A Study of the Impact of Data Elements on the Export Quality of China's Manufacturing Industry

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Abstract. Against the background of the continuous weakening of traditional comparative advantages, data elements have become a new driving force for the improvement of China's manufacturing export quality. This paper adopts China's provincial panel data from 2011-2022 to study the relationship between data elements and the quality of manufacturing exports and the intrinsic influence mechanism. The results find that: data elements have a U-shaped influence effect of inhibiting and then promoting the improvement of technological complexity of China's provincial manufacturing exports; technological innovation, cost savings, and resource allocation are important mechanisms for data elements to promote the improvement of manufacturing export quality. This study provides a clear and feasible path for China's manufacturing industry to utilise the data factor dividend to drive export quality improvement in the context of digital economy.

Keywords: data elements, manufacturing export quality, "U" shaped relationship, mediation effects

1   INTRODUCTION AND LITERATURE REVIEW

The traditional advantages of manufacturing are fading as a result of China's slowing population growth and increasing pressure on resources and the environment. Currently, China's manufacturing sector is facing problems of insufficient technological capabilities and being locked in at the lower end of the value chain. As the process of a new round of information technology revolution advances, the development of the digital economy is gaining momentum, and the status of data is rising. 2019 is the first time that China proposes data as a new factor of production, marking the official entry into the era of large-scale release of the data dividend. Data elements can create economic value beyond traditional production factors in all aspects of production, circulation and application, and promote the manufacturing industry to move towards the middle and high end of the value chain. It is a rare opportunity for China's manufacturing industry to realize "changing lanes and overtaking" in a new round of international trade competition.

There are a lot of existing research results for data elements in China: on the one hand, some research results mainly focus on the process of data element generation，others have explored the quantitative measurement of data elements, with some researchers adopting the monetisation perspective of business and directly measuring the market price of data elements through the cost, price or income method[1].Due to the lack of unified concept definition standards and clear measurement methods, most of the existing studies on the impact of data elements on manufacturing exports remain at the level of qualitative analysis. Quantitative studies have rarely focused on the new core factor of production in the digital economy - the data factor[2].

To sum up, this paper tries to promote the relevant research from the following aspects: first, by constructing the index system for measuring the level of data elements, adopting the entropy value method to measure it scientifically and objectively, providing a way of thinking for the quantitative analysis of data elements. Secondly, data elements and China's manufacturing export quality are put into the same framework for research, the theoretical mechanism of data elements to promote manufacturing exports is sorted out, and the empirical study of how data elements can improve the quality of manufacturing exports is carried out.

2　　THEORETICAL MECHANISMS AND RESEARCH HYPOTHESES

As a new type of element with multiple characteristics, data elements can bring direct multiplier or multiplier effects to the development of the manufacturing industry through multiple channels. On the one hand, data elements themselves can upgrade the manufacturing industry such as intelligent manufacturing. On the other hand, data elements have the characteristics of infinity and high mobility, which can produce a multiplier effect by combining with traditional elements, and thus improve the productivity of products in various sectors[3].However, there may be problems such as privacy leakage and virus dissemination in the production and circulation of data, and the security of data storage is difficult to be guaranteed. So when the level of data elements is low, there are greater data security risks and higher storage costs, which will hinder the improvement of the quality of manufacturing exports. When the level of data elements can be improved, this hindering effect is gradually replaced by a positive effect. Therefore, this paper puts forward the following hypothesis.

Hypothesis 1a: There is a positive contribution of data elements to the quality of manufacturing exports.

Hypothesis 1b: The impact of data elements on the quality of manufacturing exports is characterised by a "U" shaped non-linear pattern of inhibition followed by promotion.

