Information technology integration and the competitiveness of textile industry in China

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ABSTRACT – REZUMAT

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The aim of study is to analyse the relationship between the competitiveness and integration of Information technology (IT) into textile industry. This research has constructed a theoretical framework to explore how the textile industry integrating IT can improve the competitiveness. A regression model was established for analysing the relationship between them by using the data of textile industry in China from 2004 to 2015. The empirical results revealed that the integration of textile industry and IT industry not only enhanced the temporary competitiveness but also contributed to the sustainable competitiveness of the textile industry. Thus, the findings suggest that the textile industry integrated with IT industry will promote competitiveness of China's textile industry and it will be new trend of industrial development.

Keywords: *textile industry, information industry, industrial integration, coupling coordination degree, competitiveness*

Integrarea tehnologiei informației și competitivitatea industriei textile din China

Scopul studiului este de a analiza relația dintre competitivitate și integrarea tehnologiei informației (IT) în industria textilă. Această cercetare a dezvoltat un cadru teoretic pentru a analiza modul în care industria textilă ce integrează IT-ul poate înregistra o creștere a competitivității. S-a stabilit un model de regresie pentru analiza relației dintre acestea utilizând datele industriei textile din China din perioada 2004–2015. Rezultatele empirice au arătat că integrarea industriei textile și a industriei IT nu numai că a îmbunătățit competitivitatea temporară, ci a contribuit și la competitivitate durabilă a industriei textile. Astfel, rezultatele sugerează că industria textilă integrată în industria IT va promova competitivitatea acesteia și va reprezenta o nouă tendință de dezvoltare industrială.

Cuvinte-cheie*: industria textilă, industria tehnologiei informației, integrarea industrială, gradul de coordonare a asocierii, competitivitate*

INTRODUCTION

The textile industry is an important sector of Chinese economy. China is one of the largest producers and exporters of textile and apparel products in the world. In recent years, in order to enhance the competitiveness of textile products, the Chinese government has proposed a series of measures such as the development of the industrial Internet, the promotion of intelligent manufacturing, and the encouragement of scientific and technological innovation. The implementation of these policies has strengthened the informatization level of China's textile industry. However, whether the enhancement of the competitiveness of the textile industry coincides with the improvement of the level of informatization still needs practical proof.

The purpose of this article is to investigate the relationship between the degree of IT integration into the textile industry and competitiveness of textile industry under the circumstances of implementation of big data and artificial intelligence. The article organized as follows. The first section conducts a literature review and forms a number of hypotheses on the relationship between industry integration and textile industrial competitiveness. The second section introduces the methodology to calculate the competitiveness index of textile industry and the integration degree of IT into the textile industry respectively. The third section analyses the relationship between the competitiveness of the textile industry and IT integration by using a regression analysis method. The last section provides a discussion of the obtained results and some conclusions.

LITERATURE REVIEW

The competitiveness has long been a popular topic for scholars to discuss in industrial performance research. Some of the researches focused on the measurement of competitiveness. Havrila and Gunawardana [1], Yilmaz and Karaalp-Orhan [2], Tripa et al. [3] respectively employed Balassa index, Vollrath index, Grubel-Loyd index, Lafay index as the measurements to reveal comparative advantage. Shafaei analysed competitiveness by using a method based on Porter's diamond of competitive advantage to measure the competitive performance of Iranian companies in sectors of the textile industry [4]. Other researchers attempted to explore the determinants of competitiveness in the textile industry. The results of studies indicated that many intra-industrial factors, such as investment, product diversity, domestic market share, foreign market development, would foster the competitiveness. Moreover, firm networking, industrial clustering, technological externalities, participating in the industry associations and availability of government's incentives also had a large effect on the competitiveness of the firms [5–9].

With IT and knowledge-based economy being the theme of the time, the concept of industrial competitiveness had been expanded. Innovation, energy efficiency, environmental impact and sustainable development were considered to create the competitiveness of textile industry. The concept of competitiveness in this paper consists of temporary competitiveness and sustainable competitiveness.

