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RESEARCH ARTICLE

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Measuring Intellectual Capital and Its Effect on Financial Performance: Evidence from the Capital Market in Taiwan

Abstract This paper studies intellectual capital in companies in Taiwan, China. Intellectual capital is an invisible, yet important resource for companies. The first aim of this paper is to provide a systematic investigation on how to measure intellectual capital. Results show that the coefficient of value-added intellectual capital is positively related to return on assets and market capitalization in both fix and random effects. Similar results are also obtained with dynamic panel data. Furthermore, innovation variables such as research and development expenditure are more accurate than structural capital in measuring intellectual capital. The author thus suggests that companies need to keep a close track of their intellectual capital and focus on internal information delivery to gain competitive advantage.

Keywords intellectual capital, financial performance, structural capital, value added method, ROA

1 Introduction

Intellectual capital, as one of the intangible assets, such as talents, images and intellectual property, is becoming increasingly important for today's companies. In recent years, research on intellectual capital has become a worldwide trend, and has spawned considerable interest about its impact on firm performance and employee behaviors. According to the latest study conducted by OECD (2006), intellectual capital is a key driver of innovation and core value in the new economy, which enables companies to understand the value creation process, as

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well as to incubate competence to combat uncertainty surrounding the future success of R&D (Kim and Kumar, 2009).

From a resource-based view, a firm's heterogeneous resource architectures are the primary sources of income. Their apparently valuable, rare, inimitable, and nontransferable qualities can contribute to the competitive advantage of firms (Barney, 1991; Wernerfelt, 1984). From a traditional viewpoint, the main purpose of managers is to focus on earning maximization. More recently, however, scholars tend to believe that managers need to pay more attention to internal knowledge accumulation and development in their organizations (Edvinsson, 1997; Bontis, 2001; Ordonez de Pablos, 2002).

Among numerous studies concerning strategic management mentioned competition among competitors, Solitander and Tidstrom (2010) analyzed the content of business relationship between firms. In terms of incorporating intellectual capital when making decisions, the added value of many enterprises is intimately related to intellectual capital. These benefits cannot easily be specified in annual financial reports, but they may increase the competitive advantage and improve company performance, and may also satisfy stakeholders. For example, poorly performing employees may have their pay cut or be dismissed, but their management experience may be an important intangible asset for the company. This is another view of the social perspective of networks (Moeller, 2009).

This paper specifically examines the relationship between intellectual capital and firm performance in a time window from 2001 to 2009. New innovation variables are used to explore the variance in firm performance. A model of panel data is used including fixed effect, random effect and dynamic threshold panel data.

The rest of the paper is organized as follows. Section 2 is a literature review. Section 3 details the data and operational definitions. Section 4 describes the research method and sample design, and explains the data collection procedure, alone with data analysis. Section 5 provides the result. Discussion and conclusions are presented in Section 6.

2 Literature Review

Choong (2008) reviewed literature on intellectual capital and categorized intellectual capital into three main types, namely human resource capital, structural capital and customer related capital, which are adopted in this paper.

2.1 The Composition of Intellectual Capital

Various definitions for intellectual capital can be found in the extant literature.

For example, Mavridis defined it as “an intangible asset with the potential to create value for the enterprise and the society itself” (Mavridis, 2005). Martinez and Meca (2005) stated that knowledge, information, intellectual property and experience that can be used to create wealth can be regarded as intellectual capital. Kamath (2006) argued that the intellectual capital of a firm is perceived as a potential strategic asset to measure both tangible and intangible assets. Itami (1991) indicated that “intangible assets are invisible assets that include a wide range of activities such as technology, consumer trust, brand image, corporate culture and management skills.” Smith (1994) defined intellectual capital as all the elements of a business enterprise that exist in addition to working capital and tangible assets. They are the elements that make business work and are often the primary contributors to the earning power of an enterprise.

