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Equity Undervaluation and Intellectual Capital Efficiency: Evidence from an Emerging Market

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Abstract: This paper examines whether equity undervaluation influences the intellectual capital efficiency (ICE) using empirical data collected from Chinese setting. Applying signalling theory as the underlying framework, this study assumes that when firms are undervalued, they are more likely to increase their intellectual capital efficiency (ICE) to signal their superior private information to the market. The sample used in this paper is Chinese listed firms from 2014 to 2021. The findings indicate that equity undervaluation is positively and significantly associated with ICE. This paper also examines the influence of equity undervaluation on four elements of ICE. Among these four elements, undervalued firms increase human capital efficiency the most. The results of this paper provide theoretical and managerial implications. From a theoretical point of view, the results provide more clarity on the effects that the equity undervaluation has on ICE in the context of China. From a managerial point of view, the results are useful for owners and managers of Chinese listed firms where the vision of the components of the analyzed intellectual capital highlights the importance for management to assign attention to the management of intellectual capital since it is clear the effect it has on firm performance.

1. Introduction

Intellectual capital represents a valuable and non-replaceable resource that enhances firm performance and stock price. In the digital economy, only firms that account for their intellectual capital can positively influence investment decisions and the value of firms[1-4]. Firms that do not disclose intellectual capital generate information asymmetries and a lack of transparency, so this deficiency in intellectual capital reporting means that financial reporting partially loses its relevance[5,6]. Therefore, reporting intellectual capital will enhance the relevance of accounting numbers for investors.

Equity undervaluation occurs when managers' assessments of a firm's economic value exceed the market value: i.e., they believe the firm's intrinsic value is greater than the market value. The market does not react to firms' economic value efficiently. If managers believe that a firm is undervalued relative to their superior private information, they may attempt to disclose this potentially value-increasing information[7].

Based on signalling theory, this paper assumes that when firms are undervalued, they are more

likely to increase their intellectual capital efficiency (ICE) to signal their superior private information to the market. Therefore, this paper examines whether equity undervaluation incentivises firms to increase their ICE to increase the value of their equity. The sample used for this study is based on Chinese listed firms' data from 2014 to 2021. The year 2014 was selected as China entered the digital economy in 2012, and hence two years was allowed for firms to adapt to the new economy. The results find evidence that, on average, there is a significant positive relationship between equity undervaluation and subsequent ICE, suggesting that equity undervalued firms are more likely to increase ICE in the subsequent year. These results were confirmed in additional tests. Comparing the four elements of ICE (i.e., human capital efficiency [HCE], capital employed efficiency [CEE], structural capital efficiency [SCE], relational capital efficiency [RCE]), equity undervalued firms were found to increase HCE the most, as this showed the highest Pearson coefficient and the largest adjusted R square value, suggesting that the HCE model has a greater explanatory power than other three ICE elements models. The coefficient of equity undervaluation on SCE is similar to the coefficient on CEE, suggesting equity undervalued firms increase their SCE and CEE to similar degrees.

This paper makes several contributions to the extant literature: first, to the best of the researcher's knowledge, there are no empirical studies investigating the relationship between equity undervaluation and ICE. Thus, this study adds to the literature by examining the influence of equity undervaluation on ICE. Second, much of the extant intellectual capital literature has focused on studying listed companies in developed economies, such as the United States [8], Singapore [9], Britain[6] and Australia [10]. Recently, intellectual capital research in developing countries has received increasing interest. However, limited studies have documented the empirical analysis of intellectual capital in China. This study aims to fill this research gap.

The remainder of this paper is organised as follows. Section 2 provides a literature review. Section 3 explains the theoretical framework and hypotheses development. Section 4 describes the research design of this paper. Section 5 presents the descriptive statistics, pearson correlations, regressions results, and additional tests. Section 6 provides the implications of this study. Section 7 presents the conclusion.

2. Literature Review

2.1 Intellectual Capital and Economic Values

From the perspective of market valuation, many studies found that investors perceive intellectual capital as value-relevant with regards to decision-making, and they generally react favourably to such reporting, so a firm's stock price or market value would be enhanced in this sense.

The most widely used tool to measure the market valuation of intellectual capital is market-to-book ratios. Studies have confirmed that intellectual capital has positive effects on the market-to-book ratios in Taiwan China[11,12], Greece[13], Hong Kong China[14,15] and Thailand[16], which suggests that intellectual capital is value-relevant for market valuation because it increases the market value of a firm. Notwithstanding those results, some scholars have criticised the market to book ratio as a market valuation measurement.

