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The Impact of Innovation Efficiency and Standards Constraints on the Quality of China's Manufacturing Export Products - The Case of Six Manufacturing Segments

Xueying Yu[1]
[1]School of Finance and Economics, Jiangsu University, 212013, Zhenjiang, China

Abstract— *This paper selects manufacturing industries with different and representative degrees of production factor intensity for analysis, applies the entropy-weighted TOPSIS method to determine the index weights based on both their product profitability and market position, and constructs an index for evaluating the quality of export products. At the same time, data at the level of the six manufacturing industries from 2008 to 2019 were selected to conduct an overall empirical test using a panel model. The study finds that innovation efficiency has a significant contribution to export product quality, while standard constraints have a significant inhibitory effect.*

Keywords— *Export product quality; Innovation efficiency; Manufacturing; Standards constraints.*

I. Introduction

World trade figures show that China's total imports and exports reached US$4.3 trillion in 2014, making it the world's largest trading nation, with exports accounting for 12% of total global exports, or US$2.34 trillion. "Made in China" has made a huge contribution to global economic growth, and the expansion of scale and cheap resource inputs are important reasons for this achievement. However, as China's resource and environmental constraints continue to strengthen and the cost of production factors such as labour continues to rise, the crude development model of relying mainly on resource factor inputs and scale expansion is unsustainable. Especially in the face of the harsh external environment and complex trade situation, China has entered a critical period of speed shift, structural adjustment, transformation and upgrading, and is at an important juncture from quantitative to qualitative change. The way out of this hurdle lies in taking the road of innovation, which is the first driving force to lead development. In addition, standardisation has also become an indispensable means to reshape the country's competitive advantage. Therefore, the issues studied in this paper are of practical significance.

II. Literature Review

At present, export product quality is a key area of concern for many scholars, and some scholars have conducted theoretical analyses and empirical studies on factors that may affect export product quality, such as R&D investment, the degree of foreign investment entry, industrial agglomeration, environmental regulation, and the digital economy. This paper focuses on the impact of innovation efficiency and standardization constraints on export product quality.

In terms of innovation efficiency. Innovation efficiency is the conversion rate of innovation input and output, and its level reflects the level of innovation capability of an industry or enterprise. The existing literature on innovation efficiency includes data envelopment method (DEA) and indicator evaluation method, etc. Luo and Lai both use DEA method to measure innovation efficiency, but since the data between different industries are susceptible to extreme value interference, this paper refers to He's research method and adopts output-input characterisation ratio to measure innovation efficiency. Although the research on innovation efficiency is relatively mature, there are fewer studies on innovation efficiency on export product quality by scholars at home and abroad, so an attempt is made to study it in order to play a leading role. In this paper, the mechanism of innovation efficiency to improve the quality of export products mainly lies in the following: Firstly, by applying innovative technology to product development or improving the design, process and procedures of existing products, the quality of products can be improved and the advantages of products can be highlighted. Secondly, high innovation efficiency also enables the industry to obtain more financial subsidies and more tax incentives, which can guarantee financial support for the product and also increase the risk tolerance. Thirdly, innovation efficiency is not only in terms of technology, but also in terms of management and institutional innovation, which effectively mobilise staff initiative. All in all, the three aspects of "human, material and financial resources" to increase innovation investment, as much as possible to promote innovation output, in order to promote the upgrading of export product quality. Based on the above analysis, hypothesis one is that innovation efficiency has a catalytic effect on export product quality.

In terms of standardisation. Referring to Tao's article, standardisation mainly affects the quality of export products by promoting specialised production, regulating the market system and promoting the realisation of economies of scale. In this paper, the mechanism of the role of standard constraints in improving export product quality mainly lies in the following: Firstly, standardisation promotes specialised production, which facilitates industry enterprises to carry out refined management in accordance with standard requirements, and is also more conducive to special and systematic control of product production processes, procedures, as well as distribution and sales, making product quality more effectively and comprehensively guaranteed. Secondly, in the international market competition led by standards, standards impose "order" on the diversified production process, and there are corresponding index constraints on the use of production technology and product quality grade requirements, etc. Standardisation can make the inner quality, design and ecological, health and safety performance of products are fully guaranteed. Thirdly, standardisation can appropriately eliminate product variability and gradually unify production and management schemes, making it easier for product output to reach a critical mass of appropriate scale, and achieving economies of scale while maintaining quality and quantity. Hypothesis 2: Standard constraints have a catalytic effect on the quality of export products.