Stewart (1997) indicated knowledge has turned out to be the key source of wealth at an organizational as well as national level, and countries with knowledge-intensive activities will be the winners in terms of future wealth creation (Bounfour and Edvinsson, 2004). Bannany (2008) stated intellectual capital that covers knowledge and experience can be used to gain competitive advantages for companies through applying creative strategies. Therefore, intellectual capital can influence firm performance, as assumed above.

In relevant literature in the early 1990s, intellectual capital was considered as an intangible asset. Non-accounting researchers defined “intellectual capital” as the “difference between the firm’s market value and its book value” (e.g., Edvinsson and Malone, 1997; Stewart, 1997; Sveiby, 1997; Mouritsen et al., 2001). To accounting researchers, however, the difference between the market value of an entity and the book value of the entity’s identifiable assets is defined as goodwill.

However, the valuation of intellectual capital has a different standard from an academic prospect. The Skandia Value Scheme developed by Edvinsson (1997) consists of both financial and non-financial capital. Royal (2008) continued to subdivide it into structural capital, composed of customer capital and organizational capital. Choong et al. (2008) divided intellectual capital into human capital, structural capital and customer related capital. Although intellectual capital has been defined from different perspectives, it is generally agreed that intellectual capital can be divided into human, structural and customer related capitals.

Royal and O’Donnell (2008) embedded human resource capital into social capital and knowledge management. Wiig (2004) stated that human resource capital is a part of intellectual capital, consisting of the knowledge, understanding, skills, experience and relationships of its employees.

Compared with human resources capital and physical capital, structural capital is the supportive infrastructure for innovation in organizations. Structural capital helps to amplify the value arising and thus multiplies the overall intellectual capital. Accordingly, Kong (2009, 2010) argued that structural capital can assist companies to create organizational value that facilitates organizational learning and knowledge creation, leading to innovation for the pursuit of social and commercial activities.

2.2 Intellectual Capital Measurement and Financial Performance

As discussed above, intellectual capital is believed to be able to bring forth higher valued asset. The elements constituting intellectual capital can therefore boost firm performance and value creation. Chen et al. (2005) found that intellectual capital and physical capital have positive impacts on market returns, as well as on the current and future financial performance of firms in Taiwan. Tan et al. (2007) confirmed these results using publicly traded companies in Singapore. Similarly, Fire and Williams (2003) sampled companies in South Africa, and Zeghal and Maaloul (2010) in the U.K., and drew similar conclusions. Kamath (2008), in a study on the effect of intellectual capital on pharmaceutical industry, found that intellectual capital is positively related to firm performance in developing economics like India. Bannany (2008) indicated that investments in intellectual capital variables have a significant impact on the intellectual capital performance of the banking industry in the UK.

The research framework of Moeller (2009) contained two groups of independent variables (trust, participate and strategic relevance) and network performance. Ghosh and Mondal (2009) sought to estimate and analyze the relationship between intellectual capital and pharmaceutical companies for a period of five years from 2002 to 2006. Ting and Lean (2009) examined the association between intellectual capital and financial performance. Following these papers, this study uses VAIC (value added intellectual capital) and VAIN (value added structural capital) as aggregate measures for corporate intellectual ability.

2.3 Review of Studies on Intellectual Capital

Recently, Solitander and Tidstrom (2010) adopted Verna Allee's value network analysis (VNA) to study intellectual capital, which provides a suitable framework for analyzing transactions among firms and keep track of the intellectual capital flow in the whole networks. Ortiz (2009) analyzed and grouped the intellectual capital components of multinational organizations through a humanistic model called contextual intellectual capital components valuations. Kasztler and Leitner (2009) argued that the established approaches are unable to trace system dynamics as they take into consideration only unidirectional cause-and-effect relationships. Accordingly, they used indicators of the social network analysis (SNA) to cope with feedback loops and indirect causality.

Jacobsen et al. (2005) introduced the Intellectual Capital Rating approach as a useful tool for management consulting. Alwert et al. (2009) discussed intellectual capital reporting to contribute a more homogeneous rating based solely on information from financial reports. Moeller (2009) focused on social capital as a network's core resource, and investigated how networks are linked with the creation of intellectual capital. Three important factors were indentified in his research, namely trust, participation and strategic relevance. Secundo et al. (2010) used the balanced scorecard to provide a more comprehensive knowledge-based view of business performance. Joia and Malheiros (2009) found that the benefits will be greater when innovation alliances are well-developed. Jhunjhunwala (2009) used value map for monitoring and measurement.

