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The Influence of Digital Transformation of Manufacturing Industry on Human Capital

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Abstract. With the rapid development of the digital economy in China, digital transformation's impact has penetrated various industries and enterprises. Manufacturing is the main body of the national economy and the country's foundation. the digital transformation is more important for manufacture enterprises, at the same time, human capital is also an essential factor in promoting digital transformation. Based on this background, this paper analyzes the impact results and mechanism of digital transformation on human capital. Taking Shanghai A-share prominent companies from 2014 to 2020 as the research object, this paper conducts an empirical study on the impact of digital transformation on human capital, constructs A benchmark model, and tests the robustness of the conclusion. It is found that digital transformation can promote human capital investment. Finally, according to the research conclusions, this paper puts forward suggestions for improving enterprise human capital from three aspects: enterprise, government and individual.

Keywords. Manufacturing enterprise, Digital transformation, Human capital

1. Introduction

In recent years, the digital economy has become increasingly important with the rapid development of technology industries such as big data, cloud computing, the internet of things, and artificial intelligence. According to the White Paper on the Development of China's Digital Economy, the scale of China's digital economy reached 39.2 trillion yuan in 2020, accounting for 38.6% of GDP, with a nominal year-on-year growth of 9.7%[1]. The 14th Five-Year Plan for Digital Economy Development points out that the digital economy is the main economic form after the agricultural economy and industrial economy [2]. On the one hand, the rapid development of the digital economy has driven the transformation of production and lifestyle, and brought new vitality to many enterprises. The Ministry of Industry and Information Technology officially issued the "14th Five-Year Plan" for the Deep Integration of Informatization and Industrialization, pointing out that the focus of the deep integration of informatization and industrialization in the 14th Five-Year Plan period should be fully deployed, the digital transformation of manufacturing industry should be accelerated and the deep integration of informatization and automation should be continued [3]. Accenture and National Industrial Information Security Development Research Center launched the "2020 Chinese Enterprise Digital Transformation Index Research" and pointed out that in the participating enterprises, about 60% of the enterprises regard digital transformation as the top priority and have

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formulated a clear digital transformation strategy, which according to the national financial industry standards, The manufacturing industry took the first place with a proportion of 42.3% [4].

For manufacturing, the urgency of digital transformation is more vital, and the transformation is more rapid. However, according to McKinsey's report on digital transformation, the success rate of enterprise digital transformation is only 20%. Therefore, how to make the manufacturing industry's digital transformation successful has become a hot topic in recent years. The research on the digital transformation of the manufacturing industry at home and abroad generally shows an increasing trend and has increased significantly since 2014, entering a period of rapid growth [5]. Research hotspots on manufacturing digital transformation mainly focus on the related concepts, dynamics, technologies ,and modes of digital transformation, whose development stages are divided into three phases: digital information, digital enterprise business, and industrial ecology[6]. Through the analysis of domestic and foreign literature on the digital transformation of the manufacturing industry, it divides the factors affecting the digital transformation of manufacturing industry into internal and external factors. Among these, the interior elements can be generally summarized as the organizational behavior of enterprises, such as human capital, organizational commitment, and so on. External factors are the market environment and related policies, such as tax policies and consumer demand. Among them, there is little research on human capital in the digital transformation of enterprises. Therefore, Therefore, this paper studies the impact of digital transformation on the human capital of manufacturing enterprises.

2. Literature review and mechanism analysis

2.1. Human capital

Human capital first appeared in Adam Smith's "The Wealth of Nations," which believed that labor is the source of wealth. By the middle of the 20th century, Schulz and Becker's modern human capital theory had come into being. Schulz further proved that human capital is the source of economic growth through "residual analysis of economic growth" [7]. Becker affirmed the role of educational investment in human capital and divided human capital into dedicated human capital and general human capital[8]. With the deepening of research on human capital at home and abroad, Liu Fanglong and Wu Nengquan (2013) once again defined dedicated human capital and general human capital. Specific human capital mainly refers to the knowledge and skills formed and accumulated in work [9] .In contrast, universal human capital refers to the knowledge and skills that can be used across industries or enterprises, most of which are not formed and accumulated in the work of enterprises.

