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How brand equity affects firm productivity: The role of R&D and human capital

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ABSTRACT

This article provides fresh insights into the link between brand equity and firm-level productivity, including the direct effect and the potential interaction effect with research and development (R&D) and human capital. A panel data model using Chinese listed companies' accounting data from 2012 to 2017 is constructed to test our hypotheses. The main findings are as follows: First, both the direct effects and the potential interaction effects with R&D and human capital are significant. Second, a larger direct effect exists in large enterprises, state-owned enterprises, and manufacturing sector enterprises when considering firm heterogeneity. Third, when it comes to the interaction effect, firms are able to use R&D and human capital to enhance the impact of brand equity on firm productivity, while this effect is insignificant in non-state-owned and service sector enterprises. Overall, our results suggest brand equity will play an important role in future growth in China, and proper attention should be devoted to it in terms of policy and regulation.

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1. Introduction

There is consensus among academics and policymakers that intangible capital plays an increasingly important role in achieving business success and sustainable economic growth in the knowledge economy, where competition is essentially based around ideas and innovations (Marrocu, Paci, & Pontis, 2012). However, in spite of a large amount of empirical evidence, there remains little understanding of the mechanisms for how intangible capital influences firm performance. The reason is twofold. On the one hand, some scholars regard intangible capital as a whole and ignore the characteristics of different types of intangible capital. Even though some scholars consider type, many focus specifically on the role of research and development (R&D) rather than on a broader range of intangible assets, including software, databases, human

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capital, business intelligence, brands and intellectual property (Corrado, Hulten, & Sichel, 2005; Noja, 2018; Urueña, Arenas, & Hidalgo, 2018).

On the other hand, the mechanisms for how intangible capital affects firm performance exist mainly in developed economies like the US, the UK, Australia and European countries, where firms are incentivised to invest resources to develop intangibles (Borgo, Goodridge, Haskel, & Pesole, 2013; Corrado et al., 2009; Fukao, Miyagawa, Mukai, Shinoda, & Tonogi, 2009). Whether these mechanisms exist in the transition economy should be examined carefully, as legal systems, institutions, and the stages of development differ in the transition economy compared to the developed economy. Hence, with the increasing interest in explaining the difference in firm performance (Gabrielczak & Serwach, 2018; Wang, Lavelle, & Gunnigle, 2018; Wang, Li, & Wang, 2018), this article focuses on a specific form of intangible capital, brand equity, and attempts to uncover how it contributes to firm productivity in the case of China, the largest transition economy in the world.

The literature of intangible capital considers brand equity to be an economic competency (Corrado et al., 2005), and it is defined as the competitive advantage enjoyed by branded products over unbranded products. In an increasingly competitive market, the substantial effects of brand equity on firm performance should no longer be overlooked. The non-physical nature of brand equity means deciding how to measure its effects represents an enormous challenge. The most used methodology is proposed by Corrado et al. (2005, known as the CHS framework), and is applied to construct this variable. Consistent with the CHS framework, we interpret firms' advertising expenditures as investment in brand equity and measure firm-level brand equity from advertising expenditure accounting data using the perpetual inventory method.

This article aims to make a threefold contribution to the literature. First, to our knowledge, previous studies have mostly investigated the effect of brand equity on firm financial performance or on productivity at a macro level, while this article focuses on the effects of brand equity on productivity gains with firm heterogeneity, which are essential for enterprises obtaining a sustainable competitive advantage. As not all branding efforts achieve success, investment in brand equity may decrease profit in the short term. The underlying contribution of brand equity is perhaps obscured by improper measurement of firm performance.

Second, while following a relatively narrow approach to explain the direct effect of brand equity on firm productivity, this article explores the potential interaction effects with possible contingency factors, R&D and human capital, on this relationship, which provides fresh insights into the mechanism of how brand equity enhances firm productivity.

Third, this article studies the case of China, the largest transition economy in the world, where brand development seriously lags behind economic development, which adds new evidence to relevant research fields. Even though some studies have confirmed the positive effect of brand equity on regional productivity in China (Hulten & Hao, 2012; Li & Wu, 2018), heterogeneous characteristics provided by microdata are meaningful for developing a more comprehensive brand policy.

The article proceeds as follows. Section 2 presents the theoretical framework and proposes the hypothesis. Section 3 presents the variable description and econometric

methodology. Section 4 presents the empirical evidence about the effect of brand equity on firm productivity. Section 5 draws conclusions and discusses the main findings.