3 Research Framework and Design

3.1 Operational Definitions

Public (1998, 2000) was the first researcher to use *VAIC* to measure intellectual capital of companies. The abbreviations adopted in the *VAIC* approach are defined as follows:

Output = Gross income (1)

Input = Operating expenses (Excluding personal costs) (2)

VA = Output – input (3)

CE = capital employed = book value of a firm's net asset (4)

$VACE = VA/CE$ = total VA divided by the total amount of CE (5)

VA of human capital ($VAHC$) = VA/HC; HC = total salary and wage cost (6)

VA intellectual capital ($VAIC$) = $VAHC + VACE$ (7)

The *VAIC* approach is now commonly used to explore the relationship between financial performance and intellectual capital (Chen et al., 2005; Shiu, 2006; Kujansivu and Lonnqvist, 2007; Tan et al., 2007; Yalama and Coskun, 2007; Chan, 2009). In the above researches, most researchers used the above indicators to measure intellectual capital. However, Andriessen (2004) argued that the basic assumption for *VIAC* approach is problematic and incomplete. Public (2004) therefore redesigned the above indicators as follows:

$SC = VA - HC$; $\mathrm{STVA} = SC/VA$ (8)

$VAIN = VAHC + STVA$ (9)

Since there is no consensus on the operational definition for structural capital, this paper tries to integrate the IT system to better measure the capital. Using

Bannany (2008) as a reference, this paper defines IT systems as the IT resources allocated mainly to serve the managerial purposes of a company.

To make it more measurable, we use barriers to entry (*BATE*) as a proxy variable, defined as the ratio of fixed assets to total assets for firm *i* in year *t*, and used the ratio of staff costs to total revenue for firm *i* in year *t* instead of the proxy variable for efficiency of investment in intellectual capital (*EIIC*).

Another indicator for structural capital is the R&D. The success of innovation mainly depends on well-educated or experienced individuals' capabilities in areas such as innovation capacity, skills and know-how. There is a visible paradigm shift in the sense that the world is moving from business process outsourcing to knowledge process outsourcing. Kamath (2008) argued that employees are bringing intellectual capital into their organizations, as embodied in a series of important aspects such as skilled manpower, R&D infrastructure and patents.

Innovation capital refers to a company's revolutionary capability, innovative achievement, and potential build up of new product and service. R&D investment is found to have a positive relationship with firm performance (Wang, 2008). A company's competitiveness and components are the major determinants for its long-term survival.

3.2 Independent Variables

According to Stewart (1997), the selection of independent variables is based on performance measurement. Economic Value Added is used as the variables for capital budgeting, financial planning, goal setting, performance measurement, shareholder communication, and incentive compensation to determine the corporate value. Sveiby (2002) suggested that different measurement methods have different advantages, and the financial methods for valuation such as *ROA*, *MC* and *OCASH*, are useful for stock market valuations. Tan et al. (2008) proposed that the market value added represents the spread between the cash that a firm's investors invest in the business and the present value of the cash that they can earn by selling their shares. This paper refers to previous research to operationalize the variables to be tested (Tan et al., 2008; Zeghal and Maaloul, 2010; Kamath, 2008) as defined as below:

OCASH: ratio of the operating income divided by total assets, used as a proxy for economic performance.

ROA: ratio of the earnings before interest and taxes divided by book value of total assets, used as a proxy for financial performance.

MC: ratio of the total market capitalization (share price times number of outstanding common shares) to book value of net assets, used as a proxy for stock market performance.

3.3 Control Variables

This paper uses a multiple linear regression model to test the relationship between intellectual capitals and firm performance with panel data from 2001 to 2008. The control variables used in the model, include *LCAP* (the synonym of firm size), defined as the natural log of the total assets that represents the size of the firm and Lev (the synonym of leverage), defined as the ratio of the total debt divided by the book value of the assets of the firm.