Temporary competitiveness is achieved through cost savings and efficiency improvements, whereas sustainable competitiveness is possessed by valuable, inimitable and non-substitutable attributes resources, such as intelligent capital and innovation capabilities accumulation [10]. From temporary competitiveness aspect, manufacturing technologies applied in textile industry boosts the labour productivity to gain the market share [11]. Meanwhile, managerial innovation, as an essential element for enterprise competitiveness, is created by the combination of management and technology. The simplicity and easiness of using information technology paves the way for managers to make an accurate and opportune decisions through sharing internal information of enterprises from the textile sectors, reducing decision-making cost and improving managerial efficiency [12]. IT utilized in textile industry motivates learning processes within organization by facilitating exchange of skills and knowledge across functional sections, hence enhancing the internal communication supports to decentralized decision structure, which, in turn, is associated with higher financial performance [13, 14]. In addition, interface integration and operation information sharing between organizations lowers the information transfer cost. Information transparency and collaborative capacity between up-stream and down-stream organizations has made the entire structure more flexible and competitive. Intranet and extranet solution provided by IT improved the communication with suppliers and clients. Due to the rapidly response speed of supply chain, more customers and business partners would be attracted, which creates added-value in supply chain to enhance industrial competitiveness [15]. As for sustainable competitiveness, IT applied in textile industry spurs innovation activities to meet the customer demand. Technological convergence results in completely new types of products [16]. New market opportunity is created because IT accelerates flow of knowledge shifting from knowledge-centred high-tech industry to traditional industries. For the requirements of high-quality products, development of intelligent products, and customized service platform construction, an innovation system will be developed simultaneously [17]. Additionally, IT can help generate competitive advantage by leveraging human resources. Human capital comprises knowledge, skills and entrepreneurship. E-learning technology has positive influence in organizational learning effectiveness, while on-job management education may provide entrepreneurs specific information on the applications of IT to improve the operation efficiency [18–20]. In this way, more employers with knowledge and skills could be attracted and intellectual capital accumulated, thus promoting the long-term competitiveness.

Based on the above theories, this paper proposes the following hypotheses: integration of textile industry and IT industry enhances textile industrial competitiveness through improving temporary competitiveness and fostering sustainable competitiveness.

There are three paths to foster the textile competitiveness (figure 1). Firstly, IT applied in textile industry increases the labour productivity, saves the cost