In terms of export product quality measurement. At present, domestic and foreign scholars' methods for measuring product quality at the micro level mainly include the unit value method, the product-specific characteristics method and the inverse demand information method. Schott, Hummels & Skiba, Yin and Li all use this method. However, product prices are also influenced by factors other than quality, such as market supply and demand, exchange rates, and consumer preferences. The second is the product-specific approach, in which Crozet and Auer measure a specific indicator for a particular product. This method is accurate but cannot be applied to all products in the six major manufacturing industries in this paper. The third method is the inverse demand information method, in which Khandelwal, Shi and Zhang argue that the better the market performance, the higher the quality of the product, provided that the price of the good is the same. This method is more accurate and feasible, so it has become the preferred method for scholars to measure export product quality. In this paper, we attempt to construct six indicators for evaluating the quality of export products in the manufacturing industry from two dimensions: profitability and market position of export products, using the entropy-weighted Topsis method.

III. SELECTION OF REPRESENTATIVE MANUFACTURING INDUSTRY SEGMENTS IN SEVEN CATEGORIES

Based on the representativeness of capital and technology-intensive industries and the availability of data, this thesis examines seven representative sub-sectors of manufacturing industries, namely chemical raw materials and chemical products manufacturing, pharmaceutical manufacturing, iron and steel manufacturing, electronic computer and office equipment manufacturing, electronic and communication equipment manufacturing, and vehicle transportation manufacturing.

In view of the fact that China's National Economic Classification (NEC) does not correspond to the HS Code tariff, the correspondence between NEC and HS Code tariff is summarised (see Table I) in order to facilitate the search and statistics of the manufacturing industry segments.

TABLE II. Correspondence table between industry standard classifications and harmonised code article numbers.

Industry Standard Classification for National Economy	HS Goods Customs Code Tariff
Chemical raw materials and chemical products manufacturing C26	15.18 15.20 Chapter 28 29 31 32 33 34 35 36 37 38 Chapter 39.01 40.02
Iron and steel manufacturing C31-311 & 312	Chapter 72 73
Vehicle Transportation Equipment Manufacturing C37	Chapter 86 87 88 89
Pharmaceutical Manufacturing C27	Chapter 30
Electronic and Communication Equipment Manufacturing C35-356 C39-392 397 398 399	85.17-29 85.40-43
Electronic computer and office equipment manufacturing C39-391 C34-347	84.42-43 84.70-73

IV. EXPORT PRODUCT QUALITY INDICATORS MEASUREMENT AND ANALYSIS

The research samples in this paper are all taken from the China Statistical Yearbook, from which the representative products of the six industries from 2008 to 2019 are selected as research objects. The products selected account for a larger share in both export quantity and export value, so the export product quality index excluding the inflation factor is more convincing and objective.

TABLE III. Export Product Quality Index indicator weights.

Primary indicators	Secondary indicators
Profitability level (0.1980)	Export unit value change （0.4201）
	Import/export spread （0.5799）
Market position （0.8020）	Competitive advantage index （0.4485）
	Intra-industry trade index （0.5515）

The results of the entropy weights using the Topsis method show that for the six manufacturing industries, the market position weight of 0.8020 is higher than the profitability weight of 0.1980, indicating that market position is a more critical factor in the measurement of export product quality. When market position and profitability are examined separately, the import/export spread in profitability is weighted at 0.5799, which is more significant than the change in the value of export units. The intra-industry trade index is an important indicator in determining market position, with a weight of 0.5515.

Between 2008 and 2019 the quality of products exported by the three major manufacturing industries of steel, electronic computers and electronic communications has basically stabilised at a medium to high level. Since 2006 China has been the world's largest exporter of steel, so the steel manufacturing industry has a high starting point. The most likely reason for this is that on January 10, 2017, the expanded meeting of the Board of Directors of the China Steel Association requested China to completely clear out "ground steel" and other backward production capacity. But the good times are not long,

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due to the rise of trade friction constraints on the development of China's steel industry, export product quality is also hampered. Data from the twelve years show that the quality of export products in the electronic computer manufacturing industry has not changed significantly, with the average value at 0.6. While the quality of export products in the electronic communications manufacturing industry has changed slightly, but the overall trend is still down.

TABLE III. Export Product Quality Index indicator weights.