3.4 Research Hypotheses

H1 There is a significant relationship between performance and *VAIC* companies.
H2 There is a significant relationship between performance and *VAIN* companies.
H3 There is a significant relationship between the *BATE* and *VAIN* companies.
H4 There is a significant relationship between the *EIIC* and *VAIN* companies.

The panel data regression is set as follow:

$$\text{Performance(firm } i) = \beta_{0i} + \beta_{1i}*VAIC_i + \beta_{2i}*VAIN_i + \beta_{3i}*BATE_i + \beta_{4i}*EIIC_i + \beta_{5i}*LCAP_i + \beta_{6i}*Lev_i + \varepsilon \quad (10)$$

$$\text{Performance(firm } i) = \beta_{0i} + \beta_{1i}*VAIC_i + \beta_{2i}*R\_D_i + \beta_{3i}*BATE_i + \beta_{4i}*EIIC_i + \beta_{5i}*\text{LCAP}_\text{i} + \beta_{6i}*Lev_i + \varepsilon \quad (11)$$

4 Results

4.1 Description of Statistics

Data was collected from the Taiwan Economic Journal Data base (TEJ). A total of 310 items of missing data were deleted, leaving 4 625 items of final usable data. The period of 2001 to 2008 was used for balanced panel data regression on the listed companies of the Taiwan. There were 578 items in each year of operation, as summarized in Table 1.

Operating cash flow ratio was obtained by dividing total assets with operating cash flows, ranging from a minimum value of –0.688 to a maximum value of 3.122. The mean is close to the medium at 0.06, indicating that most the sampled companies had poor operating cash flows. Lack of the capability of internal funding denotes poor operating performance. The return on asset averaged 5.664%, with the median approximately 5.22%, showing that most of the sampled companies need to work harder to improve their profit margin.

Table 1 Descriptive Statistics

Variables	Minimum	Maximum	Mean	Median	S. D.
OCASH	–0.688	3.122	0.07	0.06	0.11
ROA	–100.7	50.64	5.664	5.22	9.555
MC	0	16.43	1.48	1.16	1.175
VAIC	–1040.76	3383.86	10.184	1.28	103.44
VAIN	–6583.25	3384.66	9.13	1.77	146.08
R_D%	0	38.16	0.35	0.008	1.835
BATE	0	0.922	0.26	0.223	0.184
EIIC	0.14	2274.78	9.25	6.11	38.07
LCAP	12.3	20.3	15.64	15.47	1.234
D%	0.015 5	111.51	5.04	0.421 2	13.84

Note: *OCASH* = Operating cash flow; *ROA* = Return on asset; *MC* = Market capitalization; *VAIC* = Value Added Intellectual Coefficient; *VAIN* = Value added intangible coefficient; *R_D%* = R&D percent; *BATE* = barriers to entry. The variables were collected from the Taiwan Economic Journal Data Base (TEJ). A total of 310 items of missing date were deleted, leaving 4 625 items of final testable data. The period of 2001 to 2008 was used for balanced panel data regression on the listed companies in Taiwan.

In addition, Table 1 also shows that averaged market capitalization was 1.48, median was 1.16, minimum *ROA* was –100.7, and maximum value was 50.64, indicating the returns of assets of listed companies varied greatly, although they had quite close average and median Like *OCASH*.

Both *VAIC* and *VAIN* had more deviations, as shown in Table 1. One of the defects of adoption of value-added calculation approach is that, when the net loss of a company is large, its market value becomes negative, regardless of the actual amount of resources possessed by the company. However, the average falls positively between 10 to 9, which implies a positive relationship between a company's intellectual capital, and its daily operating activities. The mediums show that many companies have R&D expense ratio close to zero, possibly because that the total asset is very high, thus resulting in a low R&D expense ratio. As the R&D expense ratio of many firms is zero, it can be used to enhance the structural capital because structural capital emphasizes on knowledge creation.

