VILNIUS TECH
Vilnius Gediminas Technical University

Journal of Business Economics and Management
ISSN 1611-1699 / eISSN 2029-4433
2022 Volume 23 Issue 4: 773–796
https://doi.org/10.3846/jbem.2022.16406

IS TOO MUCH A GOOD THING? THE NON-LINEAR RELATIONSHIP BETWEEN INTELLECTUAL CAPITAL AND FINANCIAL COMPETITIVENESS IN THE CHINESE AUTOMOTIVE INDUSTRY

Jian XU[1], Feng LIU[2*], Jingci XIE[3]

[1]*School of Economics and Management, Qingdao Agricultural University, Qingdao, China*
[2]*Business School, Shandong University, Weihai, China*
[3]*School of Management, Shandong University, Jinan, China*

Received 19 July 2020; accepted 08 November 2021; first published online 02 March 2022

Abstract. As one of the five largest industries in China, the automotive industry may well become a prosperous market of production and a large consumer market, but with the 2019 novel coronavirus (COVID-19) outbreak, automotive companies have suffered great losses. How to maintain financial competitiveness (FC) through innovation and knowledge after this calamity has become an area of focus for researchers and practitioners. By analyzing listed Chinese automotive companies over the period 2013–2018, the research focus is to determine the non-linear effect of intellectual capital (IC) on FC. IC is measured by the modified Value Added Intellectual Coefficient (MVAIC) model, and FC is measured through a comprehensive index system. The results reveal a cubic relationship between IC and FC. In addition, physical, innovation, and relational capitals have an S-shaped relationship with FC, whereas human capital has an inverted S-shaped curve. The non-linear effect of SC on FC is not significant. It is recommended that managers optimize investment in IC to drive FC in organizations.

Keywords: intellectual capital, human capital, structural capital, innovation capital, relational capital, financial competitiveness, automotive industry, non-linear relationship.

JEL Classification: O34, G30, L25.

Introduction

The assertion that intellectual capital (IC) can create competitive advantage and generate economic returns than tangible assets has become commonplace (Yaseen et al., 2016; Kamukama & Sulait, 2017; Urban & Joubert, 2017; Teixeira & Ferreira, 2019; Xu & Li, 2019, 2022; Hermawan et al., 2020; Ge & Xu, 2021; Liu et al., 2021b; Xu & Liu, 2021). In the knowledge economy, companies that effectively manage and utilize IC resources can

*Corresponding author. E-mail: *liufeng@sdu.edu.cn*

attain financial sustainability and competitive advantage (Jordão & de Almeida, 2017; Liu et al., 2021a; Xu & Wang, 2018; Gross-Gołacka et al., 2020; Xu & Liu, 2020). The automotive industry depends largely on tangibles, and IC management in automotive companies has not been brought into focus yet (Kompalla et al., 2016). Furthermore, the utilization efficiency of IC in the automotive industry is lower than that of other industries such as banking (Kalantar, 2013; Kompalla et al., 2016). In recent years, this industry has experienced a radical change due to new technologies (Cioca et al., 2019). Automotive companies must respond quickly to dynamic environmental change and efficiently configure their valuable resources (Shvetsova et al., 2021). These developments highlight the need to increase the awareness of IC management in the automotive industry.

Financial competitiveness (FC) extends the theory of corporate core competitiveness from a financial perspective. This term is defined as a kind of knowledge- and innovation-based competitiveness, which integrates financial capability to gain the competitive edge (Zhu et al., 2019). It also can reflect the strategic advantages of an organization. Meanwhile, FC is a determinant of the success or failure of an organization during a global economic slowdown (Dai & Wei, 2010).

The 2019 novel coronavirus (COVID-19) has brought great losses to automotive companies. It was reported that Beijing Benz Automotive Co., Ltd. lost about 400 million yuan (52 million euros) every day due to the stagnation of production. According to a report issued by China Association of Automobile Manufacturers (2020), car sales decreased by 43.3% in the first quarter of 2020 compared with the same period last year. Therefore, Chinese automotive companies need to achieve their financial transformation and strengthen FC. How to maintain strong FC in the long term has been much discussed. An accurate evaluation of FC is crucial to assessing sustainable growth of firms (He et al., 2011; Volkova & Shagum, 2017).

The current paper attempts to determine the relationship between IC and FC from a non-linear perspective based on data from automotive listed companies in China over the period 2013–2018. IC is measured by the modified Value Added Intellectual Coefficient (MVAIC) model, and FC is measured through a constructed index system.

This study makes several contributes to the growing literature on IC. Firstly, few studies have examined the non-linear relationship between IC and FC in the context of emerging markets, and this study attempts to fill this gap. Secondly, this study attempts to present a comprehensive index system to assess FC on four aspects (i.e. solvency, development capability, operating capability, and profitability). Finally, this study can provide insights for the automotive industry to improve FC through the effective utilization of IC resources.

The remainder of this research is organized as follows. Section 1 presents an overview of the literature on both IC and FC. Section 2 describes the research methodology, and Section 3 provides the estimated results and discusses the findings. Finally, the conclusions, limitations, and propositions for future research are presented.

1. Theoretical background

1.1. IC definition and measurement

IC was defined as the combination of intangible assets of the market, intelligence, human resources, and facilities that empower firms to operate (Brooking, 1996). Along the same lines, Edvinsson and Malone (1997) stated that IC is the ownership of knowledge, expertise, experience, technology, and customer relationships, which brings about competitiveness. Numerous studies (e.g., Vishnu & Gupta, 2014; Jelínková & Jiřincová, 2015; Sardo & Serrasqueiro, 2018; Smriti & Das, 2018; Cagáňová et al., 2019; Cheikh & Noubbigh, 2019; Lee & Wong, 2019; Sardo & Serrasqueiro, 2019; Xu & Li, 2019; Yao et al., 2019; Costa et al., 2020; Masoomzadeh et al., 2020; Nigam et al., 2021) have provided evidence that IC can be categorized into human capital (HC), structural capital (SC), and relational capital (RC). Specifically, HC can be considered as an essential factor of firm value creation (Smriti & Das, 2018), and is widely accepted as the amalgamation of skills, competencies, capabilities, and experiences of employees (Morris, 2015; Jelínková & Jiřincová, 2015). SC can be broadly described as organization capital, which consists of culture, routines, databases, processes, patents, copyrights, and trademarks (Janoševic & Dženopoljać, 2012). RC includes both internal and external relationships with stakeholders (Yu et al., 2015).

Firms are required to accurately measure IC in monetary terms by certain approaches in order to manage IC efficiently. Multiple methods have been developed by scholars. Among them, the VAIC method gains its popularity in the IC literature. First, to avoid the limitations of subjective evaluations such as surveys, it uses publicly financial data from consolidated financial reports (Vishnu & Gupta, 2014). Second, this method allows comparative investigations across firms and countries because it is a standardized measurement that integrates capital employed efficiency (CEE), human capital efficiency (HCE), and structural capital efficiency (SCE). However, several criticisms of this method have also been noted. First, because the VAIC method is limited to historical data from annual financial statements, it may be inappropriate to assess firms' future value-creating potential. Second, some expenditures such as research and development (R&D) and advertising costs are not included in this method because both of them are classified as expense items (Ståhle et al., 2011; Lu et al., 2021; Zhang et al., 2021). Therefore, this study applies the MVAIC method, which will be further discussed in Section 2.2.

1.2. FC evaluation

FC can effectively integrate the ability of financial systems and act on financial controllable resources in an organization (Zhu et al., 2019). Academics have not yet reached a consensus on the assessment of FC (He et al., 2011). Using the fuzzy comprehensive evaluation method, He et al. (2011) analyzed the FC of the world's top 20 telecom companies on five aspects: profitability, solvency, assets management capability, growth ability, and cash support capability. Liu and Lin (2011) used factor analysis to conduct a comparative study on FC of fertilizer manufacturing firms with nine financial indicators. Based on principal component analysis, Ran and Zhang (2011) presented a quantitative method to analyze FC in three ar-

eas of profitability capability, debt paying capability, and operation capability. Xie and Wang (2014) argued that the overall FC in China's biological pharmaceutical industry needs to be strengthened in terms of solvency and development ability. Tálas and Rózsa (2015) assessed the FC of leading milk-processing companies in Hungary through the analysis of liquidity, working capital, and profitability. Luo (2017) used factor analysis to determine the FC of publicly traded agricultural companies on three dimensions: financial viability, financial development, and financial potential. A study conducted by Yang and Sun (2017) showed that FC is not balanced in various industries in the context of China. Analyzing Chinese insurance companies, Lin et al. (2019) built an index system to assess FC from two aspects (i.e. solvency and operation capacity). Lu and Wang (2019) constructed FC evaluation index system with 13 indicators by analyzing firms' profitability, capital structure rationality, solvency, and growth ability. Based on data mining, Lv and Salam (2020) proposed a new evaluation method to study the FC of innovation-driven enterprises.