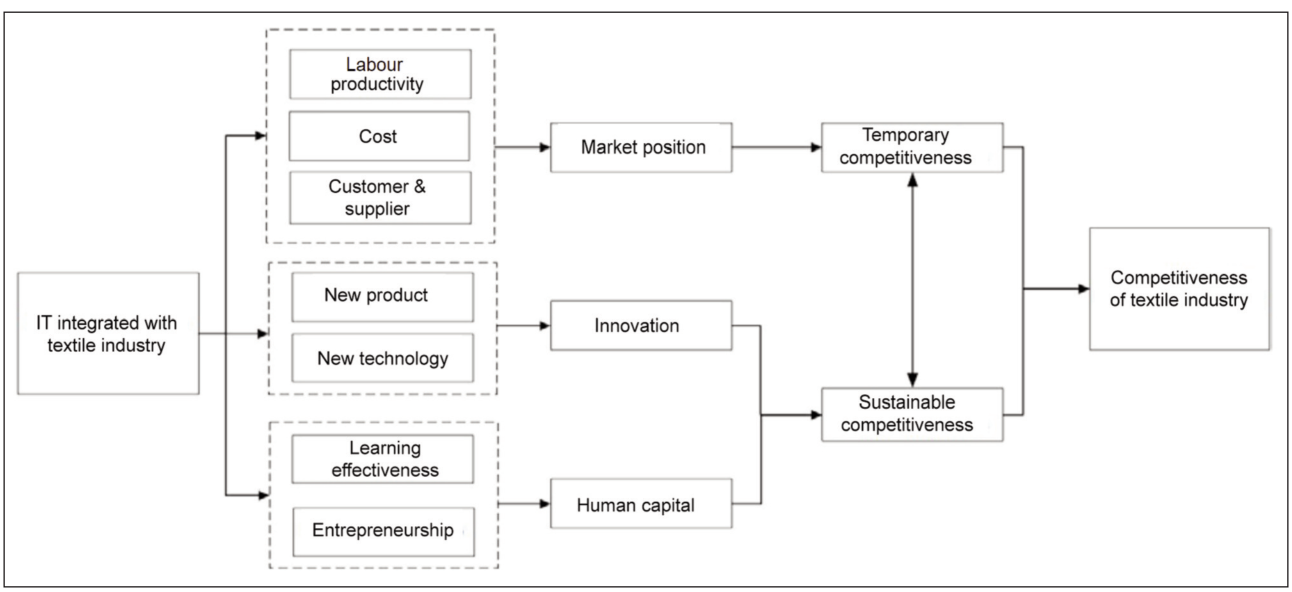

Fig. 1. The paths to improve the competitiveness by integration of IT in textile industry

and integrates the supply chain to get profit and market share. The application of IT in textile industry improves productivity and reduces production and decision-making cost. Participants in the supply chain, coordinating their activities through information sharing mechanisms, obtain the market status to heighten temporary competitiveness. Secondly, IT moderates existing process and brings new solutions to facilitate the process innovation. For the adoption of IT machinery, the time that elapses from order placement to the customer is reduced, thereby increasing product innovation. Finally, on-job training system assisted by IT speeds up the diffusion of tacit knowledge, and knowledge spill over effect has emerged. The knowledge spill over effect enhances learning efficiency and accelerates the accumulation of human capital. IT introduced into products and embedded in organizational management may allow for faster flow of knowledge, information and innovations, which may ultimately enhance the entrepreneurial cultures, and thus enhance the retention of talented and skilled employees. In this way, human capital would be maintained for obtaining sustainable competitiveness.

RESEARCH METHODOLOGY

In order to investigate the relationship between competitiveness of textile industry and integration of textile industry with IT industry, the calculation of the textile industry competitiveness index and Integration degree of the degree of industrial integration are the most critical variables. The detailed calculation method is as follows.

Construction of Textile Industrial Competitiveness Index

This study considers that competitiveness of textile industry consists of two aspects: temporary competitiveness and sustainable competitiveness.

Temporary competitiveness is mainly determined by the market position, and sustainable competitiveness is highly correlated with innovation and human capital levels. Therefore, selling value of industry is chosen to measure the temporary competitiveness, since this indicator explains the economic performance of textile industry. Sustainable competitiveness is measured by innovation and human capital. In terms of innovation, the number of patents is selected to estimate innovation capability. As for the human capital, which is difficult to be assessed according to available data, this study adopts a simplified method to evaluate it. Human capital is generally strongly correlated with income of the employees. The higher is the income, the higher is the level of human capital. Therefore, this research employs the average wage of the textile industry as an indicator to measure human capital. All data is separately obtained from China Textile Development Report, China Industry Economy Statistical Yearbook, China Labour Statistical Yearbook and Patent Information Service Platform.

Different evaluation indicators have distinct dimensions. In order to eliminate the dimensional influence between indicators, this study adopted Min-max normalization method to normalize the raw data. The formula for calculation is as follows:

$$Z^*_{qit} = \frac{Z_{qit} - \min Z_{qit}}{\max Z_{qit} - \min Z_{qit}} \times 100 \qquad (1)$$

where Z^*_{qit} is the value of the indicator after normalization, Z_{qit} – the value of the indicator before normalization, $\min Z_{qit}$ – the minimum value of the indicator within certain year, $\max Z_{qit}$ – the maximum value of the indicator within certain year, q – the type of indicator, i – the province and t – the year.