Most of the listed company had to pay licensing royalty to foreign firms; this explains why R&D expenditure rate was low and the median was a mere 0.008. As denoted by the median, many companies' R&D expenditure approached zero: it was not because they did not invest in R&D, but the proportion of funds invested in R&D was extremely small in comparison with their huge total assets.

Table 2 Pearson Correlated Test

	ROA	*MC*	*VAIC*	*VAIN*	*R_D%*	*BATE*	*EIIC*	*LCAP*	*D%*
OCASH	0.313	0.244	–0.036	–0.024	0.072	0.06	–0.021	0.014	–0.032
(Operating cash flow)	0.000	0.000	0.014	0.102	0.000	0.000	0.156	0.352	0.028
ROA		0.5	0.176	0.12	0.012	–0.173	–0.056	0.067	–0.047
(Return on asset)		0.000	0.000	0.000	0.413	0.000	0.000	0.000	0.001
MC			0.157	0.102	–0.066	–0.155	–0.014	–0.014	–0.16
(Market capitalization)			0.000	0.000	0.000	0.000	0.33	0.353	0.000
VAIC				0.709	–0.016	–0.087	–0.023	0.149	–0.025
(Value added intellectual coefficient)				0.000	0.289	0.000	0.123	0.000	0.095
VAIN					–0.009	–0.077	–0.013	0.106	–0.013
(Value added intangible coefficient)					0.549	0.000	0.386	0.000	0.372
R_D%						–0.064	0.000	–0.017	0.31
						0.000	0.988	0.242	0.000
BATE							0.047	0.03	–0.033
(Barriers to entry)							0.1	0.053	0.023
EIIC (Efficiency of investment in intellectual capital)								–0.068	0.014
								0.000	0.353
LCAP									0.052
(Firm size)									0.000

Note: As *BATE* is highly correlated with other variables, to test their collinearity diagnostics, at the tolerance, *BATE* with *EIIC* is 0.995, with *VAIC* is 0.492, with *VAIN* is 0.498, with scale is 0.969, with debt is 0.9, with *R&D*% is 0.9. At the *VIF*, *BATE* with *EIIC* is 1, with *VAIC* is 2.03, *VAIN* is 2, with scale is 1.03, with debt is 1.11, *R&D*% is 1.11. No collinearity problem has been founded.

Surprisingly, we also found, from the data collected, that many sampled companies' debt ratio was as high as 111.51%. These companies might have to find more fund-raising channels so as to improve their capital structure. Our results also showed that both the median and average of *BATE* were around 0.24, while the values for *EIIC* varied greatly (the maximum was 2 274.78), indicating that some companies' expenditure on personnel was far bigger than their income. However, the values for mean (9.25) and median (6.11) also showed that such extreme cases were only exceptions: a majority of listed companies in Taiwan are still R&D oriented.

The Pearson correlation coefficients are presented in Table 2. As shown, *OCASH* was found highly correlated with *ROA* and *MC*. Except for the R&D percentage ratio, *ROA* was significantly correlated with other variables. The same goes to market capitalization. These results show that firm performance is affected by the elements of intellectual capital.

As value-add is a common factor of *VAIC* and *VAIN*, there is a significant correlation between them; however, the relational coefficient of *VAIC* and *VAIN* to the R&D expense ratio is not significant. Therefore, this paper increases the R&D expense ratio to make it a new structural capital.

Quite counter-intuitively, The *BATE* is highly correlated with other variables, resulting in possible collinearity problems. Consequent collinearity test shows no significant result (details are presented upon request). The *LCAP* is highly correlated with the R&D expense ratio, but they cannot be combined into one variable because their have different levels of attributes.