Several studies examined the relationship between intellectual capital and stock prices or stock returns to measure its value-relevance; for example, [9] found a positive relationship between intellectual capital and stock returns in 150 Singapore listed firms, while Vafaei[6] investigated whether the extent of textual intellectual capital information in annual reports and its components (human, structural, relational and general) is value-relevant to the share market, and whether intellectual capital disclosure moderates the incremental value-relevance of reported International Financial Reporting Standards (IFRS) adjustments to earnings and equity, based analysing the

contents of the text in annual reports using a sample of listed firms in Australia (63 firms), Britain (58 firms), Singapore (50 firms) and Hong Kong China (49 firms). Intellectual capital was measured using the scorecard measurement. The study found that intellectual capital disclosure was positively related to the market price of firms in non-traditional industries in two (Britain and Hong Kong China) of the four countries. Furthermore, the incremental value relevance of IFRS earnings and IFRS net assets was insignificant, but the interaction of IFRS earnings with intellectual capital disclosure increased the basic coefficients and explanatory power of the models quite considerably, which suggested that intellectual capital moderated the value-relevance of reported IFRS earnings numbers. Abdolmohammadi[8] examined the effects of intellectual capital disclosure on the market capitalisation of firms by analysing the contents of annual reports of a sample of 500 firms in the USA; market capitalisation was measured using a logarithm of market capitalisation, and intellectual capital was measured using a scorecard measurement. The results indicated a positive relationship between the market value of equity of firms and intellectual capital disclosure.

On the other hand, a few studies found that the market cannot incorporate IC and immediately absorb all the intellectual capital information. Ferraro and Veltri[17] applied a simplified Ohlson model[18] to examine the value relevance of intellectual capital to 524 firm-year observations of Italian firms for the period of 2006 to 2008. The findings showed that the book value of equity and earnings was positively related to the stock price despite intellectual capital not having a meaningful relationship to the market value. These results suggest that Italian investors are perhaps unable to detect and incorporate information on intellectual capital to evaluate their business investments. Abeysekera[19] examined whether current-period intellectual capital disclosure can carry future earnings towards current annual stock returns during a civil war period using the top 30 Sri Lankan listed firms over six years (from 1998 to 2003). The study found that an increase in the current period of intellectual capital disclosure did not influence earnings or future earnings included in the current stock returns during the civil war period. Gamerschlag[20] investigated the value relevance of human capital information where information was provided voluntarily by German firms using two established valuation models. The results indicated that human capital was significantly and positively related to the current stock price, suggesting that information regarding human capital is value-relevant to the market. Nonetheless, this information regarding human capital did not lead to short term changes in market value because the index containing these changes in human capital did not lead to changes in current stock returns. As a result, the author concluded that human capital information is value-relevant, but not immediately.

The literature reveals that whether or not intellectual capital enhances financial performance, and whether it is value-relevant for investors in decision making depends on the methodology that the study used, and the countries and research periods that were examined.

China provides an ideal context for intellectual capital reporting because the economy has entered a new phase that is different from the high-speed growth pattern exhibited in the past. China has invested more in intangible resources in recent years, especially intellectual capital resources[21]. The Chinese Government's Go Global policy encourages high-tech exports that prompt Chinese firms to learn to innovate. Moreover, the Open Door Policy has attracted trillions of inward foreign direct investments from developed countries that have significantly contributed to the country's ability to produce cutting-edge technologies[22]. China's rapid economic growth and transformation, with an increasing emphasis on intellectual capital and innovation, means the country is an ideal context for intellectual capital examination[23]. To the extent, two researches have examined the relationship between IC and firm performance in China. Xu and Li[24] examined the relationship between the intellectual capital and firm performance by comparing the high-tech and non-high-tech firms using the data of Chinese small- and medium-sized enterprises (SMEs) from 2012 to 2016. The results indicate a positive relationship between intellectual capital and the financial

performance of high-tech and non-high-tech SMEs. Specifically, intellectual capital is positively associated with firms' earnings, profitability and operating efficiency. Xu and Li[25] examined the impact of intellectual capital and its components on the performance of listed manufacturing companies in China for 2012–2016. The results suggest that intellectual capital can enhance firm performance in China's manufacturing sector in general. Looking at the intellectual capital elements, physical capital is the most influential contributor to firm performance. The research on intellectual capital is still in its infant stage in China, it is worth to examine.

2.2 Equity Undervaluation

Most extant literature on equity undervaluation has investigated the relationship between undervaluation and share repurchase. For example, D'Mello and Shroff[7] examined whether managers repurchase stock when the equity is undervalued. The authors estimated economic value using an earnings-based valuation model. They found that 74% of firms that repurchase shares via fixed-price tender offers are undervalued relative to their preannouncement economic value, and the tender premium is highly correlated with the magnitude of undervaluation[7]. Kurt[26] investigated whether accelerated share repurchases are driven by managerial opportunism (i.e., managing earnings per share) or managerial optimism (i.e., signalling undervaluation) and whether stock market participants see through these motives. The paper finds that signalling undervaluation is a motivation for repurchases. Hung and Chen[27] analysed share repurchase programs, which are subject to specific legal restrictions in Taiwan China, to determine whether the unique item repurchase price range conveys information regarding the degree of undervaluation and future prospects of a firm. The authors found that the price range conveys such information, not only about the past, but also the future. Companies with a higher upper bound of the repurchase price range experience better abnormal returns than companies that do not. The lower bound of the price range does not efficiently convey the undervaluation effect owing to the exemption clause in the announcement. Finally, the announced price range, in turn, conveys favourable information about the repurchasing firm and is a more powerful signal of future prospects than is the legal price range. Rath and Rashid[28] analysed the importance of undervaluation, vis-à-vis information asymmetry, as a determining factor in 'going private' transactions in Australia. The empirical results show that market undervaluation is a dominant factor in private equity takeovers.

