Enterprise Performance, R & D Expense Ratio and the Total Factor Productivity of TCM Listed Enterprises
-- Empirical Research in the Context of New Quality Productivity

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Abstract: This study, focusing on the high-quality development of traditional Chinese medicine (TCM) enterprises, examines A-share listed TCM companies from 2018 to 2022. It uncovers that operational performance positively influences total factor productivity, with R&D expenses exerting a negative intermediary effect. This impact is more pronounced in smaller firms. Enhancing operational performance is thereby crucial for the successful transformation and high-quality growth of TCM enterprises.
Keywords: TCM; Enterprise performance; R & D expense ratio; TFP

In September 2023, President Xi Jinping introduced the concept of "new-quality productivity, " emphasizing innovation-driven growth and TFP enhancement. Given the dearth of research on TFP in the traditional Chinese medicine (TCM) sector, this study homes in on TCM-listed firms operating in a highly competitive market. It reveals a positive impact of corporate performance on TFP and the mediating role of R&D investment, thereby providing economic guidance and theoretical support for sustainable, high-quality development of TCM.

1. Literature review and research hypotheses

The research on total factor productivity is the focus of academia in recent years. At present, most of the literature focuses on manufacturing, agriculture and finance, and there is not much research on the pharmaceutical industry. In addition, most scholars focus on the total factor productivity research on the external environment of enterprise operation, internal research and development, equity system and technological innovation, and focus on the impact of government subsidies, tax policies, enterprise research and development and human capital on the total factor productivity of enterprises. For example, Ye Bin (2010) believes that the equity balance is significantly positively related with total factor productivity[1]; Zhang Xiaodi, Yao Yao (2011) discuss the impact of human capital on regional innovation and its total factor productivity from the perspective of entrepreneurial talent[2]; Fan Jianshuang (2011) believes that the growth of total factor productivity in the construction industry is mainly driven by the technological progress rate, while the economy of scale plays the opposite role[3]; Based on the above literature analysis, the relationship between enterprise performance and total factor productivity is close. However, most studies show that enterprise performance is the explained variable, and they discuss the relationship between total factor productivity and enterprise performance. This paper takes enterprise performance as an explanatory variable and studies the relationship between enterprise performance and total factor productivity. In addition, it is found that most scholars have taken the R & D investment into consideration when studying this problem. This paper also verifies whether the intermediary effect of R & D investment exists in TCM enterprises. Considering the heterogeneity factors, the following hypothesis is propose.

Suppose H1: TCM enterprise performance is positively correlated with their total factor productivity.

Suppose H2: There is an intermediary effect between the R & D expense ratio on the total factor productivity of TCM enterprises.

2. Model design

2.1 Sample selection and data source

In this paper, the data of TCM listed enterprises based on "Shenyin and Wanguo Industry Classification 2021 Revised edition" from 2018 to 2022, and the ST and * ST stocks are selected. First, we removed missing samples to ensure data accuracy; second, 1% and 99% reduced continuous variables to reduce the interference of extreme values; finally, centralized data to avoid multicollinearity problems. After careful screening and processing, 291 valid observation values of 67 listed TCM enterprises were finally obtained based on the Guotai'an Database (CSMAR).

2.2 Variable selection

2.2.1 The explained variable

This study adopts total factor productivity (TFP) as the dependent variable. TFP is conventionally measured via the Cobb-Douglas production function, albeit with acknowledged limitations. The OP and LP approaches address these issues, with OP accounting for investment where actual investment must exceed zero, while LP is more suited to small samples. Given the literature's preference for LP in estimating TFP, this study follows suit, complemented by an OP approach for robustness checks, ensuring reliable outcomes.The specific quantitative model is as follows:

$$\ln Y = \beta_0 + \beta_1 \ln K + \beta_2 \ln L + \beta_3 \ln E + \varepsilon_{i,t} \tag{1}$$

Among them, what Y means is the operating revenue. K is capital investment, this paper according to most scholars practice, use the net value of fixed assets instead, L is labor input, this paper to replace the number of employees, E is other may affect the middle of the TFP, this paper will add most statistics, including sales cost, is said is the residual item. The higher the TFP, the higher the enterprise tends to develop. ε_i

2.2.2 The explanatory variables

This paper employs Return on Assets (ROA, calculated as net profit divided by the average balance of total assets) to gauge corporate performance, with data sourced from the Guotai Database. A higher ROA signifies better corporate performance.

2.2.3 Mediation variables

This paper takes the R & D expense ratio (rd) as the intermediary variable and measures the ratio to the operating income.

2.2.4 Control variables

Selecting control variables across three aspects: financial indicators (size, leverage), corporate governance (board size, independent director ratio, ownership concentration), and company basics (establishment years, media attention, industry competition intensity), to ensure rigorous research with no key variables overlooked.