2. Theoretical framework and hypothesis

2.1. Direct effect of brand equity

Marketing literature has been devoted to finding a proper definition of brand equity since the concept was first put forward in the 1980s (Aaker, 1996; Keller, 1993; Tax, Brown, & Chandrashekaran, 1998; Yoo & Donthu, 2001; Yoo, Donthu, & Lee, 2000). Although other research provides the different dimensions of brand equity, it can be summarised as consumers' knowledge, perceptions and awareness of the products and services produced by a firm. Many pieces of marketing research have confirmed the positive effects of brand equity on superior financial and marketing performance (Belo, Lin, & Vitorino, 2014; Morgan & Rego, 2009). Recently, this topic has attracted the attention of economists who used it to explain the source of productivity gains and related economic growth, both at a macro level (Corrado et al., 2005; Li & Wu, 2018; OECD, 1998) and a micro level (Marrocu et al., 2012; Verbič & Polanec, 2014).

There are two possible mechanisms for how brand equity affects firm productivity. First, branding is regarded as the core dynamic marketing capability (Maklan & Knox, 2009), which includes the process of customer relationship management, new product development, and supply chain management (Wang & Sengupta, 2016). The innovations, organisational learning, and knowledge integration emerging in these processes enable firms to make the most efficient and competitive use of related resources to improve firm productivity. For example, innovation capabilities and their effects in combination with learning capabilities can improve the speed, efficiency and effectiveness of new product development, thereby improving firm performance (Bruni & Verona, 2009).

Second, according to resource-based theory (hereafter RBT), brand equity is a valuable asset that enables firms to own a competitive advantage by creating economic value that no branding firms could recreate (Barney, 2014). On the one hand, a firm can leverage a brand to increase its efficiency and effectiveness in ways that competing firms cannot. For example, the firm could use new market knowledge to reconfigure organisational resources and change operating routines (Barrales-Molina, Martínez-López, & Gázquez-Abad, 2014). On the other hand, brand equity enables the firm to earn expected returns referred to as economic rent. Usually, consumers use price as an important extrinsic cue and indicator of a product's quality or benefits, and they tend to pay a premium price for a product with a stronger brand, which increases firm revenues. The same goods earning higher revenue indicates that products and services with brands have a higher input–output ratio, therefore, brand equity enables the firm to be more efficient and have greater productivity.

Based on the above statement, we propose the following hypothesis:

H1: Brand equity has a positive effect on firm productivity.

2.2. Interaction effect of brand equity

2.2.1. The role of R&D

Research and development, the most important innovative activity of a firm, is an important dynamic capability, as well as driver, of brand equity. Brand equity summarises the cognition of products and services by firms for customers. Successful innovations help strengthen brand associations, create and support brands' points-of-difference, increase brand attitudes, and ultimately improve brand equity and profitability (Brexendorf, Bayus, & Keller, 2015). In addition, many brands, such as Apple, use 'innovativeness' as part of their brand personality and in their brand positioning and claims. Brands seen as innovative earn innovation credit, which is defined as an intangible asset that involves the equity a brand accumulates from consumers in appreciation of efforts to develop new products, services, or other innovative practices for the market (Barone & Jewell, 2013). As the results of R&D investment frequently take the form of product innovation, successful R&D can carry and enhance brand equity by delivering value and benefits for customers (Ward, Light, & Goldstine, 1999). A branded producer is likely encouraged to undertake more R&D investments, in order to improve brand equity.

Therefore, we propose the following hypothesis:

H2a: Research and development enhances the impact of brand equity on firm productivity.

2.2.2. The role of human capital

Human capital, defined as 'the individual employee's knowledge, skills and abilities' (Youndt, Snell, Dean, & Lepak, 1996), is another important intangible asset that improves a firm's brand equity, thereby promoting superior economic performance. Human capital is not developed only through formal education, but also through formal and informal on-the-job training, which could affect brand equity in at least two ways. First, the firm-specific professional marketing talents who are trained to gain the unique skills and knowledge of design, manufacturing, sales, delivering products and services, responsiveness to changing tastes and to any customer service-related issues, and other skills, will certainly contribute to a successful brand strategy and improve brand equity. Second, even without specific professional marketing talents, employees are likely to be leveraged by identifying with the company, which strongly influences the extent to which they use their resources (Ashforth & Mael, 1989). That is, if a firm regards successful implementation of brand strategy as the firm's development goal, the employees will take full advantage of their resources to perform tasks related to markets, customer information exchange, and customer acquisition, in accordance with the firm's goal. In general, a higher level of human capital means a higher capability to realise the firm's goals, most of which apply equally to improving brand equity. Therefore, we propose the following hypothesis:

H2b: Human capital enhances the impact of brand equity on firm productivity.