1.3. IC and firm performance

Most scholars have analyzed the influence of IC on firm performance with mixed results, and there is a lack of research on the IC-FC relationship. In Europe, Sardo and Serrasqueiro (2018) found a positive linkage between IC efficiency of the current period and financial performance measured by return on assets (ROA). By investigating Croatian small and medium-sized enterprises (SMEs), Dabić et al. (2019) concluded that higher performance is positively associated with higher level of IC. Ousama et al. (2020) and Xu and Liu (2021) also documented a positive relationship between them. However, based on the pay-performance relation, Ting et al. (2020) used ordinary least square (OLS) regression to study the dynamic performance effect of IC. Their results showed that IC hinders firm performance.

In terms of IC components, Rafiei et al. (2011) found that SC and RC directly spur economic performance in the Iranian automotive sector, while HC has an indirect impact. In another study, Dadashinasab et al. (2012) observed that physical capital, HC, and SC have a direct influence on the performance of Iranian automotive companies. Dženopoljac et al. (2016), using the VAIC model, found that only CEE significantly affects financial performance of Serbian information communication technology (ICT) companies. Ginesti et al. (2018) pointed out that financial performance is positively related to physical and structural capital, but negatively related to HC in Italian non-listed companies. Another study conducted by Sardo et al. (2018) suggested that HC and RC are the main contributors to hotel financial performance. For Turkish manufacturing firms, both SC and innovation capital (INC) significantly contribute to firm productivity (Bayraktaroglu et al., 2019). Further, the findings of Cheikh and Noubbigh (2019) showed that HC contributes the most to the market value of Tunisian listed firms. Analyzing 1,000 Spanish companies, Alcalde-Delgado et al. (2020) found that there are inconsistent contributions to the value added of three IC components in different business life cycle. From the perspective of Polish SMEs, Gross-Gołacka et al. (2020) showed that only HC has the greatest influence on business sustainability. Xu et al. (2020) suggested that physical capital and executive HC positively affect sustainable growth of high-tech agricultural companies in the case of China. Taking Turkish engineer-

ing consultancy firms as the sample, Ulubeyli and Yorulmaz (2020) found that firms with strong HC and SC have a good firm reputation but that RC does not result in the same effect. In the Indian banking sector, Weqar et al. (2020) reported that HC is the most important IC component in enhancing profitability and productivity. While SC is important for bank profitability, the impact of RC is nominal. Ge and Xu (2021), applying the MVAIC method, pointed out that physical and human capitals can significantly improve firm performance in China's pharmaceutical sector. As reported by Ovechkin et al. (2021), the stock of HC and SC has the biggest influence on firms' profitability in the Russian agricultural sector. Zhang et al. (2021) pointed out that physical capital and HC are strong factors spurring the performance of textile and apparel companies in the case of China.

2. Research methodology

2.1. Sample selection

The sample comprises companies in the automotive industry listed on the Shanghai and Shenzhen stock exchanges during 2013–2018. This study deletes companies with incomplete data, companies that issue other kinds of shares, and special treatment (ST) companies. The final unbalanced panel sample consists of 517 observations for 117 automotive listed companies. The original data come from two different public databases, namely, the China Stock Market & Accounting Research (CSMAR) database and the Wind database.

2.2. Variable definitions

(1) Dependent variable. In Table 1, an index system with 11 indicators is used to assess FC of listed Chinese automotive companies on four aspects: solvency, development capability, operating capability, and profitability. Solvency reflects a company's ability to fulfill its financial obligations to other market entities. Development capability is an aggregated measure of the development potential accumulated by the production and operation activities (Myszewski, 2014). Operating capability measures the company's capability of asset utilization to earn profits (Zhang, 2019). Profitability determines the company's bottom line and its return to its investors.

(2) Independent variables. The MVAIC method is applied to measure IC efficiency by adding two extra IC components-INC and RC. The larger the MVAIC, the higher level of IC. First, the firms' total value added (VA) is calculated. Second, the MVAIC calculation is based on the efficient utilization of physical capital, HC, SC, INC, and RC through computing CEE, HCE, SCE, innovation capital efficiency (INCE), and relational capital efficiency (RCE). Among them, CEE shows the addition in the firm's value creation by using one monetary unit of its capital employed. HCE indicates the amount added by employing one monetary unit on HC. SCE is the representation of the value addition by investing one monetary unit in SC. INCE measures how much value has been created by one invested unit of INC. RCE indicates how much value has been created by RC. The calculations are as follows:

$$\text{VA} = \text{Total revenues} - \text{total expenses} + \text{employee costs}; \quad (1)$$

Table 1. FC evaluation index system

Variable	Symbol	Description
Solvency	Current ratio (Y1)	Current assets/Current liabilities
	Quick ratio (Y2)	(Current assets – inventory)/Current liabilities
	Equity ratio (Y3)	Total shareholders' equity/Total assets
Development capability	Growth rate of return on equity (Y4)	(Current year's return on equity – last year's return on equity)/Last year's return on equity
	Net profit growth rate (Y5)	(Current year's net profit – last year's net profit)/ Last year's net profit
Operating capability	Total assets turnover (Y6)	Net sales/Total assets
	Current assets turnover (Y7)	Net sales/Current assets
Profitability	Asset profit ratio (Y8)	Net profit/Total assets
	Ratio of profits to cost (Y9)	Total profits/(Operating costs + total expenses)
	ROA (Y10)	(Total profits + financial expenses)/Average total assets
	Earnings before interest and tax (Y11)	Earnings before interest and tax/Total sales

$$\text{CEE} = \text{VA}/\text{Book value of net assets}; \tag{2}$$

$$\text{HCE} = \text{VA}/\text{Total costs of employees}; \tag{3}$$

$$\text{SCE} = (\text{VA} - \text{total costs of employees})/\text{VA}; \tag{4}$$

$$\text{INCE} = \text{R\&D expenses}/\text{VA}; \tag{5}$$

$$\text{RCE} = \text{Marketing, selling and advertising expenses}/\text{VA}; \tag{6}$$

$$\text{MVAIC} = \text{CEE} + \text{HCE} + \text{SCE} + \text{INCE} + \text{RCE}. \tag{7}$$

(3) Control variables. Guided by previous literature (Nimtrakoon, 2015; Sardo & Serrasqueiro, 2018; Sardo et al., 2018; Smriti & Das, 2018; Xu & Li, 2019; Xu & Wang, 2019; Xu et al., 2019; Yao et al., 2019; Xu & Liu, 2020, 2021; Ge & Xu, 2021; Xu & Zhang, 2021; Zhang et al., 2021), firm size (SIZE), firm leverage ratio (LEV), firm age (AGE), and gross domestic product growth rate (GDP) are included in regression models. More specifically, this study determines SIZE as the natural logarithm of total assets, LVE as the total liabilities to total assets, and AGE as the natural logarithm of years since setup of enterprise. Moreover, a year dummy (YEAR) is employed to control for changes through time in the given business environment.