To summarise, the previous literature found that when firm equity is undervalued, firms may buy back the shares to signal the future prospects of the firms. Based on this reasoning, this paper assume that intellectual capital could serve a good signal to signal the future prospects of the firm when their equity is undervalued, to influence investors' perceptions of firms future performance and increase the stock price. The details of our hypothesis development are given below.

3. Hypothesis Development

According to signalling theory, signalling makes investors and other stakeholders reassess the value of a firm before making decisions[29]. Firms have several ways of signalling information about themselves, of which voluntary disclosure of positive accounting information is considered one of the most effective[30]. Studies found that increased voluntary disclosure leads to an increase in stock price. This means that due to the significance of intellectual capital for future wealth creation and forward-looking benefits, the usage of intellectual capital efficiently could be a very effective means for firms to signal their superior quality[29,31]. Efficiently use of intellectual capital could distinguish firms with a strong intellectual capital base from low-quality firms[32]. This could mean that a firm's share price would rise with efficiently usage of intellectual capital, which in turn means that failure to apply the ICE could weaken a firm's financial position and reduce its competitiveness.

This paper argues on the basis of signalling theory, which assumes that a firm is likely to use multiple signals to entice its investors to view the firm favourably. Intellectual capital is a very effective signal to the market of firm quality because it is rarely imitable and replaceable. The signalling process makes investors reassess firm value, so ICE, an inimitable resource that signals future growth, enhances the stock price because investors place more value on firms that use their intellectual capital more efficiently[33,34]]. Intellectual capital underlines the importance of using the capital generated by human beings and resources to generate products and services in a competitive manner, and this is reflected in strong firm performance and the creation of value[16,35,36]. If intellectual capital is employed efficiently, resources are efficiently utilised to generate products and services in a competitive manner and to generate future economic benefits. When equity is undervalued, if firms believe that their intellectual capital gives a potential growth and competitive advantage, they prefer to signal their firm's prospects, which can be reflected in intellectual capital, and increase their ICE subsequently to influence market perceptions of firm performance. Therefore, this paper develops the following hypotheses:

H1: Equity undervaluation is positively and significantly related to subsequent ICE.

H2: Equity undervaluation is positively and significantly related to the four ICE elements (i.e., HCE, CEE, SCE and RCE).

4. Methodology

4.1 Data and Sample Selection

This study used Chinese firms listed on the Shenzhen stock exchanges for the period 2014–2021 as the sample. The financial data were collected from the China Stock Market and Accounting Research (CSMAR) Database. Firms involved in the financial sectors and firms with Special Treatment (ST) were excluded because they are subject to different reporting requirements. The top and bottom 1% of the sample were trimmed and firms with missing data for the variables of interest and control variables were excluded. Firms issues other kinds of shares, like B, H, S, ADR, etc., are excluded from the original sample. Because market value measurement for those firms is different from firms with only A-shares. The final sample consisted of 13050 firm-year observations.

4.2 Measurement of ICE

The widely used approach to measure ICE was the VAIC^{TM} which was developed by the Austrian Intellectual Capital Research Centre under Pulic[37] . An important concept in the VAIC^{TM} methodology is a firm's intellectual ability which is measured by its value added intellectual coefficient. This value added intellectual coefficient refers to the total value creation efficiency because both physical capital and intellectual capital function in concert in a business environment[38]. Furthermore, VAIC^{TM} is an indicator of the overall ability or efficiency of a firm to use the total resources of physical capital and intellectual capital to create value for a particular firm[14]. A higher VAIC^{TM} coefficient shows that more value is created with the same amount of resources[38]. The VAIC^{TM} model uses values from balance sheets and income statements to measure any occurrences of adding value that either stems from or can be attributed to the development of firm's intellectual capital. For example, labour expenses are argued to equate human capital as an investment rather than an expense. VAIC^{TM} measures how efficiently and how much intellectual capital and capital are used to create the value of a firm based on three major components: (1) capital employed; (2) human capital; and (3) structural capital.

VAIC^{TM} has been used by many researchers to investigate different aspects of ICE. For examples, studies have been found in Taiwan China[11]; Hong Kong China[14,15]; Singapore[9];

Thailand[16]; India[39,40]; South Africa[33]; Australia[4,10].