The component score is calculated after normalization, given in the equations as follows:

$$\begin{bmatrix} com_{1it} \\ com_{2it} \\ \vdots \\ com_{nit} \end{bmatrix} = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1m} \\ w_{21} & w_{22} & \cdots & w_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ w_{n1} & w_{n1} & \cdots & w_{nm} \end{bmatrix} \begin{bmatrix} z^*_{1it} \\ z^*_{2it} \\ \vdots \\ z^*_{mit} \end{bmatrix} \qquad (2)$$

where com is the component score, w – the weight of each indicator, n – the amount of retained components and m – the amount of variables.

Finally, the total component score can be calculated as follows:

$$COM_{it} = \sum_{j=1}^{n} W_j com_{jit} \qquad (3)$$

where $j = 1, 2, 3, ..., n$. COM is the dimension score of competitiveness, that is competitiveness index. W is the weight of each component.

Therefore, from equations 1 to 3, competitiveness index of the textile industry is calculated by computing dimension score of each province within t year. The results are illustrated in table 1.

The results presented in table 1 show that the nationwide competitiveness of the textile industry, in general, declined from 2004 to 2015. From the regional

Table 1

COMPETITIVENESS INDEX OF TEXTILE INDUSTRY

Region	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
East	38.12	38.59	37.33	36.03	34.18	32.67	33.74	33.69	33.34	33.04	33.14	33.34
Central	22.71	22.87	21.88	21.63	21.33	20.36	21.17	22.19	23.81	24.28	24.88	24.81
West	16.51	15.83	14.25	15.31	12.85	12.46	12.61	11.80	12.11	11.84	13.53	12.18
Nationwide	26.41	26.40	25.11	24.91	23.28	22.30	22.98	22.97	23.39	23.31	24.10	23.69

perspective, competitiveness index of the eastern region is highest in China. It is about 2.6 times than that of the western region, approximately 54% higher than the central region, and nearly 45 percent above the national average. From the time perspective, competitiveness index of textile industry of the eastern region decreased slightly from 2004 to 2015. By contrast, due to underscoring the strategic position of the central region, and designating it as the country's key advanced manufacturing centre and key area for comprehensive opening up, competitiveness index of the central region has increased rapidly since 2010.

Calculation of the integration degree

This paper, based on industry integration theory and coupling coordination degree model, constructed the evaluation index system and used coupling analysis method to calculate the integration degree of textile industry and IT industry. The first step for calculation is to establish the evaluation index systems for assessing integration degree of the two industries. According to the principles of efficiency, scale and industrial development, major indicators affecting industry integration are selected for estimating the integration degree of textile industry and IT industry, and then, the evaluation index systems for assessment are established, which are shown in table 2.

Table 2 tabulates the indexes of indicator layer for estimation. The efficacy coefficient of each system can be calculated by following equations:

$$E_{ij} = \frac{x_{ij} - x_{ij}^{s}}{x_{ij}^{H} - x_{ij}^{s}} \quad (4)$$

where E_{ij} is the efficacy coefficient of indicator j of order parameter i, $E_{ij} \in [0, 1]$, x_{ij} is each index value of indicator j of order parameter i, x_{ij} is a positive indicator that contributes positive efficacy to the system, therefore, the greater the value of x_{ij}, the better the system efficiency, x_{ij}^{s} – the minimum value of the indicator, x_{ij}^{H} – the maximum value of the indicator.

The integration value of subsystem of textile industry and IT industry can be calculated as follows

$$u_{ki} = \sum_{j=1}^{m} \theta_{ij} E_{ij} \quad (5)$$

where u_{ki} is the integration value of subsystem of k industry, θ_{ij} – the weight of each order parameter (based on our previous research the weights are equally distributed), i – the order parameter, j – the number of indicators of each system.