2.2. Research on the impact of digital transformation on human capital

At present, about the digital transformation and the research achievements of the human capital, most tend to think of human capital as an intervening variable or a control variable, Shang Xuan, etc. (2022), it is concluded that the digital transformation by improving the use efficiency of human capital and enhance enterprise total factor productivity[10]. Zhang Guosheng, Du Pengfei (2022), it is concluded that digital transformation by improving the human capital investment, Reduce the human capital of local creative

business and promote the technological innovation of enterprises [11]. Bai Fuping (2022) concluded that digital transformation could improve enterprise financial performance at the enterprise level [12]. Liu Honghong (2022) analyzed that improving human capital can effectively promote the optimization of consumption structure [13]. On the other hand, Huang Lijv (2022) believes that digital transformation has promoted the transformation of enterprise human resource management concepts and industrial structures[14] and affected workers' income. According to Chen Nanxv and Li Yi (2022), the digital economy can improve the level of human capital, and the impact is related to urbanization and industrial structure[15]. It will replace enterprises that need more professionals and gradually reduce repetitive and low-innovation positions[16] .Based on the above analysis, it can be concluded that there are few direct studies on the relationship between digital transformation and human capital, so it is still essential to further analyze the relationship between them.

2.3. Research on the influence mechanism of digital transformation on human capital

Digital transformation relies on digital technologies, mainly artificial intelligence, blockchain, cloud computing, and big data (ABCD technology for short) [17]. The impact of digital transformation on human capital is divided into two aspects. On the one hand, digital technology has changed the post structure of enterprises. Li Baomin and Wang Geng (2022) believe that digital technology progress has a substitution effect on the labor force[18]. Artificial intelligence has a particular substitution for low-tech jobs. Sun Wenjie and Shen Kunrong (2009) believe that there is a pronounced threshold effect on the accumulation of human capital of technical personnel in domestic enterprises, below which the improvement of the technical learning ability of domestic enterprises will be very limited[19]. Therefore, this paper believes that the proportion of technical personnel will increase in the digital transformation of enterprises.

On the other hand, digital transformation has changed the market's requirements for people[20]. Kong Xiaoting (2017) believes that highly educated employees significantly promote enterprises to participate more in R&D and innovation activities[21]. Chen Hong et al. (2022) assume that digital transformation influences human capital structure by promoting its adjustment[22], and enterprises need high-quality professional talents to meet the promotion of digital transformation. High-quality talents can drive the labor productivity and innovation of enterprises. Therefore, this paper believes that digital transformation can promote the level of highly educated personnel in enterprises and increase the investment of human capital.

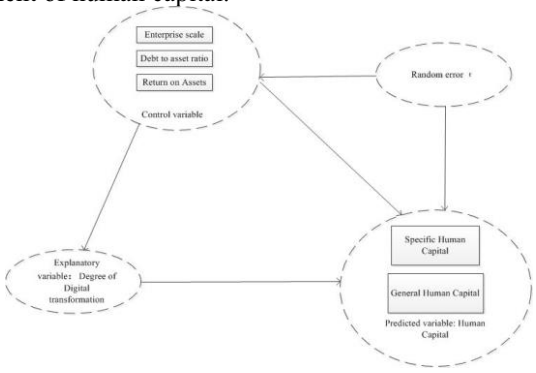

Figure 1. Conceptual model

3. The empirical research

3.1. The data source

Taking Shanghai A-share manufacturing enterprises from 2014 to 2020 (industry standard of 2012 edition of China Securities Regulatory Commission) as research samples, the proportion of employees with bachelor's degrees or above and the ratio of technical personnel in the total number of employees were obtained from the wind database. The employee compensation data were obtained from the CSMAR database and processed by excel according to the definition of variables. Excel was used to eliminate ST, delisting, missing data, and other sample data, and data was used to shrink the enterprise data by 1%-99%.

3.2. Research hypothesis

The higher the level of education, the higher the quality of specific human capital. With the development of digital transformation, enterprises need high-quality and innovative human capital as the input of production factors to meet their demand for highly educated talents. Based on the above analysis, the following research hypotheses are proposed.

H1: Digital transformation has a positive impact on specific human capital.