Table 1: Variable definitions

type of variable	name	symbol	defined declaration
explained variable	Total factor productivity	TFPlp	Calculate the total factor productivity using LP
explanatory variable	Enterprise performance	ROA	Average balance of net profit / total assets
metavariable	RESEARCH and development expense ratio	rd	R & D expenses / operating revenue
controlled variable	scale	size	Take the natural log of each items of the asset
	asset-liability ratio	Lev	Total liabilities / Total assets
	Board size	bs	Natural log of the number of directors plus 1
	Independent board ratio	pid	The ratio of the number of independent directors to the size of the directors
	Equity concentration	conc	The sum of the shareholding ratio of the top three major shareholders of the company
	enterprise age	age	The difference between the fiscal year and the enterprise listing year is + 1, take the natural logarithm
	Media attention	media	The total number of news reports related to the company in that year is + 1 by the natural log
	Industry competition	HHI-D	Calculate the industry market share by using a single company's operating revenue

2.3 Model setting

Based on the above simple description of each variable, to explore whether enterprise performance will have an impact on enterprise total factor productivity through R & D investment, this paper is based on the model construction of the relationship between government investment and total factor productivity by Lu Chuncheng (2023), and builds the following benchmark regression model and intermediary effect model.

$$TFPlp_{i,t} = \alpha_0 + \alpha_1 ROA_{i,t} + \alpha_2 \sum controls_{i,t} + \lambda_{i,t} + \mu_{i,t} + \varepsilon_{i,t} \tag{2}$$

Among them, subscript i represents the enterprise, subscript t represents time, TFPlp represents total factor productivity and is quantified by LP method, ROA represents enterprise performance, and controls represents the control variables shown above. According to the general requirements of the empirical paper, double fixation is adopted, which represents the time fixed effect and eliminates the influence of the factors changing with time. $\lambda_{i,t}$ $\mu_{i,t}$ Denote individual fixed effects designed to eliminate heterogeneity that does not change over time but over the individual. $\varepsilon_{i,t}$ Indicates the residuals.

For the mediation effect model, inspired by the existing references, this paper affects whether the enterprise performance has an impact on the total factor productivity through the R & D expense ratio. Therefore, the following mediation effect model is constructed.

$$rd_{i,t} = \alpha_0 + \alpha_1 ROA_{i,t} + \alpha_2 \sum controls + \lambda_{i,t} + \mu_{i,t} + \varepsilon_{i,t} \tag{3}$$

$$TFPlp_{i,t} = \alpha_0 + \alpha_1 ROA_{i,t} + \alpha_2 \sum controls_{i,t} + \alpha_3 rd_{i,t} + \lambda_{i,t} + \mu_{i,t} + \varepsilon_{i,t} \tag{4}$$

$\lambda_{i,t}$ $\mu_{i,t}$ $\varepsilon_{i,t}$ Where i, t, TFPlp, ROA, controls, which is the same as formula (2), rd is the intermediary variable and represents the R & D expense ratio.

3. Empirical studies

3.1 Descriptive statistics

Significant performance disparities among firms are evident, with a range from a low of 14.207 to a high of 17.881, and a substantial standard deviation of 0.665. The low mean of the explanatory variable, coupled with wide variation between its maxima and minima, points to uneven performance within the industry. Meanwhile, the low average and existence of zero values for the intermediary variable underscore the pressing need for R&D innovation among listed traditional Chinese medicine (TCM) enterprises.

3.2 Correlation analysis

Table 2 reveals a significant positive correlation between corporate performance (ROA) and total factor productivity (TFP_lp), while an inverse correlation exists with the R&D expense ratio (rd). Due to the weak association between ROA and rd, multiple regression analysis is employed. Figure 2 exhibits strong inter-variable correlations alongside low variance inflation factors (VIFs), indicating no multicollinearity, a finding corroborated by regression tests.

Table 2: Correlation analysis

	TFPlp	ROA	rd	age	media	conc	size	lev	PE	bs	pid	HHI D
TFPlp	1											
ROA	0.263***	1										
rd	-0.296***	0.0440	1									
age	0.415***	0.0210	-0.0940	1								
media	0.450***	0.0970	-0.139**	0.195***	1							
conc	0.00700	0.302***	0.0750	-0.392***	0.0380	1						
size	0.784***	0.168***	-0.157***	0.531***	0.499***	0.0610	1					
lev	0.308***	-0.214***	-0.184***	0.103*	0.200***	-0.0400	0.293***	1				
PE	-0.148**	-0.276***	0.00400	0.0100	0.0650	-0.137**	-0.168***	-0.0390	1			
bs	0.406***	0.0790	-0.220***	0.189***	0.245***	-0.146**	0.317***	0.106*	-0.0530	1		
pid	-0.121**	-0.0730	0.0680	-0.0220	-0.0110	0.154***	0.0300	0.139**	0.0700	-0.616***	1	
HHI D	0.0910	-0.0170	-0.0520	-0.0690	-0.099*	-0.178***	-0.0350	0.158***	-0.0150	0.0340	-0.0450	1

*** $p<0.01$. ** $p<0.05$. * $p<0.1$

4. Research conclusions

This study, based on 2018-2022 data from Chinese medicine listed firms, examines their performance linked to total factor productivity (TFP) and its mechanisms. Empirical findings show: 1) TFP has a substantial positive impact on firm performance; 2) Growth rate mediates the relationship between performance and TFP, with performance negatively correlated with R&D spending, implying performance indirectly curbs TFP via growth rate; yet, it overall boosts TFP for TCM firms. 3) Firm size matters: Small firms exhibit a significant positive correlation between performance and TFP, whereas large firms see the least performance-driven TFP enhancement.

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