The comprehensive efficacies of the textile industry and the IT industry system are calculated separately by using an integrated methodology. The expression of the comprehensive efficacy is:

$$U_k = \sum_{i=1}^{n} \lambda_{ki} u_{ki} \quad (6)$$

where U_k stands for the comprehensive efficacy of k industry, λ_{ki} – the weight of each order parameter of k industry. This paper adopted the Delphi and AHP method to reflect the weight of factor layer, since

Table 2

INDICATORS FOR EVALUATING TEXTILE INDUSTRY AND IT INDUSTRY SYSTEMS

System layer	Factor layer	Weight (λ)	Indicator layer
Textile Industry System (TIS)	Scale (X_1)	0.33	Selling Value of Industry (X_{11})
			Number of Enterprises (X_{12})
			Annual Average Employees (X_{13})
			Tax from Principal Business (X_{14})
	Efficiency (X_2)	0.33	Ratio of Profits to Total Industrial costs (X_{21})
			Ratio of Profits, Taxes and Interests to Average Assets (X_{22})
			Labour productivity (X_{23})
	Development (X_3)	0.34	Growth rate of Selling (X_{31})
			Growth rate of Annual Average Employees (X_{32})
			Growth rate of Tax (X_{33})
Information Technology Industry System (ITS)	Scale (Y_1)	0.33	Selling Value of Industry (Y_{11})
			Number of Enterprises (Y_{12})
			Annual Average Employees (Y_{13})
			Tax from Principal Business (Y_{14})
	Efficiency (Y_2)	0.33	Ratio of Profits to Total Industrial costs (Y_{21})
			Ratio of Profits, Taxes and Interests to Average Assets (Y_{22})
			Labour productivity (Y_{23})
	Development (Y_3)	0.34	Growth rate of Selling (Y_{31})
			Growth rate of Annual Average Employees (Y_{32})
			Growth rate of Tax (Y_{33})

semi-structured interviews and questionnaire data from the managers of enterprises, industry experts and policy makers are collected in our previous research.

Then the integration degree can be calculated through coupling coordination degree model, and the equations are given as follows:

$$D = \sqrt{C \times T} \quad (7)$$

$$C = \left[\frac{U_{TIS} \times U_{ITS}}{(U_{TIS} + U_{ITS})^2} \right]^{\frac{1}{2}} \quad (8)$$

$$T = \alpha \times U_{TIS} + \beta \times U_{ITS} \quad (9)$$

In equation 7, D is the coupling coordination degree, i.e., integration degree, $D \in [0,1]$, C – the coupling degree, T – the comprehensive coordinating index of the coupling system. Coupling degree can be calculated by equation 8, U_{TIS} and U_{ITS} respectively stands for the comprehensive efficacy of textile industry system and IT industry system. Equation 8 indicates $C \in [0,1]$. Coupling degree represents the degree of dependency or interaction between the two systems. When $C = 0$, the textile industry system and the IT industry system are uncorrelated. When $C = 1$, the textile industry system and the IT industry system are coordinated. In equation 9, T reflects the overall level of the textile industry system and the IT industry system. α and β respectively represent the contribution of the textile industry and the IT industry, and $\alpha + \beta = 1$. As the revenue from principal business of the IT industry is about 2.7 times than that of the textile industry, therefore, in this case, $\alpha = 0.37$ and $\beta = 0.63$. U_{TIS} and U_{ITS} in equations 8 and 9 can be separately calculated by equation 6.

The statistical data is chosen from China Textile Development Report and Year Book of China Information Industry for calculating the integration degree of textile industry and IT industry according to equations 4 to 9. The computational results are shown in figure 2.

Figure 2 displays that the integration degree of textile industry and IT industry systems had been raising rapidly from 2004 to 2015. It increased steadily from 0.533 to 0.612 and then dropped slightly since 2007, due to the impact of the international financial crisis. Whereas, with the adjustment of domestic manufacturing industry structure and implementation of IT industry policy, the integration degree increased considerably to approximately 0.7 in 2011. Due to the promotion proposal of Made-in-China 2025, the integration has further increased to 0.731 after 2014.