2.3. The role of firm type

2.3.1. Size

The impact of brand equity on firm productivity is quite possibly related to firm size. First, large firms are more able to take the risks mandated by the uncertain

returns of brand equity investment, as well as other types of intangible assets, compared to small firms. Second, large firms are able to make greater efforts in terms of generating intellectual property, and can be more effective in protecting their innovations through brand equity compared to small firms. Third, large firms face fewer resource constraints, meaning they are better able to exploit economies of scale in resource accumulation (brand equity, R&D, human capital) than small firms. As stated in RBT, a firm may avoid further expansion of their brand portfolio by lowering investment in R&D due to the pressure of resource constraint. The discussion above indicates that large firms have a greater incentive to invest in brand equity, and they own a greater amount of stock, which leads to a larger impact on firm productivity.

Therefore, we propose the following hypothesis:

H3a: Brand equity has a larger positive effect on firm productivity in large firms than that in small and medium-sized enterprises (SMEs).

H3b: The interaction effect of brand equity and R&D (human capital) on firm productivity is greater in large firms than in SMEs.

2.3.2. Ownership

Due to the significant difference between institutions in transition and developed economies, the role of firm ownership should be fully considered. In the process of China's ownership reform, state-owned enterprises (hereafter SOEs) play a vital role in boosting the Chinese economy. As the name implies, SOEs possess the dual characteristics of being 'state-owned' and 'enterprises'. 'State-owned' implies that the firms are entrusted to implement national strategies and policies. For example, as the main force for implementing the National Strategy of Innovation-driven Development (hereafter NSIDD) proposed in 2016, SOEs allocate more resources to innovation elements like brand equity, R&D, human capital, and so on. In addition, as they are owned by the state, SOEs receive more financial and technical support from the government, while non-SOEs suffer from much more severe resource constraints. An 'enterprise' always pursues profit maximisation under the economic hypothesis of 'a rational economic man'. Driven by profit, firms also tend to allocate resources to innovation elements in a knowledge economy. Although scholars put forward the argument for inefficiency, SOEs are likely to invest more in brand equity, R&D and human capital than non-SOEs, enjoying the associated interaction effect.

Based on the above arguments, we posit the following:

H3c: SOEs enjoy a greater positive effect on firm productivity from brand equity than non-SOEs.

H3d: The interaction effect of brand equity and R&D (human capital) on firm productivity is larger in SOEs than in non-SOEs.

2.3.3. Industry context

According to RBT, environmental factors, such as industry context, should also be considered when explaining a firm's superior returns because of the obvious

difference in operations and management, which are also reflected in the relationship between brand equity and firm productivity. The differences between the manufacturing and service industries are discussed in this study. Compared to manufacturing, the goods of service industries are intangible, heterogeneous, have inseparable production and consumption, and are perishable (Vomberg, Homburg, & Bornemann, 2015), which means customers face a higher information cost in overcoming uncertainty about quality when deciding to consume service goods. Keller (2008) notes that brands attenuate this cost, to some extent, because customers may interpret high brand equity as an indication of service consistency, which reduces the uncertainty provoked by service heterogeneity. In addition, the cost-reducing effect is more pronounced for intangible service goods than for tangible manufacturing goods. For this reason, service industry firms are thought more likely to engage in branding efforts to improve brand equity and ensure firm productivity.

Our final hypotheses are, thus, as follows:

H3e: Brand equity has a larger positive effect on firm productivity in the services industries than in manufacturing.

H3f: The interaction effect of brand equity and R&D (human capital) on firm productivity is larger in the services industries than in manufacturing.

3. Methodology and variables

3.1. Methodology

This section proposes a two-step process to test the above-stated hypotheses. First, firm-level total factor productivity (hereafter TFP) is estimated with the Cobb–Douglas production function. The model specification is as follows:

$$Y_{it} = A_{it}K_{it}L_{it}M_{it} \tag{1}$$

While the TFP goes into logarithm form

$$\mathrm{TFP}_{it} = \ln\ Y_{it} - \ln K_{it} - \ln L_{it} - \ln M_{it} \tag{2}$$

Where Y is the gross output, K is the fixed capital input, L is the labour input, and M is the intermediate input. i represents the ith firm and t represents the year.

The second step involves investigating the direct and indirect effect of brand equity on firm-level TFP. A benchmark model is constructed to investigate the direct effect of brand equity on the TFP retrieved from the first step. The model specification is as follows:

$$\mathrm{TFP}_{it} = \beta_0 + \beta_1 brand_{it} + \beta_2 brand_{it} \times Dummy_i + \alpha' control_{it} + \mu_i + \varepsilon_{it} \tag{3}$$

Where brand_{it} represents brand equity; $Dummy_i$ includes size, ownership, and industry dummy; $\mathrm{control}_{it}$ represents the control variables, including R&D capital,

human capital, age and debt-to-assets ratio (ROA); u_i represents the unobserved individual effect; ε_{it} is a mean zero random error term.