In addition, data factors will indirectly affect the quality of manufacturing exports through different mechanisms[4]. First of all, the transnational flow of data elements provides a new way of interaction between various economies, provides an opportunity for knowledge linking between different economies in the world, and forms a research and development network, which is conducive to the improvement of technological innovation capability. Secondly, by improving the information asymmetry between the

two sides of the transaction, data elements reduce the search cost and matching cost, while weakening the time and space restrictions, reducing the fixed cost of enterprises' export, which is conducive to smes' products entering the export market[5]. Finally, data factors can promote the optimization and reorganization of traditional factors, maximize production benefits and optimize efficiency, and thus maximize the efficiency of resource allocation[6].As a result, this paper proposes the following hypothesis:

Hypothesis 2: Data elements will enhance the quality of manufacturing exports through enhanced technological innovation.

Hypothesis 3: Data elements will improve the quality of manufacturing exports by reducing trade costs.

Hypothesis 4: data factors will improve the quality of manufacturing exports by optimising resource allocation.

3   VARIABLE SELECTION AND MODEL SETTING

3.1   Modelling

For hypothesis 1, the following panel data fixed effects model is constructed based on the results of the Hausmann test:

$$Expy_{it} = \alpha_0 + \alpha_1 Data_{it} + \alpha_2 Data_{it}^2 + a_m \sum_m Control_m + \mu_i + \varepsilon_{it} \qquad (1)$$

Where i denotes region, t denotes year, Expy is the technological complexity of manufacturing exports, Data is the level of data elements, Control is a control variable, µ is a random error term, and all variables are regressed after taking logarithms, except for the two variables of the level of data elements and the level of infrastructure.

In response to hypotheses 2-4, a mediating effect model is introduced:

$$Medv_{it} = \beta_0 + \beta_1 Data_{it} + \beta_m \sum_m Control_m + \mu_i + \varepsilon_{it} \qquad (2)$$

$$Expy_{it} = \lambda_0 + \lambda_1 Data_{it}^2 + \lambda_2 Data_{it} + \lambda_3 Medv_{it}^2 + \lambda_4 Medv_{it} + \lambda_m \sum_m Control_m + \mu_i + \varepsilon_{it} \qquad (3)$$

Where Medv denotes the mediating variable and the other variables are as in equation (1).

3.2   Variable selection and measurement

1. Explained variables

Technological sophistication of manufacturing exports (Expy): There are many ways to measure the quality of a country's manufacturing exports, including using export competitiveness-related indicators, measuring position in the value chain, or constructing a system of indicators[7].

2. Explanatory variables

Data element level (Data): The data element level measurement framework of this paper covers 7 dimensions in 4 stages of data supply, data circulation, data application and data governance, containing 23 specific indicators, and the entropy value method is used to assign weights to each indicator[8].

3. Control variables

In addition to the data elements, this paper selects the following control variables: the level of economic development (Gdp), which is expressed as the regional GDP per capita; the degree of government intervention (Gov), which is expressed as the ratio of the general government budget expenditures to the GDP; the industrial structure (Is), which is expressed as the ratio of the tertiary to the secondary industry; and the level of foreign direct investment (Fdi), which is expressed as the amount of the actual utilisation of foreign investment in the year; Infrastructure level (Inf), expressed as the ratio of total regional railway and road mileage to population[9].

4. Mediating variables

The mediating variables involved in the mediation effect model of this paper are as follows: technological innovation (Tech): measured by the number of patent applications; trade cost (Cost): expressed by the marketisation index; and resource allocation efficiency (Allo): expressed by the resource mismatch index.

3.3   Data sources

The manufacturing export data in this paper comes from the National Research Network, and after excluding agricultural products and other industries, the remaining total of 16 categories of manufacturing industries are matched with the two-digit code of manufacturing industries of the National Economic Industry Classification (NEC). Explanatory variables, control variables and mediator variables are obtained from China Statistical Yearbook, Industrial Statistical Yearbook, Science and Technology Statistical Yearbook, and provincial statistical yearbooks, and the panel data of 30 provincial administrative units in China, except Tibet, Hong Kong, Macao and Taiwan, are finally obtained for the period of 2011-2022, and missing values are supplemented by linear interpolation method.