In terms of distinct regions, integration degree has its own characteristics. Figure 2 also reflects the differences of integration degree among different regions in China. From 2004 to 2010, the integration degree of textile industry and IT industry system in the eastern region is generally higher than that of the central and western regions. Since 2009, the implement of industrial upgrading and relocating policy has made great progress in the central region. Therefore, the integration degree in the central region had shown a trend of substantial growth, and the growth rate is significantly higher than that in the eastern and western regions. The strategy of large-scale development of the western region also accelerated integration of textile industry and IT industry. In 2015, the integration degree of the western region surpassed that of the eastern and central regions.

Regression model

In order to understand the way by which textile industry and IT industry integration affects competitiveness of textile industry, we establish linear regression models. The metrological expression of the industry integration degree and industry competitiveness can be constructed as follows:

$$COM = \alpha_1 D + V \quad (10)$$

where COM is competitiveness index of textile industry, D – integration degree of textile industry and IT industry systems, V – the control variable, including local economic development, financial, human capital and innovation.

On both sides of the logarithm, equation 10 can be written as follows:

$$\ln COM_{i,t} = \beta_1 \ln D_{i,t} + \beta_2 \ln GDP_{i,t} + \beta_3 \ln GFE_{i,t} + \beta_4 \ln HC_{i,t} + \beta_5 \ln INNO_{i,t} + \varepsilon_{i,t} \quad (11)$$

Where GDP is the local gross domestic product, GFE represents local government fiscal expenditure, HC reflects human capital, $INNO$ is the quantity of patents, i stands for the certain province and t represents the time. The data originates from China Statistical Yearbook, China Labour Statistical Yearbook and Patent Information Service Platform.

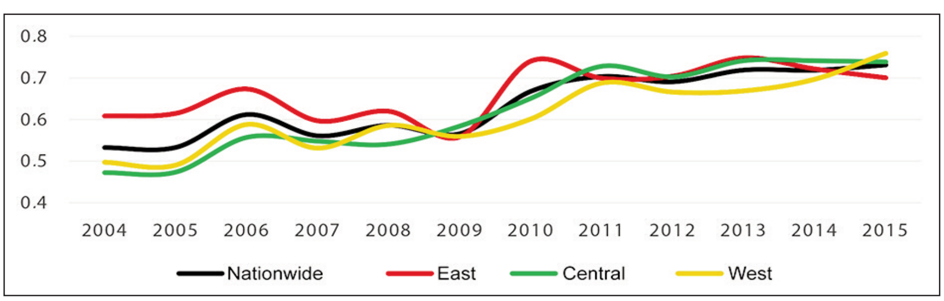

Fig. 2. Integration degree of textile industry and IT industry (2004–2015)

This study adopts panel data for analysis, and uses four models to carry out regression. Model 1 employs pooled ordinary least squares (OLS) to make regression analysis. Considering heteroscedasticity and autocorrelation of panel data, before the regression, heteroscedasticity and autocorrelation tests are carried out. The test results show that group wise heteroscedasticity exists. Therefore, panel-corrected standard error method is adopted for estimation. Model 2 and Model 3 are random-effects and fixed-effects regression respectively. Hausman test conducted those fixed-effects regression is the best model. By considering the endogeneity of key variables in our regression models, we applied Davidson-MacKinnon endogeneity test for endogeneity. The results (Davidson-MacKinnon test of exogeneity: 8.543, P-value = 0.0037) show that we should utilize a panel Instrumental Variable Generalized Method of Moments (IV-GMM) estimation. Since this method allowed for arbitrary heteroscedasticity, we adopted IV approach and GMM method to resolve the problem of endogeneity (Model 4). The lagged logarithm values of integration and the output value of IT industry are used as instrumental variables for estimation.