However, the VAIC^{TM} model has several limitations that are criticised by some scholars. Ståhle [41] asserted that VAIC^{TM} model designates the efficiency of the firm's labor and capital investment rather than intellectual capital by describing VAIC^{TM} model via its calculation and discussing its theoretical "misperceptions." The model cannot take into account the synergy effects that exist between different forms of tangible and intangible assets[42]. The VAIC^{TM} measurement produces inconsistent results and raises questions on its effectiveness[13]. It also does not take into account the existence of relational capital and innovation capital. Finally, the model assumes zero beginning and ending inventory. Concerning the limitations of the VAIC^{TM} model, this study following[25], use modified the VAIC^{TM} model by adding relational capital efficiency as part of ICE.

The calculation of the Modified VAIC^{TM} model is as below:

The first step is to calculate the ability of a firm to create value added (VA) to all stakeholders. Following previous studies [9-11], [25]. VA can be expressed as follows:

$$VA=S-B \quad (1)$$

where: S is net sales revenues (output); B is cost of goods sold (input)

4.2.1 Human capital efficiency (HCE)

Human capital (HC) includes the knowledge, experiences, skills, productivity, and employees competence[9,10,11,25]. HCE is calculated as:

$$HCE = VA/HC \quad (2)$$

HC is defined as salaries and wages at a point in time[9,10,11,25]. HCE indicates the amount of VA generated by a dollar spent on HC.

4.2.2 Structural capital efficiency (SCE)

Structural capital (SC) includes IC items such as strategy, organisational networks, patents, and brand names. Following the previous studies[9-11], [25]. this paper calculates SCE as follows:

$$SCE = SC/VA \quad (3)$$

SC is measured as VA minus HC. SCE, therefore, demonstrates the dollar of SC within the firm, for every dollar of value that is added, and as HCE increases, SCE increases.

4.2.3 Capital employed efficiency (CEE)

Capital employed efficiency (CEE) includes the efficiency that HCE and SCE fail to capture. Pulic[37] argues that IC cannot create value on its own, and so must be combined with (physical and financial) capital employed (CE). Following the previous studies[9-11],[25].this paper calculates CEE as follows:

$$CEE = VA/CE \quad (4)$$

CE is calculated as total assets minus intangible assets and CEE demonstrates the amount of VA created by a dollar spent on CE.

4.2.4 Relational capital efficiency (RCE)

Modified VAIC^{TM} model including relational capital as the new intellectual capital element was

developed by Vishnu and Gupta[43]. Marketing, selling and advertising expenses were introduced as the proxy for relational capital. Relational capital efficiency (RCE) was measured as the ratio of marketing, selling and advertising expenses to VA. In addition, Nimtrakoon[44], Xu and Li[24], Yao[45], and Xu and Li[25] also confirmed that the modified VAICTM model with the introduction of relational capital is more accurate than the original VAICTM model to measure IC. Thus, following previous studies[24-25], [44-45], this study measures the RCE as below:

$$RCE=RC/VA \tag{5}$$

RC the relational capital, measured by marketing, selling and advertising expenses. RCE represents the relational efficiency.

4.2.5 ICE Modified VAIC^{TM}

ICE is measured by modified VAIC^{TM} which includes the four individual efficiencies and is the aggregation of the four efficiencies:

$$ICE = HCE+ CEE + SCE+RCE \tag{6}$$

A greater ICE represents greater efficiency in intellectual capitals employed, and thus greater value generated to the firm.

4.2.6 Measurements of equity undervaluation

The proxy for equity valuation used in this paper is based a powerful representation and more precise measurement of equity valuation[46]. Jensen[47] states that a firm is overvalued when 'a firm's stock price is greater than its underlying value,' i.e., it occurs when the ratio of stock price to underlying value exceeds 1. While, a firm is undervalued when 'a firm's stock price is less than its underlying value,' i.e., it occurs when the ratio of stock price to underlying value is less 1. Following Badertscher[48], this paper uses residual income approach model to get an equity valuation measure.

The residual income approach model can be empirically estimated as follows:

$$V_{j,t} = B_{j,t} + \frac{(ROE_{j,t+1}-r_{PEG})}{(1+r_{PEG})} B_{j,t} + \frac{(ROE_{j,t+2}-r_{PEG})}{(1+r_{PEG})^2} B_{j,t+1} + \frac{(ROE_{j,t+3}-r_{PEG})}{(1+r_{PEG})^2 r_{PEG}} B_{j,t+2} \tag{7}$$

Where: $V_{j,t}$ represents a j firm's intrinsic value in year t. $B_{j,t}$ is the book value and ROE is the return on equity. Since the year-end book value depends on current-year return on equity (ROE), this paper uses a sequential process to estimate future ROEs. The cost of equity (r_{PEG}) is measured by the PEG ratio method. This paper uses the implied cost of equity model to measure the cost of equity for listed firms where the implied cost of equity is a discount rate that equates current share prices to expected future payoffs. Many models were designed to measure the implied cost of equity stem from the dividend discount model. There are many studies that apply empirical methods to calculate the implied cost of equity[49-52]. Although different models use various approaches and assumptions for valuation, they are all based on estimating the current share prices and future earnings. Of the various models, Easton's[50] model is considered to be superior to the others because the evaluation of expected return is more predictably and consistently associated with risk proxies such as size, beta, residual risk, leverage and growth[49,53]. Therefore, Easton's[50] model was used in this paper, and is represented in equation (8). PEG is the price-earnings-growth ratio (PEG ratio), which is calculated by equation (9):

$$\text{Cost of Equity} = \sqrt{\frac{1}{PEG\times 100}} \tag{8},$$

where PEG = (P/E Ratio)/(Annual EPS Growth) (9)