4   ANALYSIS OF EMPIRICAL RESULTS

4.1   Benchmark regression

Column (1) of Table 1 shows that the coefficient of Data is positive at the 1 per cent level, indicating that the data factor significantly enhances the technological complexity of manufacturing exports, and that Hypothesis 1a holds. Column (2) shows that the coefficient of the squared term of Data is significantly positive, indicating that there is a U-shaped nonlinear effect of Data on China's manufacturing exports, and hypothesis 1b holds. After adding control variables one by one, the coefficients of Data and Data^2 in Columns (3)-(7) are still significant at 1% level, and the parameter estimates of the core explanatory variables are relatively robust, which verifies the U-shape effect of

the data factor on the technological complexity of China's manufacturing exports, and Hypothesis 1 is proved.

Table 1. Benchmark regression results

	Expy (1)	Expy (2)	Expy (3)	Expy (4)	Expy (5)	Expy (6)	Expy (7)
Data	1.915***		-0.310**	-0.700***	-0.764***	-0.760***	-0.695***
	(0.112)		(0.129)	(0.124)	(0.119)	(0.118)	(0.123)
Data2		0.924***	0.281***	0.511***	0.562***	0.560***	0.538***
		(0.133)	(0.091)	(0.085)	(0.083)	(0.081)	(0.082)
_cons	10.662***	10.877***	1.542***	-0.226	0.272	0.525*	0.778**
	(0.018)	(0.013)	(0.223)	(0.283)	(0.287)	(0.294)	(0.326)
N	360.000	360.000	360.000	360.000	360.000	360.000	360.000
r2	0.468	0.129	0.944	0.955	0.958	0.959	0.960

Note: *, **, *** indicate significant at the 10 per cent, 5 per cent, and 1 per cent levels, respectively; (2) Standard errors are reported in parentheses. Same below.

4.2   Robustness tests

In order to reduce the model bias, this paper adopts three methods for robustness testing. Firstly, in order to solve the trouble caused by the endogeneity problem, this paper lags the core explanatory variables by one period before regression; secondly, this paper replaces the explanatory variables with the RCA index in export competitiveness; and lastly, in order to eliminate the influence of the outliers, this paper performs a shrinkage of the samples at the 1 per cent and 99 per cent deciles. The regression results show that the coefficients of the squared terms of the data elements of the above robustness tests are all significantly positive, indicating the robustness of the model.

4.3   Heterogeneity tests

As far as the results of data elements measurement are concerned, it can be seen that the level of data elements varies greatly among different provinces. In order to further explore the regional heterogeneity of the impact of data elements on the quality of manufacturing exports, the full sample of data is divided into three regions, namely, the East, the Middle East and the West, and further analyses are made by linear regression and non-linear regression respectively, and the regression results are shown in Table 2 below.

Table 2. Results of the regional heterogeneity test

	eastern part	central section	western part

	Expy (1)	Expy (2)	Expy (3)	Expy (4)	Expy (5)	Expy (6)
Data	0.280***	-0.239	-0.558***	-0.862*	-1.748***	-1.530*
	(0.052)	(0.165)	(0.161)	(0.462)	(0.353)	(0.904)
Data2		0.299***		1.331		-0.665
		(0.091)		(1.896)		(2.540)
_cons	2.911***	1.533***	1.206***	1.090***	-1.449**	-1.309
	(0.348)	(0.535)	(0.321)	(0.362)	(0.654)	(0.848)
N	132.000	132.000	96.000	96.000	132.000	132.000
r2	0.976	0.978	0.984	0.984	0.958	0.958

From column (1) of table 2, it can be seen that the data factors in the eastern region can significantly improve the technological complexity of manufacturing exports, probably because the eastern region has a high level of scientific and technological and human resources, the factor synergy and innovation effect played by the data factors can be better utilised. Column (3) and column (5) show that the level of data factors in the central and western regions has a negative impact on manufacturing exports, and the impediment is greater in the western region. The reason for this is that the central and western regions have problems such as backwardness in science and technology, weak digital foundation and low quality of labour force, the cost of digital change is too high, and the increase of data elements will interfere with the development of the traditional manufacturing trade, resulting in inefficiency.