Years	Chemical	Pharmaceuticals	Iron and Steel	Electronic Computers	Electronic communications	Vehicle transport
2008	0.1696	0.7303	0.6659	0.5999	0.5377	0.6492
2009	0.1714	0.7191	0.7652	0.6023	0.5367	0.4386
2010	0.1787	0.7250	0.7041	0.5961	0.5265	0.3071
2011	0.2311	0.7125	0.6772	0.5965	0.5248	0.3775
2012	0.1786	0.6768	0.6515	0.6042	0.5251	0.4170
2013	0.2216	0.6065	0.6442	0.5924	0.5237	0.3875
2014	0.2226	0.5934	0.6216	0.5919	0.5223	0.3673
2015	0.2405	0.5625	0.6111	0.5972	0.5268	0.4181
2016	0.2392	0.5247	0.6181	0.6035	0.5254	0.3629
2017	0.2165	0.5181	0.6356	0.5947	0.5173	0.3663
2018	0.6632	0.5554	0.6319	0.6012	0.5154	0.4186
2019	0.4033	0.4263	0.6258	0.6027	0.5158	0.4272

From 2008 to 2019, the export product quality of the chemical manufacturing industry showed an overall upward trend. before 2017, it basically fluctuated back and forth above and below 0.2, and the export product quality was at a lower level. 2017-2018 saw a significant increase in the product quality level due to the more significant process of centralisation and scale. This was followed by multiple events such as trade frictions between the US and China, frequent accidents and production suspensions and consolidation, with a small decline in 2019.

The pharmaceutical manufacturing industry showed a decline in export product quality between 2008 and 2019, gradually decreasing from medium to high levels to medium to low levels. During this 12-year period, there were a number of bad incidents in the pharmaceutical manufacturing industry, such as the illegal sale of drugs at up to 115 websites, the contamination of Acanthopanax that killed people, and the bribery practices of Siemens' medical division in China. With the exception of 2008 when the Export Product Quality Index was at 0.6492, the vehicle transportation manufacturing industry has fluctuated around 0.4 from 2009 to 2019 with no significant change.

V. SELECTION OF INDICATORS

A. Explanatory variables

The explanatory variable in this paper is the export product quality index (QUA), which has been calculated above using the entropy-weighted Topsis method.

B. Core explanatory variables

Innovation efficiency (RE) draws on HO's research methodology and uses the ratio of R&D innovation outputs to inputs to measure innovation efficiency, where the number of valid invention patents is used to characterise innovation outputs and internal expenditure on R&D funding is used to characterise innovation inputs. The higher the innovation efficiency, the better the quality of export products.

Strength of Standard Constraints (STA). Based on the feasibility of the indicator and data availability, and with reference to Qin's environmental regulation intensity measurement method, this paper uses the incremental number of national standards by industry divided by the total value-added of national standards in the same period to express the standard constraint intensity.

C. Control variables

Financing capacity (FIN) is the ratio of interest expense to main operating income. It refers to the level of financing possible for an industry and the ability to sustain access to long-term, high-quality capital. Long-term stable financing capacity can be effective in increasing investment in innovation, supporting scale expansion and providing financial security for the production of high-quality products. Energy consumption per unit of product (EC) is the ratio of total energy consumption to the quantity of finished goods. It can comprehensively reflect the quantitative relationship between input energy and output products, and comprehensively reflect the industry's production and operation level and output efficiency level, etc. Industry size (SE) is the ratio of total assets to the number of enterprise units. This variable directly reflects the size of the industry's current assets per unit of enterprise, while the change in industry size across periods can reflect the willingness of enterprises to invest and the degree of industry prosperity. In an economy, companies can reduce the cost per unit of product by combining resources and expanding their scale to achieve economies of scale. The Asset-Liability Ratio (ALR) is the percentage of total liabilities to total assets. It reflects the average capital structure of companies in an industry. By adjusting the capital structure, companies can effectively reduce the cost of capital and optimize the allocation of resources across time. By adjusting the capital structure, companies can effectively reduce their capital costs and optimize the allocation of resources across time. The industry can also use this to facilitate expansion and improve technology and product quality.

TABLE IV. Model variable names and sources.

Variable type	Variable name	Variable symbol	Variable source
Explained variables	Export product quality	QUA	《China Foreign Economic Statistics Yearbook》
Core explanatory variables	Innovation efficiency	RE	《China Science and Technology Statistical Yearbook
	Standard constraint intensity	STA	Calculated by IBSN
Control variables	Financing capacity	FIN	《China Industrial Statistics Yearbook》 WIEGO Statistical Database
	Energy consumption per unit of product	EC	
	Industry size	SE	
	Gearing ratio	ALR	

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VI. MODEL BUILDING

To reduce the heteroskedasticity and covariance of the data in the model, to reduce the extreme values of the variables, and to smooth the series for better study, logarithmic treatment of the above variables was induced and the treated variables were noted as: *LnQUA, LnRE, LnSTA, LnFIN, LnEC, LnSE, LnALR*. the panel model was constructed as follows.

$$LnQUA = \beta_0 + \beta_1 LnRE_{it} + \beta_2 LnSTA_{it} + \beta_3 LnFIN_{it} + \beta_4 LnEC_{it} + \beta_5 LnSE_{it} + \beta_6 LnALR_{it} + \varepsilon$$

where it denotes the indicator value for industry category i in year t (i=1,2,3 ..... .6, t=1,2,3..... .12).