The equity valuation is measured by P/V (price-to-value) ratios, which is calculated by dividing the stock price (P) by a firm's intrinsic value (V). The P/V ratio is a good predictor of cross-sectional returns because P/V predicts cross-sectional returns and the book-to-market ratio[48]. Firms with P/V ratios less than 1 are identified as undervalued firms ($UNDER_{j,t}$) which is coded 1, and 0 otherwise. j is firm-year observation, t is time period from 2014 to 2018. Year 2018 was chosen as the end year since the residual income approach was used to calculate equity undervaluation three years from the base year, and updated data was available when the research was undertaken is 2021.

4.3 Empirical Model to test the Hypotheses

The models for testing hypothesis was designed as follows:

$$ICE_{j,t+1}=a_0+b_1UNDER_{j,t}+c_1Leverage_{j,t}+c_2Size_{j,t}+c_3IND_{j,t}+c_4\text{Year effects }+c_5\text{Industry effects }+e_{j,t} \quad (10)$$

where $ICE_{j,t+1}$ represents intellectual capital efficiency for firm j, year t+1. It is measured by the sum of HCE, SCE, CEE, and RCE. $UNDER_{j,t}$ represents firms equity undervaluation which is coded 1 if P/V is less than 1 for firm j, in year t, and 0 otherwise. j represents firm-year observations. t is years from 2014 to 2018.

Researchers have argued that lenders represent influential shareholders with increasing debt-to-equity ratios to monitor intellectual capital investments[19,33], which means that firms may be forced to use their intellectual capital more actively. Consistent with prior research, this study includes the leverage ratio ($Leverage_{j,t}$) as a control variable measured by short-term and long-term debt divided by total assets for firm j, in year t. Studies have found that firm size may positively influence intellectual capital value due to advantageous access to resources and market power[54-57] found that on average, large firms have a higher level of disclosure than small companies, so firm size ($Size_{j,t}$) is included as a control variable measured by the natural logarithm of total assets for firm j, at the beginning of year t. Previous studies have provided evidence that corporate governance and intellectual capital are related and that corporate governance is a major factor influencing ICE in a firm[57-59,61]. The percentage of independent directors on the board of directors was used to capture the mechanisms of corporate governance. Thus, this study includes the percentage of independent directors ($IND_{j,t}$) for firm j, in year t as proxies for corporate governance as control variables. This study also includes year and industry effects to control the unobservable confounding variables that differ from time to time, but are constant across industries, and the unobservable confounding variables that differ across industries, but are constant over time.

5. Data Analysis and Discussion

5.1 Descriptive Statistics

Table 1 presents the summary statistics of the variables for the hypotheses. Among the four ICE elements, HCE has the highest mean (2.636), indicating that human capital accounts for the major part of intellectual capital in China. The mean of CEE is the second highest, at 0.603. The mean of RCE is the lowest of the ICE elements (mean = 0.485). The sum of mean value of HCE, SCE and RCE (3.631) is much greater than the mean value of CEE (0.603), which indicates that firms can create more value by using intellectual capital rather than physical and financial capital. The average value of ICE is 4.234, suggesting that firms produce an average value of 4.234 for one monetary unit invested. In addition, the mean value of $Size_{j,t}$, $Leverage_{j,t}$, and $IND_{j,t}$ are 21.262, 0.419 and 0.375, respectively.

Table 1: Descriptive statistics of the variables for the hypotheses

Variable	Number of Obs.	Mean	Std. Dev.	Min	Max
$RCE_{j,t+1}$	13050	0.485	0.353	0.117	1.260
$HCE_{j,t+1}$	13050	2.636	1.391	0.974	5.358
$SCE_{j,t+1}$	13050	0.510	0.254	0.019	0.821
$CEE_{j,t+1}$	13050	0.603	0.539	0.092	1.767
$ICE_{j,t+1}$	13050	4.234	2.008	1.201	9.204
$UNDERPE_{j,t}$	13050	0.110	0.313	0.000	1.000
$UNDER_{j,t}$	13050	0.267	0.442	0.000	1.000
$Size_{j,t}$	13050	21.262	1.886	11.600	30.864
$Leverage_{j,t}$	13050	0.419	0.188	0.151	0.721
$IND_{j,t}$	13050	0.375	0.054	0.200	0.800

Note: $ICE_{j,t+1}$ represents intellectual capital efficiency for firm j, year t+1.