2.3. Model specification

Model (1) (Eq. (8)) aims to test the quadratic relationship between IC and FC.

$$\text{FC}_{i,t} = \beta_0 + \beta_1\text{MVAIC}_{i,t} + \beta_2\text{MVAIC}^2_{i,t} + \beta_3\text{SIZE}_{i,t} + \beta_4\text{LEV}_{i,t} + \beta_5\text{AGE}_{i,t} + \beta_6\text{GDP}_{i,t} + \Sigma\text{YEAR} + \varepsilon_{i,t}. \tag{8}$$

Model (2) (Eq (9)) is used to examine the cubic relationship between them.

$$FC_{i,t} = \beta_0 + \beta_1 MVAIC_{i,t} + \beta_2 MVAIC^2_{i,t} + \beta_3 MVAIC^3_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 LEV_{i,t} + \beta_6 AGE_{i,t} + \beta_7 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}. \quad (9)$$

Models (3)–(12) (Eqs (10)–(19)) are employed to analyze the non-linear effect of IC components on FC.

$$FC_{i,t} = \beta_0 + \beta_1 CEE_{i,t} + \beta_2 CEE^2_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 AGE_{i,t} + \beta_6 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (10)$$

$$FC_{i,t} = \beta_0 + \beta_1 CEE_{i,t} + \beta_2 CEE^2_{i,t} + \beta_3 CEE^3_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 LEV_{i,t} + \beta_6 AGE_{i,t} + \beta_7 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (11)$$

$$FC_{i,t} = \beta_0 + \beta_1 HCE_{i,t} + \beta_2 HCE^2_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 AGE_{i,t} + \beta_6 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (12)$$

$$FC_{i,t} = \beta_0 + \beta_1 HCE_{i,t} + \beta_2 HCE^2_{i,t} + \beta_3 HCE^3_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 LEV_{i,t} + \beta_6 AGE_{i,t} + \beta_7 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (13)$$

$$FC_{i,t} = \beta_0 + \beta_1 SCE_{i,t} + \beta_2 SCE^2_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 AGE_{i,t} + \beta_6 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (14)$$

$$FC_{i,t} = \beta_0 + \beta_1 SCE_{i,t} + \beta_2 SCE^2_{i,t} + \beta_3 SCE^3_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 LEV_{i,t} + \beta_6 AGE_{i,t} + \beta_7 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (15)$$

$$FC_{i,t} = \beta_0 + \beta_1 INCE_{i,t} + \beta_2 INCE^2_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 AGE_{i,t} + \beta_6 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (16)$$

$$FC_{i,t} = \beta_0 + \beta_1 INCE_{i,t} + \beta_2 INCE^2_{i,t} + \beta_3 INCE^3_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 LEV_{i,t} + \beta_6 AGE_{i,t} + \beta_7 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (17)$$

$$FC_{i,t} = \beta_0 + \beta_1 RCE_{i,t} + \beta_2 RCE^2_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 LEV_{i,t} + \beta_5 AGE_{i,t} + \beta_6 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}; \quad (18)$$

$$FC_{i,t} = \beta_0 + \beta_1 RCE_{i,t} + \beta_2 RCE^2_{i,t} + \beta_3 RCE^3_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 LEV_{i,t} + \beta_6 AGE_{i,t} + \beta_7 GDP_{i,t} + \Sigma YEAR + \varepsilon_{i,t}. \quad (19)$$

2.4. Estimation strategy

To determine the important role of IC in improving FC, this strategy employed a methodological research strategy. First of all, the Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were performed to measure the strength of the relationships among criteria, and these two tests assessed the appropriateness of using factor analysis on our dataset (Vogt & Johnson, 2011). Second, a factor analysis was carried out to determine the validity of a proposed evaluation

index system through principal component analysis. This method was selected because it is one of the most common procedures for examining the internal structure and reliability of the measurement, calculating the comprehensive score of each factor, and creating a dependent variable through a proposed evaluation index system (Abdi et al., 2013; Zhu et al., 2015, 2019). The third step was running generalized linear model (GLM), a flexible generalization of ordinary linear regression conducted for a dependent variable that has error distribution models other than a normal distribution (Dobson & Barnett, 2008). Overall, it is believed that these tests were appropriate statistical methods for this study.

3. Results and discussion

3.1. Factor analysis

The principal component analysis method of factor analysis was used to obtain comprehensive FC through the measured items. In Table 2, the KMO value (0.563) and Bartlett's test of sphericity (7101.671) confirmed a good quality of the items used for measuring FC, indicating that principal component analysis was applicable (Vogt & Johnson, 2011). Based on the screen test presented in Table 3, the results of total variance explained indicate that four components had eigenvalues greater than 1, and components 1, 2, 3, and 4 present values of 3.638, 2.822, 1.812, and 1.145, respectively. As these components explain over 85% of the variance in the correlation matrix, the proposed index system can be considered valid.

Table 2. KMO and Bartlett tests

Kaiser-Meyer-Olkin measure of sampling adequacy		0.563
Bartlett's Test of Sphericity	Approx. chi-square	7101.671
	Degree of freedom	55
	Significant level	0.000

Table 3. Total variance explained

Component	Initial eigenvalue			Extract sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.638	33.070	33.070	3.638	33.070	33.070	2.981	27.101	27.101
2	2.822	25.658	58.728	2.822	25.658	58.728	2.598	23.616	50.717
3	1.812	16.470	75.198	1.812	16.470	75.198	1.953	17.752	68.469
4	1.145	10.407	85.605	1.145	10.407	85.605	1.885	17.135	85.605
5	0.709	6.446	92.051						
6	0.466	4.236	96.286						
7	0.208	1.895	98.182						

End of Table 3

Component	Initial eigenvalue			Extract sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
8	0.132	1.197	99.378						
9	0.048	0.434	99.813						
10	0.013	0.114	99.926						
11	0.008	0.074	100.000						

Finally, the rotated component matrix is presented in Table 4, showing the most influential items. Consistent with the proposed evaluation index system in Table 1, 11 factors with scores greater than 0.7 loadings were clearly structured into four distinct groups: Factor 1 (profitability), Factor 2 (solvency), Factor 3 (operating capability), and Factor 4 (development capability). Therefore, the comprehensive score function of a firm's FC is as follows:

$$F = (27.101 \times \text{Factor 1} + 23.616 \times \text{Factor 2} + 17.752 \times \text{Factor 3} + 17.135 \times \text{Factor 4})/85.605. \quad (20)$$

Table 4. Component matrix

Variable	Component			
	1	2	3	4
Y1	0.048	0.953	–0.162	0.007
Y2	0.074	0.927	–0.152	0.007
Y3	0.254	0.744	–0.135	–0.041
Y4	0.114	0.008	0.008	0.960
Y5	0.005	–0.033	0.002	0.963
Y6	0.109	–0.232	0.884	0.010
Y7	0.048	–0.222	0.865	–0.019
Y8	0.780	0.282	0.404	0.124
Y9	0.949	0.186	–0.045	0.012
Y10	0.765	0.231	0.423	0.139
Y11	0.887	–0.082	–0.099	–0.006

3.2. Main results

The descriptive statistics are shown in Table 5. Concretely, the mean FC of 0.6438 suggests that listed automotive companies have low FC in today's international competitive market. However, a study carried out by Vijayakumar (2018) showed that automobile companies have better FC than the industry average in India. The mean value of MVAIC indicates that the value created by automotive listed companies is on average 4.3475 yuan

by investing one yuan in IC. With regard to IC components, HCE has the greatest mean value of 2.9726, implying that HC is the main determinant of value creation compared with other IC elements. This accords with previous findings (Chen et al., 2005; Maditinos et al., 2011; Nimtrakoon, 2015; Smriti & Das, 2018; Xu & Wang, 2018; Bayraktaroglu et al., 2019; Haris et al., 2019; Xu & Li, 2019; Yao et al., 2019; Xu & Liu, 2020; Zhang et al., 2021). The sum of HCE, SCE, LNCE, and RCE is 3.8624, indicating that the value generation of listed automotive companies is mainly derived from IC rather than from tangible assets. Additionally, the mean LEV (0.4543) reveals that listed automotive companies have sufficient assets to meet their obligations. The mean values of SIZE, AGE, and GDP are 22.4509, 2.9056, and 0.070, respectively.

Table 5. Descriptive statistics

Variable	N	Mean	Max	Min	S.D.
FC	517	0.6438	78.5100	–24.8455	3.8115
MVAIC	517	4.3475	10.1007	–2.1398	1.1807
CEE	517	0.4852	3.9632	0.0298	0.3834
HCE	517	2.9726	6.3452	0.1337	0.9090
SCE	517	0.6098	0.8424	–6.4817	0.3716
INCE	517	0.1169	0.5169	0.0000	0.0599
RCE	517	0.1631	2.7943	0.0191	0.1695
SIZE	517	22.4509	27.3861	19.7324	1.3852
LEV	517	0.4543	0.9820	0.0636	0.1931
AGE	517	2.9056	3.8501	1.7918	0.2782
GDP	517	0.070	0.078	0.066	0.0039

Based on the Shapiro-Wilk test, the results of Table 6 show that the data are not normally distributed ($p < 0.05$), which indicates that Pearson's correlation coefficient analysis can be conducted.