RESULTS AND DISSCUSSION

The regression results are shown in table 3.
The results from the estimated model are presented in table 3. The regression results illustrated that:

- The regression coefficients of are positive, and significance tests of regression coefficients at $p < 0.01$ in FE models. The empirical results show that integration degree of textile industry and IT industry has a positive and significant impact on competitiveness of textile industry. This implies that a 1% rise in integration degree of textile industry and IT industry increases textile competitive index by about 0.6% without considering the endogeneity of the data. When taking endogeneity into account, the coefficient of $\ln D$ increases to 4.58, which hints that a 1% rise of integration of the two industries causes the increase of textile industrial competitiveness by around 4.58%.
- The findings are partly consistent with that of Li and Huang study for the mechanism of the integration of textile industry and electronic information industry to promote the competitiveness of textile industry, which pointed out that the improvement of the level of industrial integration plays an important role in promoting quality of textile industry [21]. The main difference lies in that the level of industrial integration has direct effect instead of lag effect on competitiveness.
- As for control variables, the coefficients of local government fiscal expenditure and human capital are negative in all models, although statistical significance fails to reach the significant requirement. The result implies that fiscal expenditure of government has a negative effect on competitiveness of textile industry. Human capital, which occupies an important position in knowledge economy, plays a limited role in promoting the competitiveness of the textile industry, because the textile industry is still a labour-intensive industry in China.

CONCLUSIONS

This paper has investigated the relationship between competitiveness of textile industry and integration of textile industry and IT industry in China. The empirical results indicate that integration of textile industry and IT industry has a significant role in promoting the

Table 3

RESULTS OF ESTIMATES OF THE TEXTILE INDUSTRY COMPETITIVENESS EQUATION

VARIABLES	Model 1	Model 2	Model 3	Model 4
	OLS	**RE**	**FE**	**IV-GMM**
lnD	0.652***	0.545***	0.617***	4.580**
	0.233	0.190	0.190	2.265
lnGDP	0.150	1.175***	0.267	–1.049
	0.376	0.343	0.445	1.065
lnFM	–0.563**	–0.972***	–0.418*	–0.106
	0.259	0.164	0.246	0.476
lnHC	–0.481*	–0.220	–0.532*	–0.517
	0.269	0.246	0.287	0.582
lnINNO	0.0949	0.126	0.128	–0.165
	0.0743	0.0956	0.0980	0.234
Constant	–78.81	1.402	9.410**	-
	56.00	2.456	3.693	-
Observations	348	348	348	319
Number of num	29	29	29	29
Hansen J statistic	-	-	-	1.346
Chi-sq(1) P-value	-	-	-	0.2460

Note: Standard errors in parentheses in the second row: * significant at 0.1 level, ** significant at the 0.05 level, *** significant at the 0.01 level.

competitiveness of textile industry. From 2004 to 2015, integration degree of textile industry and IT industry had increased dramatically from 0.533 to 0.731. When considering the endogeneity, the integration degree of textile industry and IT industry rises 1%, the competitiveness of textile industry increases by around 4.58%.

The mechanism via which the industrial integration promoted the competitiveness of textile industry can be summarized as follows: on the one hand, industry convergence between textile industry and IT industry optimizes industrial efficiency and expands the market, thus increasing the temporary competitiveness of textile industry. On the other hand, industrial integration of textile industry and IT industry also enhances the sustainable competitiveness of textile industry. With IT has infiltrated into textile industry, industrial restructuring and upgrading of textiles taken place frequently, and consequently innovation activities emerge and new enterprises are established. Thus, the competitiveness of textile industry is boosted with the innovation ability strengthening and human capital accumulating.

Since some statistics are not available, this paper only selected the data from 2004 to 2015 for analysis, but some of the other supporting data showed that the degree of integration and competitiveness of the textile industry are still positively correlated from 2016 to 2019. Hence, the results still have considerable credibility. Due to the limitation of length, this paper mainly analyses the relevance of integration degree and competitiveness of textile industry with the method of linear regression. Although this study considers endogeneity of the data, the research concerning pathways to enhance competitiveness is insufficient.

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