In order to investigate the indirect effect of brand equity, we introduce the interaction terms $brand_{it} \times R\&D_{it}$ and $brand_{it} \times humancapital_{it}$ into the benchmark model. The model specifications are as follows:

$$TFP_{it} = \beta_0 + \beta_1 brand_{it} + \beta_2 R\&D_{it} + \beta_3 brand_{it} \times R\&D_{it} + \alpha' control_{it} + \mu_i + \varepsilon_{it} \quad (4)$$

$$TFP_{it} = \beta_0 + \beta_1 brand_{it} + \beta_2 humancapital_{it} + \beta_3 brand_{it} \times humancapital_{it} + \alpha' control_{it} + \mu_i + \varepsilon_{it} \quad (5)$$

The significance of the coefficients of the interaction term in models (4) and (5) verify the existence of the interaction effect of brand equity and R&D/human capital on firm productivity. Whether the effect is positive or negative is judged by the signal of the coefficients of the interaction term. To be specific, if $\beta_3 > 0$ in (4), there is a positive interaction effect, specifically, R&D increases the impact of brand equity on firm productivity, and decreases the impact otherwise. The same judgement applies to human capital.

3.2. Data and definitions of variables

We test our hypotheses on a sample of China-listed firms' balance sheet data from 2012 and 2017. We remove the companies with missing data to get a final balance panel containing 766 enterprises. All the variables in this article are in a nominal term due to the short sample interval and the relatively stable price level. All the data is taken from the WIND database.

3.2.1. Dependent variable

First, we estimate the dependent variable, which is firm-level TFP. There are many methods to estimate firm-level productivity, such as data envelopment analysis (DEA), ordinary least squares (OLS) estimation, fixed effect estimation, Olley–Pakes estimation, and Levinsohn–Petrin estimation (Jaržemskis & Jaržemskienė, 2018; Marrocu et al., 2012). In this article, we apply the Levinsohn–Petrin estimation method, as it offers more likelihood that proxy variables will be selected flexibly according to data availability. The variables involved in estimating TFP include output, fixed capital, labour, and intermedium input.

1. Output is measured by firm sales revenue.
2. Fixed capital is measured by the net value of fixed assets, which involves deducting overall depreciation from the original value of the fixed assets.
3. Labour is measured by the number of employees at the end of the term.
4. Intermediate input is measured by the cash outflow for product and service purchases in the cash flow chart, representing various other inputs in the production process.

3.2.2. Independent variables

The variables involved in the second step in section 3.1 include brand equity, R&D capital, and human capital. Measuring brand equity, R&D capital, and human capital represents a challenge.

(1) Brand equity. We use advertising and publicity expenditure accounting data to measure brand equity. Although it is an imperfect measure of brand equity, as advertising expenditure data does not fully capture all the investments made by a firm to develop its brand, Corrado et al. (2005) state that advertising and market research are the main investments in building brand equity. In further research, a more precise or complete measure should also incorporate the investments that firms make in the various forms of intellectual property protection (trademarks, patents, etc.), both to protect their brand equity and to enhance it. Here, we follow the literature and measure the stock of brand equity ($brand_{it}$) from advertising and publicity expenditures by using the perpetual inventory method for the ith firm in period t:

$$brand_{it} = (1 - \delta_A)brand_{it-1} + ad_{it} \tag{6}$$

To implement equation (6), the initial stock, $brand_{i0}$, and the depreciation rate, δ_A, should be decided. According to the perpetual inventory method, we first choose the initial stock as:

$$brand_{i0} = \frac{ad_{i0}}{\delta_A + g_A}$$

Where ad_{i0} is the ith firm's initial investment in brand equity, measured by advertising and publicity expenditures in first year of the sample, and g_A is the average growth rate of advertising and publicity expenditures in the sample. δ_A varies from 30% to 60% in empirical studies, and we set the depreciation rate of brand equity at 45%, following Villalonga (2004).

(2) Research and development. As Higón, Gómez, and Vargas (2017) says that brand equity is very likely to be complementary to the stock of R&D, this article also uses the stock rather than the flow of R&D. Similarly, the stock of R&D ($R\&D_{it}$) is measured from R&D expenditure by using the perpetual inventory method for the ith firm in period t:

$$R\&D_{it} = (1 - \delta_R)R\&D_{it-1} + R_{it} \tag{7}$$

To implement Equation (7), the initial stock $R\&D_{i0}$ and the depreciation rate δ_A should be decided. According to the perpetual inventory method, we first choose the initial stock as:

$$R\&D_{i0} = \frac{R_{i0}}{\delta_R + g_R}$$

Where R_{i0} is ith firm's R&D investment measured by R&D expenditure in the first year of the sample, and g_R is the average growth rate of R&D expenditure. δ_R varies from 8% to

25% in empirical studies, and we set the depreciation rate at 15%, which is widely applied by other researchers.