Table 6. Normality test

Variable	Statistic	df	Sig.
FC	0.111	517	0.000
MVAIC	0.946	517	0.000
CEE	0.670	517	0.000
HCE	0.957	517	0.000
SCE	0.235	517	0.000
INCE	0.879	517	0.000
RCE	0.480	517	0.000
SIZE	0.957	517	0.000
LEV	0.987	517	0.000
AGE	0.989	517	0.001
GDP	0.797	517	0.000

Table 7. Correlation matrix

Variable	1	2	3	4	5	6	7	8	9	10	11
1 FC	1										
2 MVAIC	0.083*	1									
3 CEE	0.075*	0.394***	1								
4 HCE	0.043	0.928***	0.080*	1							
5 SCE	0.202***	0.542***	–0.069	0.475***	1						
6 INCE	–0.142***	0.007	–0.039	–0.059	–0.097**	1					
7 RCE	–0.212***	–0.091**	0.218***	–0.101**	–0.776***	0.314***	1				
8 SIZE	–0.023	0.262***	0.193***	0.176***	0.051	0.332***	0.220***	1			
9 LEV	–0.016	0.180***	0.621***	–0.051	–0.167***	0.270***	0.398***	0.377***	1		
10 AGE	–0.065	–0.051	0.108**	–0.099**	–0.053	–0.012	0.048	0.238***	0.210***	1	
11 GDP	0.019	0.130***	0.009	0.146***	0.044	–0.056	0.028	–0.043	0.046	–0.243***	1

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The correlation analysis results are shown in Table 7. These comprise further analysis through a generalized linear model (GLM). Concretely, FC is positively correlated with MVAIC, CEE, and SCE, but negatively correlated with INCE and RCE. However, FC does not have significant correlation with HCE. In addition, all variance inflation factor (VIF) values are found to be less than 10, which implies that there is no serious multi-collinearity.

The results of Models (1) and (2) are shown in Table 8. The chi-square (degrees of freedom) for Models (1) and (2) specifications is, respectively, 25.31 (10) and 32.98 (11). Moreover, the Akaike information criterion (AIC) and Bayesian information criterion (BIC) are 2846.454 and 2893.183 for Model (1) and 2840.980 and 2891.957 for Model (2). These indicators suggest that both models offer a good quality of model fit.

Regarding the quadratic relationship between MVAIC and FC, it is observed that Model (1) reveals a non-linear and significant relationship (MVAIC: $\beta = 2.077$, $p < 0.01$; $MVAIC^2$: $\beta = -0.194$, $p < 0.01$). With regard to the cubic relationship, Model (2) shows the coefficient of MVAIC, $MVAIC^2$, and $MVAIC^3$ is, respectively, positive ($\beta = 3.470$, $p < 0.01$), negative ($\beta = -0.018$, $p < 0.01$), and positive ($\beta = 0.036$, $p < 0.01$). The results indicate that MVAIC has an inverted S-shaped relationship with FC. In their investigation of banks in Pakistan, Haris et al. (2019) found that IC has an inverted U-shaped relationship with bank profitability. Yao et al. (2019) confirmed an inverted U-shaped relationship between IC and the performance of financial institutions in Pakistan. Further, Kweh et al. (2021) in a study of Vietnamese companies also believed that there is a reversed U-shaped curve between IC and corporate efficiency and profitability. In Iran, Masoomzadeh et al. (2020) found that the automotive industry had the potential to achieve greater success by effectively utilizing IC.

Table 8. Empirical results of Models (1) and (2)

Variable	Model (1)	Model (2)
Constant	–8.066 (5.209)	–9.075* (5.190)
MVAIC	2.077*** (0.501)	3.470*** (0.715)
$MVAIC^2$	–0.194*** (0.053)	–0.018*** (0.007)
$MVAIC^3$		0.036*** (0.013)
SIZE	–0.198 (0.144)	–0.182 (0.144)
LEV	0.261 (1.028)	0.443 (1.024)
AGE	1.376** (0.644)	1.204* (0.643)
GDP	53.451 (49.281)	55.597 (48.981)
YEAR	Yes	Yes
N	517	517
Log likelihood	–1412.227	–1408.490
χ^2	25.31***	32.98***
AIC	2846.454	2840.980
BIC	2893.183	2891.957

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are in parentheses.

As for control variables, AGE positively influences FC. SIZE has a negative but insignificant impact on FC. On the contrary, using a panel quantile regression, Albulescu et al. (2021) documented a positive impact of firm size on firm growth in the Romanian automotive industry. The impact of GDP is not significant at the 5% level.

Table 9 presents the empirical results of Models (3)–(12). In Models (4), the S-shaped curve illustrates the three phases between CEE and FC. Nedelcu et al. (2014) found that within the Romanian automative marketplace, the highest impact is given by physical capital, with ROA being the dependent variable. Car production relies greatly on sophisticated equipment and automated production processes, but overinvesting in physical assets tends to consume a large amount of money. In addition, Xu and Zhang (2021) reported a U-shaped association between physical capital and ROA of shipping companies in China. According to Model (6), the coefficient of HCE is 5.814, the coefficient of HCE^2 is –1.585, and the coefficient of HCE^3 is 0.135. Thus, an inverted S-shaped relationship exists between HCE and FC. A short supply of skilled workers such as engineers and electrical mechanics is a major problem facing many automotive companies nowadays. There is no doubt that an increase in the number of high-skilled workers employed will be an optimistic scenario for sustainable growth in this industry. Koç (2017) pointed out that HC elements (such as know-how, job evaluation, changeability, and analytical thinking) are at a higher level in such industry. Asif et al. (2020) documented an inverse U-shaped relationship between firm performance and HCE and CEE. The coefficients of SCE, SCE^2, and SCE^3 are statistically insignificant, thereby confirming that SC is not a major determinant of FC. Similarly, Asif et al. (2020) and Xu and Zhang (2021) claimed that there is no non-linear relationship between SCE and firm performance. However, under Industry 4.0, digital transformation can boost production efficiency, reduce costs, and generate greater collaboration with the help of new robotics, artificial intelligence, and the Internet in the global automotive industry (Llopis-Albert et al., 2021). Models (10) and (12) reveal that INC and RC have an S-shaped relationship with FC. INC becomes a driver of wealth generation, economic growth, and human well-being (Kirikkaleli & Ozun, 2019; Ni et al., 2021). For automotive companies, digital technologies in vehicles, such as autonomous driving systems, require a huge amount of money, which in turn might lower firms' current profits. However, in the long run, once new products or services are successfully developed, they help the firm gain competitive advantage. Massomzadeh et al. (2019) stated that innovative capability plays an essential role in performance enhancement of Iranian auto parts companies. The findings of López-Fernández et al. (2014) also showed that Spanish automotive companies with more investment in technology capital obtain better financial results as a result of their competitive advantage. As for RC, it has a direct and negative impact on financial performance in South Korea, where informal social networks (*yongo*) have naturally exits for centuries (Xu & Wang, 2018). These stocial ties are sometimes perceived as a burden (Horak & Taube, 2016). Conversely, Zardini et al. (2015) pointed out that RC of the information technology (IT) department as a significant resource creates value in firms.

Finally, this study plots the cubic relationship between IC and its components and FC, following the guidelines of Royston (2013). As shown in Figure 1, the graph confirms that there is indeed an inverted S-shaped curve between MVAIC and FC. The sequence of first positive, then rectilinear, and again positive linear, indicates an inverted S-shape. Figure 2 shows the cubic relationship between IC components and FC.