4.4   Mediation effects test

In order to explore the influence mechanism of data elements on the export quality of Chinese manufacturing industry, technological innovation, trade cost and resource allocation are selected as mediating variables to carry out further analyses, and the regression results are shown in Table 3 below.

Table 3. Results of the mediation effect test

	technological innovation		Cost savings		Resource allocation	
	Tech (1)	Expy (2)	Cost (3)	Expy (4)	Allo (5)	Expy (6)
Data2		0.465***		0.600***		0.519***
		(0.100)		(0.088)		(0.083)
Data	152721.912 ***	-0.588***	0.904**	-0.832***	-0.389***	-0.655***
	(17676.853)	(0.161)	(0.438)	(0.142)	(0.082)	(0.129)
Medv2		0.000**		0.002*		-0.157***
		(0.000)		(0.001)		(0.052)
Medv		-0.000*		-0.035*		0.510***
		(0.000)		(0.020)		(0.136)
_cons	- 271946.967 ***	0.664**	- 22.647* **	0.513	-0.296	0.619*

	(97203.956)	(0.333)	(2.410)	(0.378)	(0.453)	(0.340)
N	360.000	360.000	360.000	360.000	360.000	360.000
r2	0.462	0.960	0.757	0.960	0.125	0.962

Columns (1) and (2) of table 3 report the results of the test for the mediating effect of technological innovation. Column (1) shows that the effect of data factors on technological innovation is significantly positive, while column (2) shows that the effect of technological innovation on the quality of manufacturing exports exhibits a "U"-shaped non-linear characteristic when the data factor variable is not included. Therefore, it can be seen that technological innovation plays a mediating effect in the influence of data factors on manufacturing exports, and hypothesis 2 is proved. Columns (3) and (4) report the results of the test of the mediating effect of cost savings, and the results show that technological innovation plays a mediating effect in the impact of data elements on manufacturing exports, and hypothesis 3 is confirmed. Columns (5) and (6) report the results of the test of the mediating effect of resource allocation, which shows that resource allocation plays a mediating effect in the impact of the data factor on manufacturing exports, and hypothesis 4 is confirmed.

5   CONCLUSIONS AND RECOMMENDATIONS

This paper adopts the panel data of 30 provinces in China from 2011 to 2022 to study the relationship between data elements and the quality of manufacturing exports and the intrinsic influence mechanism, and draws the following conclusions: firstly, the data elements have a U-shaped influence effect that inhibits and then promotes the enhancement of the technological complexity of manufacturing exports at the provincial level in China; secondly, technological innovation, cost saving and resource allocation are the important mechanisms by which the data elements influence manufacturing Third, the analysis of regional heterogeneity shows that data elements in the eastern region can significantly improve the technological complexity of manufacturing exports, and the level of data elements in the central and western regions has a negative impact on manufacturing exports, and the impediment is greater in the western region.

Accordingly, this paper draws the following policy insights: firstly, it is necessary to pay attention to the role of data elements in the technological upgrading of export products, and to improve the quality of manufacturing exports in all regions of China by increasing investment in data elements. As the second strongest country in the world's digital economy, China possesses unlimited potential for data factor production. Fully grasping this innate advantage and valuable opportunity to appropriately increase investment in data factor production will be an important way to enhance the technological competitiveness of China's export products. Secondly, local governments should be based on regional realities to enhance the quality of manufacturing exports with differentiated regional development strategies and promote the balanced development of regional real economy. Finally, attention should be paid to the regulation and utilisation of data elements, to prevent data risks and security issues, to promote the benign development of data exchange and application, to provide a strong

guarantee for the innovation and upgrading of the industry, and to further coordinate development and security issues.

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