(3) Human capital. There are two proxy variables for measuring human capital: The educational level of employees and expenditure on firm-specific training. In this study, we use cash payments to and on behalf of employees in cash flow statements, as the educational level of employees and expenditure on firm-specific training variables are not available in China.

3.2.3. Control variables

1. Firm size. We divide the enterprises into SMEs listed on China's growth enterprises market and large enterprises listed on China's main board market. We set the size of the dummy variable to equal 1 for SMEs, and 0 otherwise.
2. Ownership dummy. We divide the enterprises into SOEs and non-SOEs and set the ownership dummy variable to equal 1 for SOEs, and 0 otherwise. In our empirical sample, the non-SOEs are private enterprises.
3. Industry dummy. The firms belong to industries that include agriculture, mining, manufacturing, and services. Based on the objectives, we set two industry dummy variables, one for manufacturing and another for services.
4. Other control variables. We also include ROA and age, which is widely considered in other empirical research.

All the variables are treated using a logarithmic method, except for ROA and age.

4. Empirical results

4.1. Descriptive analysis

Table 1 reports some descriptive statistics for the main variables. There are significant differences among the different samples. As shown in the Table 1, we find SOEs own the largest amount of brand equity, R&D and human capital, which confirms that SOEs play a vital role in the Chinese economy. Both brand equity and human capital are larger in the manufacturing industry than in the service industry, which differs from our initial thoughts that service enterprises would be more likely to make more brand-building

Table 1. Descriptive statistics of main variables.

Sample	Var.	Obs	Mean	S.D.	Min	Max	Var.	Obs	Mean	S.D.	Min	Max
Full sample	Brand	4596	16.375	2.201	7.496	24.298	R&D	4596	18.665	1.485	11.543	24.526
Manufacturing		3594	16.427	2.232	9.105	24.298		3594	18.717	1.424	11.543	24.426
Services		516	15.774	1.951	7.496	20.823		516	18.743	1.425	13.708	22.274
SOEs		1218	16.890	2.372	10.801	24.298		1218	19.057	1.833	11.543	24.526
Non-SOEs		3378	16.189	2.105	7.496	23.775		3378	18.523	1.310	13.305	23.741
SMEs		2796	15.869	1.974	7.496	22.976		2796	18.442	1.189	13.708	23.741
Large		1800	17.161	2.302	9.179	24.298		1800	19.011	1.801	11.543	24.526
Full sample	Human	4596	19.134	1.227	15.725	24.698	TFP	4596	16.385	0.967	13.809	21.231
Manufacturing	capital	3594	19.093	1.178	15.725	24.234		3594	16.357	0.903	13.912	21.231
Services		516	18.996	1.074	16.448	21.914		516	16.000	0.807	14.308	20.366
SOEs		1218	19.935	1.317	16.585	24.698		1218	17.007	1.054	14.630	21.231
Non-SOEs		3378	18.845	1.053	15.725	23.463		3378	16.161	0.825	13.809	20.366
SMEs		2796	18.671	0.948	16.126	23.463		2796	16.023	0.757	13.809	20.366
Large		1800	19.852	1.265	15.725	24.698		1800	16.948	0.988	14.539	21.231

Note: Var. is short for variables; S.D. is short for standard deviation.
Source: Own calculations on WIND database.

efforts, while R&D shows little difference. Brand equity, R&D, and human capital are larger in large firms than in SMEs. Just as discussed before, large firms have more resources than SMEs, and so invest more in different types of assets. The biggest difference appears in brand equity.

4.2. Direct effect of brand equity

This section discusses the direct effect of brand equity on firm productivity. All the models are estimated through pooled OLS with robust standard errors, which are applied to eliminate heteroscedasticity. Table 2 shows the estimation of the benchmark model. First, we only include brand equity in equation (3). The result in column two shows that brand equity has a significant positive effect on firm productivity. We then add the control variables in sequence to verify the positive effect. The results in columns three to nine indicate that brand equity's positive effect on firm productivity is robust with different control variables. Therefore, hypothesis H1 is confirmed.