Table 9. Empirical results of Models (3)–(12)

Variable	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)	Model (11)	Model (12)
Constant	−5.705 (5.164)	−6.142 (5.150)	−7.753 (5.454)	−9.697* (5.521)	−2.872 (5.003)	−2.799 (5.002)	−2.744 (5.087)	−1.499 (5.127)	−3.309 (5.021)	−4.256 (5.012)
CEE	2.321* (1.233)	−1.306* (2.106)								
CEE^2	−0.331 (0.391)	3.034* (1.634)								
CEE^3		−0.702** (0.331)								
HCE			1.998** (0.832)	5.814*** (2.055)						
HCE^2			−0.271** (0.123)	−1.585** (0.659)						
HCE^3				0.135** (0.067)						
SCE					0.459 (0.875)	0.340 (0.880)				
SCE^2					−0.415** (0.174)	0.660 (0.928)				
SCE^3						0.169 (0.143)				
INE							−27.026*** (7.484)	−49.953*** (15.140)		
$INCE^2$							53.050*** (20.028)	194.034** (83.412)		
$INCE^3$								−220.358* (126.574)		
RCE									−1.879 (2.106)	−9.077** (3.611)

End of Table 9

Variable	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)	Model (9)	Model (10)	Model (11)	Model (12)
RCE^2									−1.835** (0.928)	11.100** (5.364)
RCE^3										−3.838** (1.568)
SIZE	−0.048 (0.145)	−0.002 (0.147)	−0.141 (0.147)	−0.159 (0.147)	−0.168 (0.142)	−0.188 (0.143)	0.034 (0.146)	0.016 (0.146)	−0.133 (0.142)	−0.085 (0.142)
LEV	−2.592* (1.345)	−2.484* (1.341)	0.123 (1.041)	0.343 (1.043)	0.615 (1.027)	0.627 (1.026)	0.010 (1.022)	−0.070 (1.021)	1.198 (1.077)	1.472 (1.078)
AGE	1.122* (0.648)	1.069* (0.646)	1.365** (0.656)	1.148* (0.663)	1.052* (0.636)	1.130* (0.639)	0.714 (0.650)	0.718 (0.648)	1.007 (0.634)	0.933 (0.631)
GDP	59.121 (49.482)	64.351 (49.373)	57.959 (50.238)	51.912 (50.172)	51.978 (48.473)	48.134 (48.564)	38.270 (49.270)	39.858 (49.180)	52.377 (48.308)	61.562 (48.218)
YEAR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	517	517	517	517	517	517	517	517	517	517
Log likelihood	−1417.950	−1415.659	−1418.324	−1416.224	−1406.454	−1405.744	−1413.481	−1411.934	−1406.010	−1402.961
χ^2	13.67*	18.26*	12.92*	17.12*	37.31***	38.73***	22.74**	25.86***	38.24***	44.61***
AIC	2857.901	2855.318	2858.648	2856.447	2834.909	2835.488	2848.962	2847.868	2834.020	2829.922
BIC	2904.629	2906.295	2905.377	2907.424	2881.637	2886.464	2895.690	2898.845	2880.749	2880.899

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are in parentheses.

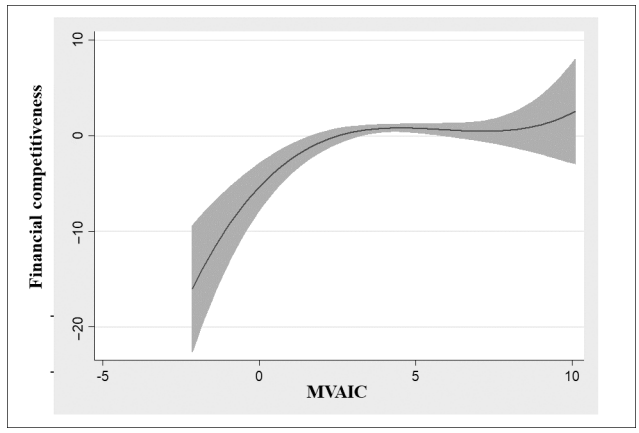

Figure 1. The cubic relationship between IC and FC

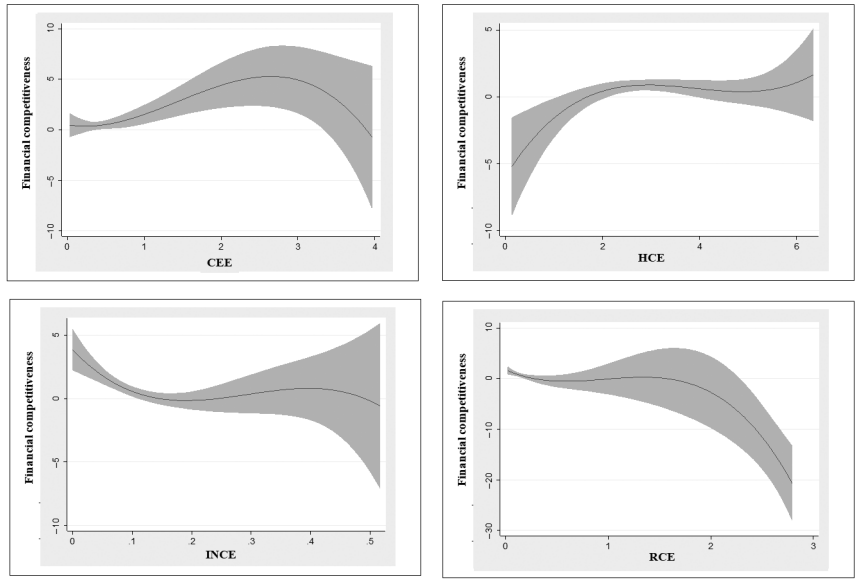

Figure 2. The cubic relationship between IC components and FC

3.3. Robustness check

LEV and return on equity (measured through the ratio of net income to average total assets) are used to replace equity ratio (Y3) and ROA (Y10) to reconstruct FC evaluation index system. The similar results are found, suggesting that the conclusion of this paper is robust.

Conclusions

This paper takes listed Chinese automotive companies during 2013–2018 as the sample, and determines the non-linear relationship between IC and its components and FC. Specifically,

a comprehensive index system is used to calculate FC, and the MVAIC method is applied to measure IC. The main conclusions are drawn as follows:

First, there exists a cubic relationship between IC and FC. This relationship can be explained by the resource-based view (RBV). Continuous IC investment leads to the increase in FC because margin returns from this investment are higher than its marginal costs. When a company's resources are not efficiently utilized, increased marginal costs will decrease the stimulating effect of IC. IC resources are valuable, rare, and inimitable, and it can achieve sustainable corporate success in the dynamic business world. Second, physical capital, INC, and RC show an S-shaped relationship with FC, whereas HC has an inverted S-shaped curve. In addition, the non-linear effect of SC on FC is not significant. Investing excessively in physical capital, INC, and RC might divert company resources. These findings offer a new idea for corporate managers to understand the IC-FC relationship, which will help them to utilize optimal investment strategies with their IC resources.

This paper offers three core theoretical contributions. First, it enriches the previous IC literature by investigating the impact of IC and FC in the Chinese context from a non-linear perspective, which is comparatively under-addressed than the IC-financial performance relationship. Companies must plan and monitor their investment in IC to ensure its maximum efficiency. Second, previous studies have analyzed FC only in two or three dimensions, and this study constructs an index system that can be used to comprehensively assess firms' FC. Finally, it can be viewed as a guideline for business practitioners to understand deeply the important role of IC in developing FC.

According to the conclusions made from this paper, the following suggestions are proposed. First, listed automotive companies should make an optimal investment strategy in IC and improve the utilization efficiency of IC resources. Second, automotive listed companies should reasonably develop HC, pay attention to the needs of employees, support their innovative ideas, and strengthen vocational training to update their skills. They can also be involved in education and training systems to have close links with technical colleges and universities. Third, managers should attach importance to the role of SC by setting up a sound management system, implementing advanced information systems and tools, and building a good corporate culture. Meanwhile, such companies should keep closer ties with their stakeholders, establish a good cooperative relationship, and improve their service quality on the basis of customer demand. Finally, management should invest more resources in R&D and implement agile innovation management, and R&D division should achieve the transformation of management model from the input to the output by the utilization of INC in a more positive way.

Despite this paper has significant contributions, two main limitations in this study should be addressed. First, as the research sample only comprises the automotive industry, a follow-up study in this area could be a deeper analysis of other industry segments. Second, this paper is carried out in the transition market (China), and the findings may not be applicable to other emerging markets. It is suggested that future researchers aim at comparing the findings with other countries or regions. Therefore, further research on the subject is required to be fully investigated.

Acknowledgements

We would like to thank the Editor-in-Chief (Prof. Romualdas Ginevičius), the Associate Editor (Dr. Martinkutė Kaulienė), and the anonymous reviewers for their useful comments on earlier drafts. We also thank Shifan Jia, Jiahuan Weng, Jing Zhang, and Yidian Zhao for their outstanding research assistance.