The higher the proportion of technical personnel, the higher the quality of universal human capital. The digital transformation of enterprises needs high-end technical talents as a guarantee. Investing in universal human capital promotes the progress of digital technology and improves the labor productivity of enterprises. Based on the above analysis, the following hypotheses are proposed.

H2: Digital transformation has a positive impact on universal human capital.

3.3. Variable setting

Predicted variable: Lou Runping et al. (2021) measured the proportion of undergraduates and above in the total number of employees as human capital[23]. It is not complete to measure the input of human capital only by the degree of education. This paper introduces Becker's division of human capital into general human capital and special human capital, combines the definition of the two by Liu Fanglong and Wu Nengquan [9], and takes the proportion of employees with bachelor's degree or above as the measurement of special human capital by referring to Lu Xin[24]. The proportion of technical personnel as a measure of universal human capital.

Explanatory variable: degree of digital transformation. Based on the research ideas of Qi Huaijin et al. (2020)[25], this paper takes the proportion of intangible assets related to the digital economy, such as "software," "system" and network, in the details of intangible assets disclosed in the financial report of listed companies at the end of the year to the total intangible assets as the proxy variable of the degree of digital transformation in this paper.

Control variable: With the help of existing research, the following variables will seat control variables. Enterprise Size (Size), defined as Take the logarithm of the total assets of the enterprise; Asset-liability ratio (Lev), defined as total liabilities/total assets; Return on Assets (ROA), defined as the ratio of net profit to total assets.

Table 1 Table of variable definitions

Variable nature	Variable name	Variable code	Variable definitions
Predicted variable	Specific Human Capital	Labor-edu	Percentage of employees with bachelor's degree or above
	General Human Capital	Labor-job	The proportion of technicians
Explanatory variable	Degree of Digital transformation	DT	The proportion of digital economy-related intangible assets such as "software," "system" and network in the year-end intangible assets details disclosed in the company's financial report to the total intangible assets.
Controlled variable	Enterprise scale	Size	The log of the total assets of the business
	Debt to asset ratio	Lev	Total liabilities/total assets
	Return on Assets	Roa	The ratio of net profit to total assets

3.4. Empirical model design

To test the relationship between digital transformation and human capital, the following benchmark models are set:

$$Labor - job = \beta_0 + \beta_1 DT_{i,t} + \beta_2 Roa_{i,t} + \beta_3 Size_{i,t} + \beta_4 Lev_{i,t} + ID + YEAR + \varepsilon_{i,t}$$

$$Labor - edu = \beta_0 + \beta_1 DT_{i,t} + \beta_2 Roa_{i,t} + \beta_3 Size_{i,t} + \beta_4 Lev_{i,t} + ID + YEAR + \varepsilon_{i,t}$$

Labor-edu indicates the percentage of undergraduate employees, and Labor-job indicates the percentage of technical employees, DT represents digital transformation, and the control variables are return on capital (Roa), enterprise Size (Size) and asset-liability ratio (Lev). The regression controls for Individual effect and time effect.

4. Analysis of Empirical results

4.1. Descriptive statistics

Table 2 shows the descriptive statistical results of the sample. The mean of specific human capital is 0.21, higher than the median of 0.18. It indicates that over half of the enterprises' human capital input does not reach the average value. It reflects the limited human capital input level of Shanghai A-share manufacturing enterprises to some extent. From the perspective of universal human capital, the average value of 0.17 is higher than the median value of 0.13, indicating that more than half of enterprises' human capital input does not reach the median value, which reflects the high dispersion level of Shanghai A-share manufacturing companies. In terms of the degree of digital transformation, the minimum value is 0, and the maximum value is 0.75, with a significant difference. The mean value of 0.05 is greater than the median value of 0.01, indicating that the dispersion level of the digital transformation degree of Shanghai A-share manufacturing companies is relatively high, and most enterprises have not reached the average level of digital transformation. Among the control variables, the return on assets is 0.03,the minimum value is -0.19, the maximum value is 0.19, the mean value of asset-liability ratio is 0.47, the minimum value is 0.07, the maximum value is 0.96, the mean value of company size is 9.86, the minimum value is 8.72, the maximum value is 11.32. The regression model's variance inflation factor (VIF) is less than 2, indicating no severe multicollinearity among the variables.