In Section 2.3, we discussed the necessity to consider firm size, ownership and industry context. Columns six to nine display the effect of brand equity on the firm productivity of different groups. As shown in column six, the positive effect exists in both SMEs and large enterprises, with a larger effect in large enterprises, as the coefficient of SME× brand is significantly negative. Due to the limitation of resources and the shortage of brand talent, SMEs often choose to manufacture original equipment rather develop an independent brand strategy due to the greater uncertainty. Many SMEs believe that survival is the most urgent task and only consider constructing self-owned brands when they reach a certain scale. The amount of brand equity in large enterprises is 17.161, while that in SMEs is only 15.869. The difference could be interpreted being a lack of brand awareness by SMEs, or that SMEs adopt less brand equity investment due to resource constraints, even though they acknowledge the importance of brand equity. Therefore, brand equity plays a limited role for SMEs. Therefore, hypothesis H3a is confirmed.

As shown in column seven, the positive effect exists in both SOEs and non-SOEs, with a larger effect in SOEs, with the coefficient State× brand being significantly positive. Most researchers think private enterprises are more efficient than SOEs. However, China is driving the transformation process from an investment-driven to an innovation-driven economy. SOEs, the main force behind implementing national strategies and policies in the transition economy, are encouraged to invest more in innovation assets like R&D and brand equity. In addition, as they are owned by the state, SOEs receive more financial support, which enables them to invest more in innovation assets. As shown in Table 1, SOEs own the largest amount of brand equity, R&D, and human capital among the different groups. Therefore, our results verify hypothesis H3c.

As shown in columns eight and nine, the sum of the coefficients of Brand and Manufacturing× brand (0.0425) is larger than that of Brand and Service× brand (0.0215), and both of them are positive. That is, the positive effect exists in both the manufacturing and service industries, with a larger effect in manufacturing.

Table 2. Direct effect ofbrand equity on firm-level productivity.

VARIABLES	(1) TFP	(2) TFP	(3) TFP	(4) TFP	(5) TFP	(6) TFP	(7) TFP	(8) TFP
Brand	0.214***	0.130***	0.0321***	0.0421***	0.0465***	0.0422***	0.0453***	0.0390***
	(0.0063)	(0.0059)	(0.0044)	(0.0043)	(0.0043)	(0.0043)	(0.0048)	(0.0043)
R&D		0.307***	0.0244***	0.0574***	0.0726***	0.0674***	0.0602***	0.0621***
		(0.0104)	(0.0093)	(0.0085)	(0.0087)	(0.0085)	(0.0085)	(0.0085)
Human capital			0.581***	0.450***	0.415***	0.421***	0.445***	0.452***
			(0.0115)	(0.0124)	(0.0132)	(0.0128)	(0.0126)	(0.0122)
DOA				0.0118***	0.0109***	0.0112***	0.0118***	0.0112***
				(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Age				−0.0015	−0.0054***	−0.0026	−0.0015	−0.0019
				(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)
SME× brand					−0.0104***			
					(0.0013)			
State× brand						0.0095***		
						(0.0013)		
Manufacture× brand							−0.0028*	
							(0.0015)	
Service× brand								−0.0175***
								(0.0019)
Constant	12.88***	8.541***	4.295***	5.605***	6.106***	5.966***	5.620***	5.581***
	(0.103)	(0.177)	(0.144)	(0.157)	(0.170)	(0.162)	(0.156)	(0.153)
Observations	4,596	4,596	4,596	4,596	4,596	4,596	4,596	4,596
R-squared	0.238	0.423	0.650	0.690	0.695	0.695	0.691	0.698

Note: Robust standard errors are reported in parentheses.
***Denotes level of significance at 1%.
*At 10%.
Source: Own calculations on WIND database.

A possible reason is that manufacturing is the foundation of the Chinese economy and attracts foreign direct investment, which generates a significant knowledge spillover effect. Meanwhile, the role of brand equity has not been given proper attention in the service industry, as the average stock of brand equity in services (15.774) is the smallest among the groups. Therefore, our result rejects hypothesis H3e. Additional results show that R&D, human capital, and DOA have positive effects on firm productivity, while firm age has no significant effect on productivity.

4.3. Interaction effect with R&D

Table 3 shows the interaction effect of brand equity and R&D on the firm-level productivity of different groups. All the models are estimated through pooled OLS with robust standard errors, which are applied to eliminate heteroscedasticity. As shown in Table 3, the coefficient of the interaction term, Brand× R&D, is significantly positive in the full sample. That is, R&D enhances the effect of brand equity on productivity. The results verify hypothesis H2a. Considering firm heterogeneity, there is a significant positive interaction effect in both large enterprises and SMEs, and the effect in large enterprises is greater than in SMEs. The divergence occurs in SOEs and non-SOEs, as well as in the manufacturing and service industries. Specifically, the effect is significant in SOEs and manufacturing, while it is insignificant in non-SOEs and services. Therefore, our empirical results partially confirm hypotheses H3b and H3d, and partially reject hypothesis H3f.