Funding

The research for this paper was financially supported by the Scientific Research Foundation for High-level Talents of Qingdao Agricultural University (Grant Number 6631120701), the Soft Science Research Plan of Shandong Province (Grant Number 2019RKB01222), the National Natural Science Foundation of China (No.71772106), Humanities and Social Sciences Foundation of the Ministry of Education of China (No. 17YJCZH198), Shandong Provincial Natural Science Foundation, China (No. ZR2017MG012), and Shandong Provincial Natural Science Foundation, China (ZR2019MG008).

Author contributions

Jian XU conceived of the study, and collected data, and performed the statistical analysis, and drafted the manuscript. Feng LIU participated in its design and coordination, and helped to draft the manuscript, and finally reviewed and edited the manuscript. Jingci XIE reviewed and edited the manuscript. All authors read and approved the final manuscript.

Disclosure statement

The authors declare that they have no competing interests.

References

Abdi, H., Williams, L. J., & Valentin, D. (2013). Multiple factor analysis: Principal component analysis for multitable and multiblock data sets. *Wiley Interdisciplinary Reviews: Computational Statistics*, *5*(2), 149–179. https://doi.org/10.1002/wics.1246

Albulescu, C. T., Tămășilă, M., & Tăucean, I. M. (2021). The nonlinear relationship between firm size and growth in the automotive industry. *Journal of Industry, Competition and Trade*, *21*(3), 445–463. https://doi.org/10.1007/s10842-021-00364-6

Alcalde-Delgado, R., Saiz-Barcena, L., Olmo, R., & de Armino, C. A. (2020). Empirical study of the business growth strategy related to the added value by intellectual capital. *International Journal of Production Management and Engineering*, *8*(1), 1–11. https://doi.org/10.4995/ijpme.2020.10817

Asif, J., Ting, I. W. K., & Kweh, Q. L. (2020). Intellectual capital investment and firm performance of the Malaysian energy sector: A new perspective from a nonlinear test. *Energy Research Letters*, *1*(3), 1–4. https://doi.org/10.46557/001c.13622

Bayraktaroglu, A. E., Calisir, F., & Baskak, M. (2019). Intellectual capital and firm performance: An extended VAIC model. *Journal of Intellectual Capital*, *20*(3), 406–425. https://doi.org/10.1108/JIC-12-2017-0184

Brooking, A. (1996). *Intellectual capital: Core asset for the new millennium enterprise*. International Thomson Business Press.

Cagáňová, D., Hlásniková, P. R., Vraňaková, N., & Chlpeková, A. (2019). Intellectual capital as a key factor in the automotive industry. *Mobile Networks & Applications*, *24*(6), 2024–2031. https://doi.org/10.1007/s11036-018-01206-2

Cheikh, I. B., & Noubbigh, H. (2019). The effect of intellectual capital drivers on performance and value creation: The case of Tunisian non-financial listed companies. *Journal of the Knowledge Economy*, *10*(1), 147–167. https://doi.org/10.1007/s13132-016-0442-0

Chen, M. C., Cheng, S. J., & Hwang, Y. (2005). An empirical investigation of the relationship between intellectual capital and firms' market value and financial performance. *Journal of Intellectual Capital*, *6*(2), 159–176. https://doi.org/10.1108/14691930510592771

China Association of Automobile Manufacturers. (2020). *Sales of automobiles in March 2020*. Retrieved May 7, 2020, from http://www.caam.org.cn/chn/21/cate_463/con_5229825.html

Cioca, L.-I., Ivascu, L., Turi, A., Artene, A., & Găman, G. A. (2019). Sustainable development model for the automotive industry. *Sustainability*, *11*(22), 6447. https://doi.org/10.3390/su11226447

Costa, V., Silva, L., & Paula, L. (2020). Intellectual capital and its impact on business performance: An empirical study of Portuguese hospitality and tourism sectors. *Intangible Capital*, *16*(2), 78–89. https://doi.org/10.3926/ic.1550

Dabić, M., Lažnjak, J., Smallbone, D., & Švarc, J. (2019). Intellectual capital, organisational climate, innovation culture, and SME performance: Evidence from Croatia. *Journal of Small Business and Enterprise Development*, *26*(4), 522–544. https://doi.org/10.1108/JSBED-04-2018-0117

Dadashinasab, M., Sofian, S., Asgari, M., & Abbasi, M. (2012). The effect of intellectual capital on performance: A study among Iranian automotive industry. *Journal of Basic and Applied Scientific Research*, *2*(11), 11353–11360.

Dai, L. X., & Wei, S. X. (2010). Financial competitiveness evaluation of Chinese listed companies of electrical equipment section: Based on AHP. In *2010 International Conference on Logistics Engineering and Intelligent Transportation Systems*. IEEE. https://doi.org/10.1109/LEITS.2010.5664985

Dobson, A. J., & Barnett, A. G. (2008). *An introduction to generalized linear models*. CRC Press. https://doi.org/10.1201/9780367807849

Dženopoljac, V., Janoševic, S., & Bontis, N. (2016). Intellectual capital and financial performance in the Serbian ICT industry. *Journal of Intellectual Capital*, *17*(2), 373–396. https://doi.org/10.1108/JIC-07-2015-0068

Edvinsson, L., & Malone, M. S. (1997). *Intellectual capital: Realizing your company's true value by finding its hidden brainpower*. Harper Business.

Ge, F. L., & Xu, J. (2021). Does intellectual capital investment enhance firm performance? Evidence from pharmaceutical sector in China. *Technology Analysis & Strategic Management*, *33*(9), 1006–1021. https://doi.org/10.1080/09537325.2020.1862414

Ginesti, G., Caldarelli, A., & Zampella, A. (2018). Exploring the impact of intellectual capital on company reputation and performance. *Journal of Intellectual Capital*, *19*(5), 915–934. https://doi.org/10.1108/JIC-01-2018-0012

Gross-Gołacka, E., Kusterka-Jefmańska, M., & Jefmański, B. (2020). Can elements of intellectual capital improve business sustainability? – The perspective of managers of SMEs in Poland. *Sustainability*, *12*(4), 1545. https://doi.org/10.3390/su12041545

Haris, M., Yao, H. X., Tariq, G., Malik, A., & Javaid, H. M. (2019). Intellectual capital performance and profitability of banks: Evidence from Pakistan. *Journal of Risk and Financial Management*, *12*(2), 56. https://doi.org/10.3390/jrfm12020056

He, Y., Dong, J., & Bai, R. H. (2011). The evaluation model of financial competitiveness in telecom enterprises. In Q. Zhou (Ed.), *Communications in computer and information science: Vol. 209. Ad-*

vances in applied economics, business and development (pp. 24–32). https://doi.org/10.1007/978-3-642-23020-2_4

Hermawan, S., Hariyanto, W., & Biduri, S. (2020). Intellectual capital, business performance, and competitive advantage: An empirical study for the pharmaceutical companies. *Quality – Access to Success*, *21*(175), 103–106.

Horak, S., & Taube, M. (2016). Same but different? Similarities and fundamental differences of informal social networks in China (*guanxi*) and Korea (*yongo*). *Asia Pacific Journal of Management*, *33*(3), 595–616. https://doi.org/10.1007/s10490-015-9452-x

Janoševic, S., & Dženopoljać, V. (2012). Impact of intellectual capital on financial performance of Serbian companies. *Actual Problems of Economics*, *133*, 554–564.

Jelínková, E., & Jiřincová, M. (2015). Diversity Management as a tool of managing Intellectual Capital. *Journal of Competitiveness*, *7*(4), 3–17. https://doi.org/10.7441/joc.2015.04.01

Jordão, R. V. D., & de Almeida, V. R. (2017). Performance measurement, intellectual capital and financial sustainability. *Journal of Intellectual Capital*, *18*(3), 643–666. https://doi.org/10.1108/JIC-11-2016-0115

Kalantar, F. (2013). Evaluating the efficiency of intellectual capital through data envelopment analysis approach (Case study: Automotive industry and component manufacturers). *European Online Journal of Natural and Social Sciences*, *2*(3(s)), 1397–1406.