4.2 Panel Data and Normal Distribution

As usual, panel data needs to be tested for their normality. This study used the methods of Jarque-Bera and Doomik-Hamsen to test the normality of single variables and multivariates, respectively. The presumption of Jarque-Bera test is that in a small sample pool, neither skewness nor kurtosis is close to a normal distribution. Nor are they independent. Doornik-Hamsen's multivariate normality test is suitable for fat tail situations. If the Chi-square distribution reaches 144 or the above, the test result strongly rejects the null hypothesis of normality. This paper also performed Shapiro-Wilk's normality test to ensure reliability. All the results reject the null hypothesis of a normal distribution. Meanwhile, this research used the method of Lilliefors test (also called Kolmogorov-Smimov test) to explore the multi-variance normality. The method assumes that the cumulative distribution function is the difference of the biggest absolute values:

$$D = \max \{D\text{^}\{+\}, D\text{^}\{-\}\},$$

Table 3 Variables with Normality Test

	OCASH	*ROA*	*MC*	*VAIC*	*VAIN*	*R_D%*	*BATE*	*EIIC*	*LCAP*	*D%*
Doornik-Hansen	15 013	2 898	5 743	2 10743	119 759	1 072	533	617	26 416	132 942
Shapiro-Wilk	0.792 7	0.924	0.75	0.146 5	0.115 5	0.94	0.075	0.96	0.4	0.185
Lilliefors	0.09	0.094	0.149	0.387	0.395 1	0.082	0.406	0.07	0.49	0.46
Jarque-Bera	4.141 4	15 891	68 363	2.961	1.931	502.1	1.489	667	30 183	3.09

Note: Shapiro-Wilk:

$$W=\frac{\left(\sum_{i=1}^{n}a_i x_{(i)}\right)^2}{\sum_{i=1}^{n}\left(x_i-\overline{x}\right)^2},\quad \overline{x}=\left(x_1+\ldots+x_n\right)/n,\quad \alpha_i=\left(\alpha_1,\ldots,\alpha_n\right)=\frac{m^T V^{-1}}{(m^T V^{-1}V^{-1}m)^{1/2}},$$

where $m = (m_1, \ldots, m_n)^T$. m is the order statistics of standard normal distribution (*iid*). α is constant, V is covariance matrix.

Jarque-Bera:

$$\eta_i^{\alpha s}=T\left(skewness_i\right)^2/6+T\left((kutosis-3\right)^2/24\sim x^2,$$

$$m\eta_i^{\alpha s}=\sum_{i=1}^{p}\eta_i^{\alpha}\sim x^2\left(2p\right).$$

The presumption of Jarque-Bera test is that in a small sample pool, neither skewness nor kurtosis is close to a normal distribution. Nor are they independent. Doornik-Hamsen's multivariate normality test is suitable for fat tail situations. If the Chi-square distribution reaches 144 or above, the test result strongly rejects the null hypothesis of normality. This paper also performed Shapiro-Wilk's normality test to ensure reliability. All the results reject the null hypothesis (normal distribution).

Table 4 The Empirically Result with Fix Effect of Panel Data (2001–2008)

Symbol	*OCASH*	*ROA*	*MC*	*OCASH*	*ROA*	*MC*
Constant	0.045**	2.387	2.033***	0.04***	2.62	2.014 4***
	2.21	1.361	9.512	2.03	1.49	9.41
VAIC	–0.000 4*	0.015***	0.001 8***	–0.000 35***	0.014 2***	0.001 6***
(Value added intellectual coefficient)	–1.8	8.034	7.742	–2.255	10.68	9.87
VAIN	0.000 4	–0.001	–0.000 2			
(Value added intangible coefficient)	0.28	–0.63	–0.103			
R_D%				0.002 8***	–0.177***	0.0147
				2.74	–2.02	1.382
BATE	0.036 5***	–8.032***	–0.994***	0.037***	–8.08***	–0.986***
(Barriers to entry)	4.2	–10.731	–10.894	4.292	–10.786	–10.815
EIIC	–0.000 6	–0.01***	–0.000 08	–0.000 06	–0.01***	–0.000 078
(Efficiency of investment in intellectual capital)	–1.428	–2.86	–0.177	–1.423	–2.873	–0.181
LCAP	0.001 7	0.39***	–0.021	0.0018	0.385***	–0.02
(Firm size)	1.31	3.495	–1.5	1.38	3.44	–1.469
D%	–0.002***	–0.167***	0.001***	–0.001 8***	–0.178***	0.002
(Debt ratio)	–8.21	–8.043	7.742	–7.16	–8.3	0.762
R-square	0.023 5	0.075	0.093	0.025	0.076	0.093
Adj-R^2	0.021	0.072 3	0.09	0.022 3	0.073	0.090 3
Log-likel.	3 782.9	–16 813.86	–7 080.6	3 786.66	–16 812	–7 080.182
rho	0.062 5	0.133 5	0.228 8	0.061 5	0.133	0.229
Hann.-Qu.	–7 506.16	33 687.43	14 220.94	–7 513.61	33 683.7	14 220.1
Dur.-Wats.	1.871	1.7325	1.542	1.873	1.733	1.541