There are several possible explanations for the divergence between SOEs and non-SOEs. First, SOEs have increased investment in brand equity and other intelligent assets, driven by recent national strategies, such as NSIDD and Made in China 2025. Second, soft budget constraints enable SOEs to have sufficient funds for cultivating talent and to introduce new technology. That is, SOEs usually own more resources

Table 3. Indirect effect of brand equity and R&D on firm-level productivity.

VARIABLES	(1) TFP	(2) TFP	(3) TFP	(4) TFP	(5) TFP	(6) TFP	(7) TFP
	Full	SMEs	Large	SOEs	Non-SOEs	Manufacturing	Services
Brand	0.0418***	0.0396***	0.0413***	0.0369***	0.0423***	0.0263***	0.0099
	(0.0043)	(0.0061)	(0.0062)	(0.0080)	(0.0053)	(0.0045)	(0.0133)
R&D	0.0532***	0.0971***	0.0478***	0.0180	0.0880***	0.0912***	0.0374
	(0.0086)	(0.0151)	(0.0108)	(0.0132)	(0.0118)	(0.0102)	(0.0241)
Human capital	0.4440***	0.3520***	0.4590***	0.5160***	0.3640***	0.4550***	0.2860***
	(0.0123)	(0.0204)	(0.0175)	(0.0220)	(0.0162)	(0.0144)	(0.0369)
Brand× R&D	0.0106***	0.0085**	0.0095***	0.0173***	0.0022	0.0096***	−0.0055
	(0.0024)	(0.0042)	(0.0032)	(0.0036)	(0.00311)	(0.0026)	(0.0082)
DOA	0.0119***	0.0104***	0.0120***	0.0108***	0.0117***	0.00774***	0.0169***
	(0.0005)	(0.0008)	(0.0008)	(0.0009)	(0.0007)	(0.0005)	(0.0022)
Age	−0.0007	−0.0030	−0.0042	0.0032	−0.0009	0.0009	0.0137**
	(0.0017)	(0.0022)	(0.0029)	(0.0033)	(0.0021)	(0.0018)	(0.0062)
Constant	5.770***	6.743***	5.718***	5.134***	6.604***	5.215***	8.963***
	(0.153)	(0.233)	(0.274)	(0.328)	(0.190)	(0.162)	(0.434)
Observations	4,596	2,796	1,800	1,218	3,378	3,594	516
R-squared	0.692	0.541	0.682	0.723	0.603	0.713	0.501

Note: Robust standard errors are reported in parentheses.
***Denotes level of significance at 1%.
**At 5%
Source: Own calculations on WIND database.

due to the specific economic system of China. Third, SOEs are powerful brands themselves due to the special role they play in the Chinese economy.

The possible explanations for divergence between the manufacturing and service industries are that manufacturing has always been regarded as the pillar industry of the Chinese economy, and 'Made in China' has experienced a long course of globalisation. The process of globalisation helps manufacturing firms realise the importance of branding and make more effort in this area.

4.4. Interaction effect with human capital

Table 4 shows the interaction effect of brand equity and human capital on the firm-level productivity of different groups. All the models are estimated through pooled OLS with robust standard errors, which are applied to eliminate heteroscedasticity. As shown in Table 4, the coefficient of the interaction term, Brand× human capital, is significantly positive in the full sample. That is, human capital enhances the effect of brand equity on productivity. The results verify hypothesis H2b. Considering firm heterogeneity, there is a significantly positive interaction effect in both large enterprises and SMEs, as well as in SOEs and non-SOEs. The effect in SMEs (SOEs) is greater than in large enterprises (non-SOEs). The divergence occurs in the manufacturing and service industries. Specifically, the effect is significant in manufacturing, while insignificant in services. That is, our results partially reject hypotheses H3b and H3f, and partially confirm hypothesis H3d.

It is interesting to note that the interaction effect of brand equity and human capital in SMEs (0.0343) is larger than in large firms (0.0188), while the interaction effect of brand equity and R&D in SMEs (0.0085) is smaller than in large firms (0.0095). In addition, the marginal effect of brand equity in Equation (4) (0.0481) is smaller than in Equation (5) (0.0820) in SMEs, while it does exactly the opposite in large firms,

Table 4. Interaction effect of brand equity and human capital on firm-level productivity.