Kamukama, N., & Sulait, T. (2017). Intellectual capital and competitive advantage in Uganda's microfinance industry. *African Journal of Economic and Management Studies*, *8*(4), 498–514. https://doi.org/10.1108/AJEMS-02-2017-0021

Kirikkaleli, D., & Ozun, A. (2019). Innovation capacity, business sophistication and macroeconomic stability: Empirical evidence from OECD countries. *Journal of Business Economics and Management*, *20*(2), 351–367. https://doi.org/10.3846/jbem.2019.9602

Koç, H. (2017). Differentiation of leadership manager behavior between industries in terms of intellectual capital (tourism and automotive sector example). *Journal of Tourism and Gastronomy Studies*, *5*(1), 147–159. https://doi.org/10.21325/jotags.2017.65

Kompalla, A., Kopia, J., & Tigu, G. (2016). *Analysis of correlation between intellectual capital and traditional key performance indicators within the automotive industry*. Retrieved January 20, 2021, from https://www.researchgate.net/publication/303893766_Analysis_of_correlation_between_intellectual_capital_and_traditional_key_performance_indicators_within_the_automotive_industry_Literature_review

Kweh, Q. L., Ting, I. W. K., Lu, W.-M., & Le, H. T. M. (2021). Nonlinearity in the relationship between intellectual capital and corporate performance: Evidence from Vietnamese listed companies. *Journal of Intellectual Capital*. https://doi.org/10.1108/JIC-03-2020-0105

Lee, C. S., & Wong, K. Y. (2019). Advances in intellectual capital performance measurement: A state-of-the-art review. *The Bottom Line*, *32*(2), 118–134. https://doi.org/10.1108/BL-12-2018-0051

Lin, D. C., Wen, S., Miao, X., & Ying, C. (2019). Evaluation of financial competitiveness of the listed insurance companies. In *Proceedings of the 2019 4th International Conference on Financial Innovation and Economic Development (ICFIED 2019).* Atlantis Press. https://doi.org/10.2991/icfied-19.2019.5

Liu, F., Dutta, D. K., & Park, K. (2021a). From external knowledge to competitive advantage: Absorptive capacity, firm performance, and the mediating role of labour productivity. *Technology Analysis & Strategic Management*, *33*(1), 18–30. https://doi.org/10.1080/09537325.2020.1787373

Liu, S., Yu, Q., Zhang, L., Xu, J., & Jin, Z. J. (2021b). Does intellectual capital investment improve financial competitiveness and green innovation performance? Evidence from renewable energy companies in China. *Mathematical Problems in Engineering*, *2021*, 9929202. https://doi.org/10.1155/2021/9929202

Liu, Z. T., & Lin, L. P. (2011). *Comparative studies on financial competitiveness in fertilizer manufacturing listed companies of China*. In *2011 International Conference on Management and Service Science* (pp. 1–3). IEEE. https://doi.org/10.1109/ICMSS.2011.5998442

Llopis-Albert, C., Rubio, F., & Valero, F. (2021). Impact of digital transformation on the automotive industry. *Technological Forecasting and Social Change*, *162*, 120343. https://doi.org/10.1016/j.techfore.2020.120343

López-Fernández, J., Somohano, F. M., & Garcia, F. J. M. (2014). *The Intellectual Capital and the relevance of non-financial information about innovation in the Spanish automotive sector from an accounting perspective: A proposal of an indicator*. https://doi.org/10.2139/ssrn.2864269

Lu, S. C., & Wang, M. X. (2019). Evaluation of financial competitiveness of listed companies in Hebei province. *Science & Technology for Development*, *15*(6), 598–606 (in Chinese).

Lu, Y. Z., Tian, Z. R., Buitrago, G. A., Gao, S. W., Zhao, Y. J., & Zhang, S. (2021). Intellectual capital and firm performance in the context of Venture-Capital Syndication background in China. *Complexity*, *2021*, 3425725. https://doi.org/10.1155/2021/3425725

Luo, X. T. (2017). A study on the financial competitiveness of listed companies – taking agricultural listed companies as an example. In *Proceedings of the 2017 International Conference on Education, Economics and Management Research (ICEEMR 2017)*. Atlantis Press. https://doi.org/10.2991/iceemr-17.2017.60

Lv, W. W., & Salam, Z. A. (2020). Evaluation and research on financial competitiveness of innovation-driven enterprises based on interval data mining. *International Journal of Pattern Recognition and Artificial Intelligence*, *34*(12), 2059040. https://doi.org/10.1142/S0218001420590405

Maditinos, D., Chatzoudes, D., Tsairidis, C., & Theriou, G. (2011). The impact of intellectual capital on firms' market value and financial performance. *Journal of Intellectual Capital*, *12*(1), 132–151. https://doi.org/10.1108/14691931111097944

Masoomzadeh, A., Zakaria, W. N. W., Masrom, M., & Khademi, T. (2020). Intellectual capital as key asset in Iranian automotive industry. *Journal of Environmental Treatment Techniques*, *8*(1), 429–439.

Masoomzadeh, A., Zakaria, W. N. W., Masrom, M., Streimikiene, D., & Tavakoli, R. (2019). Organizational innovation factors, capabilities and organizational performance in automotive industry. *Montenegrin Journal of Economics*, *14*(3), 83–100. https://doi.org/10.14254/1800-5845/2019.15-3.6

Morris, C. (2015). An industry analysis of the power of human capital for corporate performance: Evidence from South Africa. *South African Journal of Economic and Management Science*, *18*(4), 486–499. https://doi.org/10.4102/sajems.v18i4.1191

Myszewski, J. M. (2014). On development capability. *Research in Logistics & Production*, *4*(1), 55–66.

Nedelcu, A. C., Banacu, C. S., & Frasineanu, C. (2014). *The impact of intellectual capital on automotive firm's performance – Case study*. Retrieved January 21, 2021, from http://conferinta.management.ase.ro/archives/2014/pdf/69.pdf

Ni, Y. S., Cheng, Y.-R., & Huang, P. Y. (2021). Do intellectual capitals matter to firm value enhancement? Evidences from Taiwan. *Journal of Intellectual Capital*, *22*(4), 725–743. https://doi.org/10.1108/JIC-10-2019-0235

Nigam, N., Mbarek, S., & Boughanmi, A. (2021). Impact of intellectual capital on the financing of startups with new business models. *Journal of Knowledge Management*, *25*(1), 227–250. https://doi.org/10.1108/JKM-11-2019-0657

Nimtrakoon, S. (2015). The relationship between intellectual capital, firms' market value and financial performance: Empirical evidence from the ASEAN. *Journal of Intellectual Capital*, *16*(3), 587–618. https://doi.org/10.1108/JIC-09-2014-0104

Ousama, A. A., Hammami, H., & Abdulkarim, M. (2020). The association between intellectual capital and financial performance in the Islamic banking industry: An analysis of the GCC banks. *International Journal of Islamic and Middle Eastern Finance and Management*, *13*(1), 75–93. https://doi.org/10.1108/IMEFM-05-2016-0073

Ovechkin, D. V., Romashkina, G. F., & Davydenko, V. A. (2021). The impact of intellectual capital on the profitability of Russian agricultural firms. *Agronomy*, *11*(2), 286. https://doi.org/10.3390/agronomy11020286

Pulic, A. (2000). VAIC^{TM} – an accounting tool for IC management. *International Journal of Technology Management*, *20*(5–8), 702–714. https://doi.org/10.1504/IJTM.2000.002891

Rafiei, M., Feyzi, T., & Azimi, H. (2011). Intellectual capital and its effect on economic performance: A case study in Iranian automotive industry. *Journal of American Science*, *7*(6), 497–507.