Note: Log-likel. = log-likelihood estimates, Hann-Qu. = Hann-Quinn test, Dur.-Wats. = Durbin-Watson test. Durbin-Watson tests are to examine whether time series data show first-order auto-regressive phenomena. If the result rejects H_0, it means ε is an independent series of first-order auto-regression; otherwise ε is a correlated series. The Durbin-Watson equation is described as follows:

$$d_p = \frac{\sum_{s=1}^{N}\sum_{t=2}^{T}\left(e_{st} - e_{s,t-1}\right)^2}{\sum_{s=1}^{N}\sum_{t=1}^{T} e_{st}^2}.$$

then:

$$D^{+} = \max_{i = 1,\dots, n}\{i/n - p_{(i)}\},$$
$$D^{-} = \max_{i = 1,\dots, n}\{p_{(i)} - (i-1)/n\}, \tag{12}$$

where $p_{(i)} = \Phi([x_{(i)} - \overline{x}]/s)$. Therefore, Ph_i is always used as the cumulating distribution function of the standard normal distribution. All results are presented in Table 3. As shown, all null hypotheses of normal distribution were rejected.

As for the serial correlation, we used the Durbin-Watson test to examine the first order ARCH across the time series data. If H_0 is rejected by ε, it is series independent of first order, and it is serial correlation, otherwise. The model results did not reject H_0, as shown in Table 4.

4.3 Fix Effect

There are two common assumptions made about the individual specific effect, the random and fixed effects assumption. The former (made in a random effects model) assumes that the individual specific effects are uncorrelated with the independent variables; the latter assumes that the individual specific effect is correlated with the independent variables. If the random effects assumption holds, the random effects model is more suitable than the fixed effects model.

Because fixed effects model relies on within-group action, we need repeated observations for each group, and a reasonable amount of variation of our key X variables within each group. One potentially significant limitation of fixed effects model is that we cannot assess the effect of variables that have little within-group variation. The mean values of the variables in the observations on a given individual are calculated and subtracted from the data for that individual. Finally, they will produce between-group regression. Subtracting this from (10), one obtains (12) and the unobserved effect disappears.

$$\hat{Y} = \hat{X}_{st}\beta + \beta_0 + \varepsilon. \tag{12}$$

$$\hat{Y} = \frac{\sum_t Y_{it}}{T}, \ \hat{X} = \frac{\sum_t x_{it}}{T}, \ \hat{\varepsilon} = \frac{\sum_t \varepsilon_{it}}{T}. \tag{13}$$

This is known as the within-groups regression model because it explains the variations about the mean of the dependent variable in terms of the variations about the means of the explanatory variables for the group of observations relating to a given individual. The possibility of tackling unobserved heterogeneity bias in this way is a major attraction of panel data for researchers.

If we define a new dummy variable d_j, where d_j is equal to 1 in the case of an observation relating to individual j and 0 otherwise, the model can be rewritten as Eq. (14):

$$performance_{st} = \alpha_1 d_{1jt} + \alpha_2 d_{2jt} + ... + \hat{\beta} X_{st} + \varepsilon_{st}. \quad (14)$$

Formally, the unobserved effect is now being treated as the coefficient of the individual-specific dummy variable, the $\alpha_i d_j$ term representing α fixed effect on the dependent variable $performance_{st}$ for individual i (this accounts for the name given to the fixed effects approach). Having re-specified the model in this way, it is suitable to use the OLS approach. That is well-known as the least squares dummy variable (*LSDV*) regression model.