It is measured by the sum of HCE, SCE, CEE, and RCE. $UNDER_{j,t}$ represents firms equity undervaluation which is coded 1 if P/V is less than 1 for firm j, in year t, and 0 otherwise. $UNDERPE_{j,t}$ is another measurement of undervaluation which is coded as '1' if P/E ratio is less than 1, 0 otherwise. $Leverage_{j,t}$ is leverage ratio which is measured by short-term and long-term debt divided by total assets for firm j, in year t. $Size_{j,t}$ is firm size which is measured by the natural logarithm of total assets for firm j, at the beginning of year t. $IND_{j,t}$ is percentage of independent directors for firm j, in year t as proxies for corporate governance.

5.2 Correlation Analysis

Table 2 Panel A presents the results of Pearson correlations between ICE, its four elements, and relevant variables. The results show that HCE, SCE, CEE and RCE are significantly and positively correlated with each other. All four individual elements are highly correlated with total ICE. In addition, ICE and its four elements exhibit a significantly positive correlation with UNDER. Table 2 Panel B shows the factor analysis of the four individual elements. The results indicate that HCE, SCE, CEE and RCE are represented by one factor. The results of Table 2 indicate that using the total of the four individual elements to represent total ICE is appropriate in this paper.

Table 2: Correlation analysis and factor analysis

Panel A: Pearson correlation

	$RCE_{j,t+1}$	$HCE_{j,t+1}$	$SCE_{j,t+1}$	$CEE_{j,t+1}$	$ICE_{j,t+1}$	$UNDER_{j,t}$	$Size_{j,t}$	$Leverage_{j,t}$	$IND_{j,t}$
$RCE_{j,t+1}$	1.000								
$HCE_{j,t+1}$	0.387^{***}	1.000							
	(0.000)								
$SCE_{j,t+1}$	0.359^{***}	0.670^{***}	1.000						
	(0.000)	(0.000)							
$CEE_{j,t+1}$	0.541^{***}	0.195^{***}	0.224^{***}	1.000					
	(0.000)	(0.000)	(0.000)						
$ICE_{j,t+1}$	0.571^{***}	0.803^{***}	0.729^{***}	0.444^{***}	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)					
$UNDER_{j,t}$	0.028^{***}	0.059^{***}	0.051^{***}	0.054^{***}	0.057^{***}	1.000			
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)				
$Size_{j,t}$	0.277^{***}	0.117^{***}	0.080^{***}	0.560^{***}	0.089^{***}	0.117^{***}	1.000		

	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
$Leverage_{j,t}$	0.389***	-0.014	0.043***	0.709***	0.226***	0.068***	0.745***	1.000	
	(0.000)	(0.122)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
$IND_{j,t}$	0.039***	0.003	0.011	0.008	0.005	-0.017**	-0.022***	-0.020**	1.000
	(0.000)	(0.738)	(0.202)	(0.389)	(0.556)	(0.046)	(0.009)	(0.019)	

Panel B: Factor analysis

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	1.962	1.397	0.891	0.891
Factor2	0.565	0.665	0.257	1.148
Factor3	-0.100	0.124	-0.046	1.102
Factor4	-0.225		-0.102	1.000
Number of obs	13050			
Retained factors	1			
Number of params	4			
Prob>chi2	0.000			
Factor loadings (pattern matrix) and unique variances				
Variable	Factor1	Uniqueness		
$RCE_{j,t+1}$	0.544	0.514		
$HCE_{j,t+1}$	0.871	0.178		
$SCE_{j,t+1}$	0.867	0.187		
$CEE_{j,t+1}$	0.396	0.595		

Note: *p* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

$ICE_{j,t+1}$ represents intellectual capital efficiency for firm j, year t+1. It is measured by the sum of HCE, SCE, CEE, and RCE. $UNDER_{j,t}$ represents firms equity undervaluation which is coded 1 if P/V is less than 1 for firm j, in year t, and 0 otherwise. $UNDERPE_{j,t}$ is another measurement of undervaluation which is coded as '1' if P/E ratio is less than 1, 0 otherwise. $Leverage_{j,t}$ is leverage ratio which is measured by short-term and long-term debt divided by total assets for firm j, in year t. $Size_{j,t}$ is firm size which is measured by the natural logarithm of total assets for firm j, at the beginning of year t. $IND_{j,t}$ is percentage of independent directors for firm j, in year t as proxies for corporate governance.