VARIABLES	(1) TFP	(2) TFP	(3) TFP	(4) TFP	(5) TFP	(6) TFP	(7) TFP
	Full	SMEs	Large	SOEs	Non-SOEs	Manufacturing	Service
Brand	0.0373***	0.0477***	0.0298***	0.0216**	0.0452***	0.0232***	0.0093
	(0.0043)	(0.0060)	(0.0069)	(0.0087)	(0.0052)	(0.0045)	(0.0134)
R&D	0.0580***	0.0973***	0.0568***	0.0289**	0.0898***	0.0950***	0.0375
	(0.0085)	(0.0147)	(0.0104)	(0.0129)	(0.0117)	(0.0102)	(0.0242)
Human capital	0.4270***	0.3550***	0.4350***	0.4960***	0.3530***	0.4410***	0.2850***
	(0.0124)	(0.0194)	(0.0190)	(0.0233)	(0.0158)	(0.0146)	(0.0376)
Brand× Human capital	0.0245***	0.0343***	0.0188***	0.0253***	0.0215***	0.0229***	−0.0049
	(0.0026)	(0.0055)	(0.0042)	(0.0046)	(0.0039)	(0.00295)	(0.0111)
DOA	0.0121***	0.0104***	0.0122***	0.0111***	0.0118***	0.00800***	0.0169***
	(0.0005)	(0.0008)	(0.0008)	(0.0009)	(0.0007)	(0.0005)	(0.0022)
Age	0.0007	−0.0026	−0.0033	0.0046	−0.0003	0.0017	0.0144**
	(0.0017)	(0.0022)	(0.0029)	(0.0034)	(0.0021)	(0.0018)	(0.0060)
Constant	6.023***	6.531***	6.162***	5.531***	6.691***	5.412***	8.987***
	(0.154)	(0.236)	(0.311)	(0.364)	(0.187)	(0.163)	(0.458)
Observations	4,596	2,796	1,800	1,218	3,378	3,594	516
R-squared	0.697	0.551	0.685	0.724	0.608	0.718	0.501

Note: Robust standard errors are reported in parentheses.
***Denotes level of significance at 1%.
**At 5%.
Source: Own calculations on WIND database.

that is, 0.0508 in Equation (4) and 0.0386 in Equation (5). One possible explanation is that R&D investment is risky, as the probability of the failure of R&D activities is much higher than for human capital investment. Hence, SMEs emphasise human capital more as a way to develop brand equity and protect innovations with resource constraints, while large companies may prefer R&D and intellectual property.

Another interesting fact is that both the direct effect of brand equity and the interaction effect of brand equity and R&D are insignificant (in the interaction effect model), and the interaction effect is even negative in service sector firms. The same situation appears in the interaction effect of brand equity and human capital in service sector firms. We can infer that Chinese service sector firms make less effort in branding and may face strong resource constraints.

5. Conclusions

Brand equity has seen a significant increase in importance with the arrival of the knowledge economy era. This article focuses on analysing the impact of brand equity on firm productivity, rather than on financial performance. In order to have a better understanding of the mechanism of how brand equity affects firm productivity, the indirect effects of R&D and human capital are also considered, which prior research had always addressed separately. This article further distinguishes these effects according to size, state-owned or non-state-owned firms and manufacturing or service sector firms. All the empirical evidence comes from the listed companies of the largest transition economy in the world, China, which is an original contribution to the extant literature.

Our results confirm the direct effect of brand equity is significant in the full sample. When firm heterogeneities are considered, divergences appear within different groups. To be specific, compared to non-SOEs, brand equity plays a more important role in SOEs. Compared to SMEs, brand equity plays a more important role in large enterprises, which is consistent with the results of Krake (2005). Compared to service sector enterprises, brand equity plays a more important role in manufacturing sector enterprises, which is consistent with the results of Keller (2008).

When it comes to the interaction effect, the effect of R&D on improving the effect of brand equity on firm productivity is insignificant in non-SOEs and service sector firms, and the effect of human capital is insignificant in service sector firms. Also, the impact of R&D on enhancing the effect of brand equity on firm productivity is greater in large firms than in SMEs, while the impact of human capital is the exact opposite, which is a reminder of the greater effort made by large firms in terms of intellectual property. Hence, SMEs place more emphasis on human capital as a way to develop brand equity and protect innovations, while large firms prefer R&D and intellectual property.

This article has a few limitations that future research may address. First, one possible limitation of the article is that it does not consider investments in intellectual property to measure the efforts of companies toward their brand equity, which should be carefully considered in future studies. Second, due to the limited scope of the available market data, this article uses advertising as an imperfect measurement of

brand equity. In future research, a more precise or complete measure should also incorporate the investments that firms make in the various forms of intellectual property protection (trademarks, patents, etc.), both to protect their brand equity and to enhance it. Third, this article only considers the manufacturing and service sectors. Future work could subdivide sectors as knowledge-intensive sectors and labour-intensive sectors.

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