Table 2 Descriptive statistics

variable	N	mean	sd	min	p50	max
Labor-edu	2919	0.210	0.170	0	0.180	0.770
Labor-job	2919	0.170	0.120	0.0200	0.130	0.640
DT	2919	0.0500	0.0900	0	0.0100	0.600
Roa	2919	0.0300	0.0600	-0.190	0.0300	0.190
Lev	2919	0.470	0.200	0.0700	0.470	0.960
Size	2919	9.860	0.550	8.750	9.810	11.32

4.2. Test of correlation

The correlation between variables can be seen from the correlation test in Table 3. The degree of digital transformation is positively correlated with the input of universal and specialized human capital. All are significant at the 1% level. To improve the digital transformation of enterprises, the proportion of highly educated and technical personnel also increases.

Table3 Test of correlation

	Labor-edu	Labor-job	DT	Roa	Lev	Size
Labor-edu	1					
Labor-job	0.406***	1				
DT	0.075***	0.127***	1			
Roa	0.028	0.001	0.064***	1		
Lev	0.068***	-0.012	-0.045**	-0.417***	1	
Size	0.137***	0.012	-0.062***	0.074***	0.397***	1

Note 1: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively

4.3. Regression analysis

According to the results of Hausman test, all regressions in this paper adopt the fixed-effect model. The regression of the degree of digital transformation with specific human capital and universal human capital is significant at the 1% level. It shows that the higher the degree of digital transformation, the higher the proportion of technical personnel, the higher the proportion of highly educated personnel, and the greater the human capital investment, which is in line with the hypothesis of this paper.

Table 4 Result of regression

VARIABLES	(1) Labor-edu	(2) Labor-job
DT	0.167**	0.162***
	(2.80)	(7.92)
Roa	0.057	-0.041
	(1.26)	(-1.35)
Lev	0.011	-0.014**
	(1.60)	(-3.13)
Size	0.047***	0.006
	(25.74)	(1.68)
Constant	-0.264***	0.110**
	(-17.98)	(3.31)
Observations	2,919	2,919

R-squared	0.033	0.016
Number of YEAR	7	7
ID /Year FE	YES	YES

Note 2: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively

4.4. Test for robustness

Based on the replacement of the independent variable measure to robustness test of regression results, reference BAI Fu-ping(2021)[12], adopt "ln (paid to the worker and the worker pay cash/employee number)" to measure human capital investment, table 5 shows that digital transformation degree and human capital investment of the regression coefficient is 0.005, the percentage of 5 levels significantly, It shows that the human capital input after the change of measurement method has a significant positive correlation with the degree of digital transformation, which further indicates that this study has certain robustness.

Table 5 Test for robustness

	(1)
VARIABLES	**LABOR**
DT	0.005**
	(3.34)
Roa	0.181***
	(3.92)
Lev	-0.07
	(-1.68)
Size	0.103***
	(15.90)
Constant	4.039***
	(82.44)
Observations	2,938
Number of YEAR	7
R-squared	0.077
ID/YEAR FE	YES

Note 3: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively

5. Conclusion

In recent years, with the continuous development of digital technologies such as the Internet of Things and big data, digital transformation is an indispensable step to drive the innovation and growth of the traditional manufacturing industry and enhance the competitiveness of enterprises. This paper studies the impact of enterprise digital transformation on human capital input. This paper studies the impact of digital transformation

on human capital by sorting out the data of China's Shanghai A-share listed companies from 2014 to 2020. and mainly draws the following conclusions: Digital transformation can promote the investment of technical personnel and highly educated personnel in manufacturing enterprises. Through the research conclusions, we can draw the following inspirations: enterprises should pay attention to talent training and complement talent weaknesses. Enterprises can work with universities, research institutes and other parties to explore talent training models, such as directional training, gig mode, etc. Actively explore talents suitable for the digital transformation of enterprises, such as computer talents, information talents, etc. The government should pay attention to the impact of digital transformation on the human capital of enterprises, fill the gap between the core talents of digital technology in terms of quantity and quality, provide a guarantee for the education level of the overall social labor force, promote the implementation of talent incentive policies, actively cooperate with the enterprises of digital transformation, and provide government support; Individuals should pay attention to their work quality, keep learning, broaden employment channels, and seize the opportunities the market and the government.

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