5.3 Regression Results

Table 3 presents the year-industry fixed effects ordinary least squares regression results for H1. The results reveal that, on average, equity undervaluation will increase ICE in the subsequent year. As shown by the results for the first model in Table 3, the coefficient of $UNDER_{j,t}$ on $ICE_{j,t+1}$ is 0.306 (p-value = 0.000), indicating that if a firm's equity is undervalued, the firm is likely to increase its ICE in the next year. The result confirms H1, which proposes that if the firm's equity is undervalued the firm increases their ICE subsequently to inform investors of their superior information and influence investors' perceptions in order to increase the share price. Examining the control variables, $Size_{j,t}$ is positively and significantly associated with $ICE_{j,t+1}$ (coefficient = 0.185, p-value = 0.000), which confirms previous reports[54-56]that large firms are more likely to have high ICE. Furthermore, this paper finds a positive relationship between $Leverage_{j,t}$ and $ICE_{j,t+1}$ (coefficient = 4.035, p-value = 0.000), confirming that lenders represent an influential power for monitoring intellectual capital investments[19,33]. However, $IND_{j,t}$ is positive but not significantly related to $ICE_{j,t+1}$. This could because independent directors are not powerful enough to influence the decisions

of managers to increase ICE. The result of the summary statistics in Table 1 shows that the mean of $IND_{j,t}$ is only 0.375, which is less than half the total number of director on the board.

Table 3: Regression results for H1

$ICE_{j,t+1}$	Coef.	Std. Err.	t	P>t
$UNDER_{j,t}$	0.306***	0.039	7.910	0.000
$Size_{j,t}$	0.185***	0.015	12.020	0.000
$Leverage_{j,t}$	4.035***	0.141	28.680	0.000
$IND_{j,t}$	0.110	0.314	0.350	0.726
_cons	-3.235	2.197	-1.400	0.162
Industry	Include			
Year	Include			
Number of obs.	13050			
Adj R-squared	27.3%			

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

$ICE_{j,t+1}$ represents intellectual capital efficiency for firm j, year t+1. It is measured by the sum of HCE, SCE, CEE, and RCE. $UNDER_{j,t}$ represents firms equity undervaluation which is coded 1 if P/V is less than 1 for firm j, in year t, and 0 otherwise. $Leverage_{j,t}$ is leverage ratio which is measured by short-term and long-term debt divided by total assets for firm j, in year t. $Size_{j,t}$ is firm size which is measured by the natural logarithm of total assets for firm j, at the beginning of year t. $IND_{j,t}$ is percentage of independent directors for firm j, in year t as proxies for corporate governance.

Table 4 presents the year-industry fixed effects ordinary least squares regression results for H2. The results for the four models in Table 4 reveal the influence of equity undervaluation on the four ICE elements. The results of Models 1–4 in Table 4 show that the $UNDER_{j,t}$ is significantly and positively related to all four ICE elements. Comparing the four elements of ICE, $UNDER_{j,t}$ increases $HCE_{j,t+1}$ the most, with the highest coefficient (0.130; p-value = 0.000). The adjusted R square is also the largest (50.7%), suggesting that the HCE model has a greater explanatory power than other three ICE element models. The coefficient of $UNDER_{j,t}$ on $SCE_{j,t+1}$ (coefficient = 0.022, p-value = 0.000) is similar to the coefficient on $CEE_{j,t+1}$ (coefficient = 0.023, p-value = 0.002), suggesting $UNDER_{j,t}$ increases $SCE_{j,t+1}$ and $CEE_{j,t+1}$ to similar degrees. The results of the control variables are same as the results of the regression analysis of H1, where $Size_{j,t}$ and $Leverage_{j,t}$ are positively and significantly associated with the four ICE elements. However, $IND_{j,t}$ is positive but not significantly correlated with the ICE elements.

Table 4: Regression results for H2

	Model 1 $RCE_{j,t+1}$		Model 2 $HCE_{j,t+1}$		Model 3 $SCE_{j,t+1}$		Model 4 $CEE_{j,t+1}$	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
$UNDER_{j,t}$	0.011*	0.085	0.130***	0.000	0.022***	0.000	0.023***	0.002
$Size_{j,t}$	0.003	0.252	0.212***	0.000	0.036***	0.000	0.016***	0.000
$Leverage_{j,t}$	0.804***	0.000	1.859***	0.000	0.332***	0.000	1.913***	0.000
$IND_{j,t}$	0.222***	0.000	0.068	0.757	0.050	0.222	0.001	0.195
_cons	-1.328***	0.000	1.954	0.912	0.377	0.908	-1.790***	0.000
Industry	Include		Include		Include		Include	
Year	Include		Include		Include		Include	
Number of obs.	13050		13050		13050		13050	
Adj R-squared	12.7%		50.7%		13.3%		14.7%	

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

HCE is human capital efficiency for firm j, year t+1, SCE is structural capital efficiency for firm j, year t+1, CEE is capital employed efficiency for firm j, year t+1, and RCE is relational capital efficiency for firm j, year t+1. $UNDER_{j,t}$ represents firms equity undervaluation which is coded 1 if P/V is less than 1 for firm j, in year t, and 0 otherwise. $Leverage_{j,t}$ is leverage ratio which is measured by short-term and long-term debt divided by total assets for firm j, in year t. $Size_{j,t}$ is firm size which is measured by the natural logarithm of total assets for firm j, at the beginning of year t. $IND_{j,t}$ is percentage of independent directors for firm j, in year t as proxies for corporate governance.

