manufacturing, smart energy, smart home, energy Internet, smart medical care, smart community, smart city, smart transportation, e-government, electric vehicles, electric vehicles, new energy vehicles, charging piles, power batteries; Key equipment includes words: CNC machine tools, robots, industrial robots, sensors.