VII. EMPIRICAL TEST RESULTS AND ANALYSIS

Before regressing the formula, a Hausman test should be carried out and the results show a chi-squared value of 25.0418 and a p-value of 0.000, so the random effects are rejected at the 1% level of significance in favour of a fixed effects model.

TABLE V. Model variable names and sources.

Variables	Regression coefficient	Standard deviation	T-statistic	Concomitant probability p-value
LnRE	0.527	0.142	3.712	0.000***
LnSTA	-0.085	0.038	-2.212	0.031**
LnFIN	0.045	0.022	2.049	0.045**
LnEC	-0.007	0.041	-0.18	0.858
LnSE	1.18	0.174	6.785	0.000***
LnALR	-0.164	0.145	-1.13	0.263
C	-1.813	0.283	-6.416	0.000***
R^2	0.705			
F-value	21.508			
P-value (F-test)	0.000			

*Note: *, **, *** denote statistics significant at the 10%, 5% and 1% levels respectively.*

For innovation efficiency (RE), the original hypothesis is rejected and significant at 1% confidence level (t=3.712, p=0.000<0.01), indicating that innovation efficiency has a significant positive impact on the quality of exported products, with each 1% increase in innovation efficiency increasing the quality of exported products by 0.527 percentage points. This is also consistent with the results of Hypothesis 1 above and will not be repeated here.

For standard constraint intensity (STA), the original hypothesis is rejected and significant at 5% confidence level (t=-2.212, p=0.031<0.05), indicating that standard constraint intensity has a significant negative effect on the quality of exported products, which in turn *rejects hypothesis two proposed in the previous paper. Referring to Tao's research on the impact of standardization on exporting enterprises of different degrees at home and abroad. At this stage, manufacturing firms have a "mixed" level of exporting, resulting in "weak" firms often struggling to keep up with the existing standardization gaps and not keeping up with the pace of standard constraints, thus not achieving the desired results for them. From reading the literature, it is clear that although standardization is a facilitator in most respects, there are some drawbacks in terms of export product quality. In the early stages of export market or technology formation, standardization may reduce the risk of trial and error, but it may reduce the willingness to innovate in the production of products and lead to large deviations in the overall technological path. In the later stages of export market or technology formation, standardization, although it can play a regulatory role and eliminate backward production capacity, can lead to a monopolistic situation of standards discourse, which in turn makes high-quality products more and more perfect, while poor-quality products are still circulating in the market, and does not take into account every export product.*

VIII. RECOMMENDATIONS

A. Raising the level of innovation and carrying out innovation incentive schemes

Each manufacturing industry should adhere to breakthroughs in cutting-edge key technologies, improve innovation incentive mechanisms, strengthen the construction of software and hardware environments for key core technologies, and improve the level of construction of talent teams. China's manufacturing industry should take the fundamental path of improving innovation efficiency and innovation-driven development, gather innovation resources, and improve independent innovation capability and innovation efficiency. Enriching and improving the incentive mechanism is conducive to promoting technological innovation by core technical personnel in the manufacturing industry, prompting personnel to proactively research and develop innovation, and improving the efficiency of innovation and the ability to transform results.

B. Tailor-made standards to promote quality production

For manufacturing industries of medium to high product quality, the state should set corresponding national standards strictly according to the different export levels, so as to avoid "good and bad" export industry enterprises failing to keep pace with standardization. By promoting specialized production, standardizing the market system and promoting economies of scale, the quality of export products can be improved.

APPENDIX

Jiangsu Postgraduate Research and Practice Innovation Program Project: Influence Mechanism Research of Digital Inclusive Finance on Innovation Efficiency of Agricultural Science and Technology in Jiangsu Province (KYCX22_3575)

The 21st Batch of Research Projects for Undergraduates at Jiangsu University: A Study on Regional Differences in the Impact of Digital Inclusive Finance on the Construction of New Urbanization in Rural Jiangsu (21C104)

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