5.4 Additional Tests

Table 5: Additional test

$IC_{j,t+1}$	Coef.	Std. Err.	t	P>t
$UNDERPE_{j,t}$	0.862^{***}	0.057	15.160	0.000
$Size_{j,t}$	0.163^{***}	0.015	10.630	0.000
$Leverage_{j,t}$	3.571^{***}	0.144	24.860	0.000
$IND_{j,t}$	0.257	0.312	0.820	0.411
_cons	3.724	24.277	1.510	0.130
Industry	Include			
Year	Include			
Number of obs.	13050			
Adj R-squared	18.5%			

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

We applied another measurement of equity undervaluation to assess the robustness of the results of the regression analyses. The P/E ratio is traditionally used to value firms because P/E valuation is a substitute for the well-established discounted earnings model[46][62] and it is argued to be an important valuation price multiple. Therefore, this paper uses the P/E ratios as anther proxy for equity undervaluation, where $UNDERPE_{j,t}$ is coded as 1 if the P/E ratio is less than 1, 0 otherwise. The results of Table 5 show that $UNDERPE_{j,t}$ is positively and significantly related to $ICE_{j,t+1}$ (coefficient = 0.862, p-value = 0.000), which confirms the main result that when firms are undervalued, they are more likely to increase their ICE subsequently to signal their superior information and influence investors' perceptions of future performance.

$ICE_{j,t+1}$ represents intellectual capital efficiency for firm j, year t+1. It is measured by the sum of HCE, SCE, CEE, and RCE. $UNDERPE_{j,t}$ is measurement of equity undervaluation which is coded as '1' if P/E ratio is less than 1, 0 otherwise. $Leverage_{j,t}$ is leverage ratio which is measured by short-term and long-term debt divided by total assets for firm j, in year t. $Size_{j,t}$ is firm size which is measured by the natural logarithm of total assets for firm j, at the beginning of year t. $IND_{j,t}$ is percentage of independent directors for firm j, in year t as proxies for corporate governance.

6. Implications

The results of this paper provide theoretical and managerial implications. From a theoretical point of view, the results provide more clarity on the effects that the equity undervaluation has on ICE in the context of China. To the best of the researcher's knowledge, there are no empirical studies using the signalling theory to explain the relationship between equity undervaluation and ICE. This paper argues on the basis of signalling theory, which assumes that a firm is likely to use multiple signals to entice its investors to view the firm favourably. Intellectual capital is a very effective signal to the market of firm quality because it is rarely imitable and replaceable. When

equity is undervalued, if firms believe that their intellectual capital gives a potential growth and competitive advantage, they prefer to signal their firm's prospects, which can be reflected in intellectual capital, and increase their ICE subsequently to influence market perceptions of firm performance. Thus, this study adds to the literature by examining the influence of equity undervaluation on ICE.

From a managerial point of view, the results achieved can be useful for owners, managers, and other stakeholders of Chinese listed firms where the vision of the components of the analyzed intellectual capital highlights the importance for management to assign attention to the management of intellectual capital since it is clear the effect it has on firm performance. The results can be useful for firms' managers to increase their competitive potential and firm performance by implementing intellectual capital. Therefore, the results of this paper can make managers see the need to increase intellectual capital investment because this can improve company performance. This paper offers a strong signal to the managers to encourage them to invest in intellectual capital as one of the main drivers of value creation.

7. Conclusion

This paper uses signalling theory to examine whether equity undervalued firms are more likely to increase their ICE to influence investors' perceptions of future performance and hence increase their share price. Equity undervaluation is measured by the residual income approach and ICE is measured using a modified VAIC^{TM} model. The sample used in this paper is Chinese listed firms from 2014 to 2021. The findings show that, on average, firms with undervalued equity are more likely to increase their ICE subsequently. The results confirm our hypotheses. This paper also examined the influence of equity undervaluation on the four elements of ICE, i.e., HCE, CEE, SCE and RCE. The results show that equity undervaluation is positively and significantly related to all four ICE elements, where firms with undervalued equity increase their HCE the most, as the coefficient of equity undervaluation on HCE is the highest of those of all four ICE elements.

This study has two important limitations. First, although this paper uses models of time-industry effects to control for the unobservable confounding variables that differ from time to time and for unobservable confounding variables that differ across industries, this paper could not fully control for all other unobservable variables that influence the explanatory variables. Second, this study is the first to examine the relationship between ICE and equity undervaluation. Thus, the theoretical framework lacks support, and is not comprehensive.

Future research could use different measurement methods to measure ICE, such as content analysis of firms' annual reports using established coding frameworks. Future research could also examine the factors that cause firms to become undervalued and the interventions that can increase their undervalued equity. Moreover, future research could extend the current study of ICE and equity undervaluation into a detailed examination from a different perspective using different methods. For example, a future study could conduct interviews or surveys to examine directors' perceptions of equity undervaluation and ICE, and how they perceive the role of ICE in increasing share prices.

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