Ran, F., & Zhang, X. L. (2011). Financial competitiveness evaluation on sporting goods listed enterprises: A China study. *African Journal of Business Management*, *5*(17), 7404–7409. https://doi.org/10.5897/AJBM11.137

Royston, P. (2013). Marginscontplot: Plotting the marginal effects of continuous predictors. *The Stata Journal*, *13*(3), 510–527. https://doi.org/10.1177/1536867X1301300305

Sardo, F., & Serrasqueiro, Z. (2018). Intellectual capital, growth opportunities, and financial performance in European firms: Dynamic panel data analysis. *Journal of Intellectual Capital*, *19*(4), 747–767. https://doi.org/10.1108/JIC-07-2017-0099

Sardo, F., & Serrasqueiro, Z. (2019). On the relationship between intellectual capital and service SME survival and growth: A dynamic panel data analysis. *International Journal of Learning and Intellectual Capital*, *16*(3), 213–238. https://doi.org/10.1504/IJLIC.2019.100537

Sardo, F., Serrasqueiro, Z., & Alves, H. (2018). On the relationship between intellectual capital and financial performance: A panel data analysis on SME hotels. *International Journal of Hospitality Management*, *75*, 67–74. https://doi.org/10.1016/j.ijhm.2018.03.001

Shvetsova, O. A., Tanubamrungsuk, P., & Lee, S. (2021). Organization leadership in the automobile industry: Knowledge management and intellectual capital. *The Open Transportation Journal*, *15*(1), 16–30. https://doi.org/10.2174/1874447802115010016

Smriti, N., & Das, N. (2018). The impact of intellectual capital on firm performance: A study of Indian firms listed in COSPI. *Journal of Intellectual Capital*, *19*(5), 935–964. https://doi.org/10.1108/JIC-11-2017-0156

Ståhle, P., Ståhle, S., & Aho, S. (2011). Value added intellectual coefficient (VAIC): A critical analysis. *Journal of Intellectual Capital*, *12*(4), 531–551. https://doi.org/10.1108/14691931111181715

Tálas, D., & Rózsa, A. (2015). Financial competitiveness analysis in the Hungarian dairy industry. *Competitiveness Review*, *25*(4), 426–447. https://doi.org/10.1108/CR-03-2015-0016

Teixeira, A. A. C., & Ferreira, C. (2019). Intellectual property rights and the competitiveness of academic spin-offs. *Journal of Innovation & Knowledge*, *4*(3), 154–161. https://doi.org/10.1016/j.jik.2018.12.002

Ting, I. W. K., Ren, C., Chen, F. C., & Kweh, Q. L. (2020). Interpreting the dynamic performance effect of intellectual capital through a value-added-based perspective. *Journal of Intellectual Capital*, *21*(3), 381–401. https://doi.org/10.1108/JIC-05-2019-0098

Ulubeyli, S., & Yorulmaz, D. (2020). Intellectual capital based reputation for market internationalization: The case of engineering consultancy firms. *Journal of Intellectual Capital*, *21*(1), 40–61. https://doi.org/10.1108/JIC-01-2019-0010

Urban, B., & Joubert, G. C. D. S. (2017). Multidimensional and comparative study on intellectual capital and organisational performance. *Journal of Business Economics and Management*, *18*(1), 84–99. https://doi.org/10.3846/16111699.2016.1255990

Vijayakumar, A. (2018). Financial competitiveness of firms: A study of the Indian automobile industry. *SMART Journal of Business Management Studies*, *14*(1), 91–103. https://doi.org/10.5958/2321-2012.2018.00010.6

Vishnu, S., & Gupta, V. K. (2014). Intellectual capital and performance of pharmaceutical firms in India. *Journal of Intellectual Capital*, *15*(1), 83–99. https://doi.org/10.1108/JIC-04-2013-0049

Vogt, W. P., & Johnson, B. (2011). *Dictionary of statistics & methodology: A nontechnical guide for the social sciences*. Sage Publications.

Volkova, N., & Shagun, V. (2017). *Modern trends of development of the world economy and financial competitiveness of enterprises*. Retrieved April 14, 2020, from https://www.shs-conferences.org/articles/shsconf/pdf/2017/07/shsconf_ies2017_01031.pdf

Weqar, F., Khan, A. M., & Haque, S. M. I. (2020). Exploring the effect of intellectual capital on financial performance: A study of Indian banks. *Measuring Business Excellence*, *24*(4), 511–529. https://doi.org/10.1108/MBE-12-2019-0118

Xie, D., & Wang, J. T. (2014). Research on financial competitiveness evaluation of listed company – Take pharmaceutical and biological products industry listed companies for example. *Chinese Agricultural Science Bulletin*, *30*(26), 70–76 (in Chinese).

Xu, J., Haris, M., & Yao, H. X. (2019). Should listed banks be concerned with intellectual capital in emerging Asian markets? A comparison between China and Pakistan. *Sustainability*, *11*(23), 6582. https://doi.org/10.3390/su11236582

Xu, J., & Li, J. S. (2019). The impact of intellectual capital on SMEs' performance in China: Empirical evidence from non-high-tech vs. high-tech SMEs. *Journal of Intellectual Capital*, *20*(4), 488–509. https://doi.org/10.1108/JIC-04-2018-0074

Xu, J., & Li, J. S. (2022). The interrelationship between intellectual capital and firm performance: Evidence from China's manufacturing sector. *Journal of Intellectual Capital*. https://doi.org/10.1108/JIC-08-2019-0189

Xu, J., & Liu, F. (2020). The impact of intellectual capital on firm performance: A modified and extended VAIC model. *Journal of Competitiveness*, *12*(1), 161–176. https://doi.org/10.7441/joc.2010.01.10

Xu, J., & Liu, F. (2021). Nexus between intellectual capital and financial performance: An investigation of Chinese manufacturing industry. *Journal of Business Economics and Management*, *22*(1), 217–235. https://doi.org/10.3846/jbem.2020.13888

Xu, J., & Wang, B. H. (2018). Intellectual capital, financial performance and companies' sustainable growth: Evidence from the Korean manufacturing industry. *Sustainability*, *10*(12), 4651. https://doi.org/10.3390/su10124651

Xu, J., & Wang, B. H. (2019). Intellectual capital and financial performance of Chinese agricultural listed companies. *Custos e Agronegocio On Line*, *15*(1), 273–290.

Xu, J., & Zhang, Y. (2021). Exploring the nonlinear effect of intellectual capital on financial performance: Evidence from listed shipping companies in China. *Complexity*, *2021*, 9004907. https://doi.org/10.1155/2021/9004907

Xu, X. L., Chen, H. H. & Zhang, R. R. (2020). The impact of intellectual capital efficiency on corporate sustainable growth-Evidence from from smart agriculture in China. *Agriculture*, *10*(6), 199. https://doi.org/10.3390/agriculture10060199

Yang, J. L., & Sun, T. T. (2017). An empirical study on the financial competitiveness of A-share listed companies in Shanghai stock market under the reform of supply side. In *Proceedings of the Second International Conference on Economic and Business Management (FEBM 2017)* (pp. 443–448). Atlantis Press. https://doi.org/10.2991/febm-17.2017.58

Yao, H. X., Haris, M., Tariq, G., Javaid, H. M., & Khan, M. A. S. (2019). Intellectual capital, profitability, and productivity: Evidence from Pakistani financial institutions. *Sustainability*, *11*(14), 3842. https://doi.org/10.3390/su11143842

Yaseen, S. G., Dajani, D., & Hasan, Y. (2016). The impact of intellectual capital on the competitive advantage: Applied study in Jordanian telecommunication companies. *Computers in Human Behavior*, *62*, 168–175. https://doi.org/10.1016/j.chb.2016.03.075

Yu, H. C., Wang, W. Y., & Chang, C. (2015). The stock market valuation of intellectual capital in the IT industry. *Review of Quantitative Finance and Accounting*, *45*(2), 279–304. https://doi.org/10.1007/s11156-014-0437-5

Zardini, A., Ricciardi, F., & Rossignoli, C. (2015). The relational capital of the IT department: Measuring a key resource for creating strategic value. *Journal of Intellectual Capital*, *16*(4), 835–859. https://doi.org/10.1108/JIC-12-2014-0132

Zhang, L., Yu, Q., Jin, Z. J., & Xu, J. (2021). Do intellectual capital elements spur firm performance? Evidence from the textile and apparel industry in China. *Mathematical Problems in Engineering*, *2021*, 7332885. https://doi.org/10.1155/2021/7332885

Zhang, X. Y. (2019). Evaluation of the operating ability of China's big data industry – From the perspective of level differences of industry chain. *Journal of Tianjin University of Commerce*, *39*(4), 67–72.

Zhu, Y. M., Hipel, K. W., Ke, G. Y., & Chen, Y. (2015). Establishment and optimization of an evaluation index system for brownfield redevelopment projects: An empirical study. *Environmental Modelling & Software*, *74*, 173–182. https://doi.org/10.1016/j.envsoft.2015.09.012

Zhu, Z. H., Zhu, Z. W., Xu, P., & Xue, D. W. (2019). Exploring the impact of government subsidy and R&D investment on financial competitiveness of China's new energy listed companies: An empirical study. *Energy Reports*, *5*, 919–925. https://doi.org/10.1016/j.egyr.2019.07.013