Table 4 shows that there is a significantly negative correlation between *VAIC* and operating cash flows. The correlation with *ROA* and *MC* is significantly positive. Corporate performances have no impact on *VAIN*. However, there is a significant correlation with R&D ratio (with positive effects from *OCASH* and negative effects from *ROA*). This shows that the higher the added value, the lower the operating cash flows, and the higher the *ROA* and market capitalization. Namely, there is a reverse U-shaped relationship between added value and operating cash flows, although the coefficient is a mere 0.04%. Many companies in Taiwan focus on operating performances and are not keen on enhancing added value. They only attempt to increase added value or expenditure on human resources when operating performances are poor.

As *VAIN* has limited influence on corporate performance, this paper uses the R&D expense ratio to examine the negative impacts on *ROA* and positive impacts of *OCASH*. This confirms that structured capital consists of two elements: (1) process flow improvement and customer relationship capital; (2) innovation capital. This paper finds that innovation capital has more impact on performances. The influence of entry barriers on operational performances is positive, indicating that the higher the entry barriers, the better the operational performances. However, the effects on *ROA* and growth opportunities are negative; indicating that without innovations, entry barriers, such as price cuts, do not necessarily have positive impacts on performances. The correlation between *EIIC* and *ROA* is negative. When the efficiency of the investment on intellectual capital is lower, the impact on *ROA* is stronger; this is an interesting finding. However, the effects on other performances are not significant. In terms of control variables, company sizes have significant influence on *ROA*, possibly because larger companies tend to have poorer operational performances. This is relevant to the resource allocation of the internal capital market, which should be further studied.

4.4 Random Effect

In statistics, a random effect(s) model, also called a variance components model is a kind of hierarchical linear model. It assumes that the dataset being analyzed consists of a hierarchy of different populations whose differences relate to that hierarchy. In econometrics, random effects models are used in the analysis of hierarchical or panel data.

The decision over the use of random effects is based on two methods: The Lagrange Multiplier Test proposed by Breusch and Pagan (1980) and the Hausman Test. Various tests have been developed to detect the presence of random effects. Among them, the most commonly adopted one is the Breusch–Pagan Lagrange multiplier test, the test statistic having a chi-squared distribution with one degree of freedom under the null hypothesis of no random effects, as Eq. (15):

$$LM = \frac{NT}{2(T-1)}\left[1 - \frac{u'\left(In \otimes JT\right)u}{u'u}\right], \tag{15}$$

where N is the tested number of markets; T is the research period; u is the residual item of OLS. If the test results do not reject the null hypothesis, the ordinary least squares method will be adopted. If the test results reject the null hypothesis, a random effect model is applied.

The Hausman test equation is expressed in Eq. [16]:

$$H = \left(\hat{d}_{FE} - \hat{d}_{RE}\right)\left[AV\hat{A}R\left(\hat{d}_{FE}\right) - AV\hat{A}R\left(\hat{d}_{RE}\right)\right]^{-1}\left(\hat{d}_{FE} - \hat{d}_{RE}\right), \tag{16}$$

where $\hat{\delta}_{FE}$ is the estimation equation of fixed effects, $\hat{\delta}_{RE}$ is the estimation equation of random effects, the critical difference between *FE* and *RE* was that *FE* allowed for correlation between the unobserved effect and the explanatory variables whereas *RE* requires these to be uncorrelated. In general, we should assume that the unobserved effect is correlated with the explanatory variables. This is a more conservative approach. However, if the unobserved effect is uncorrelated with the explanatory variables, then the RE estimator is more efficient than the *FE* estimator and hence we would prefer to use it instead.

A Hausman test consists of two estimators. Under the null hypothesis, both are consistent, but one is more efficient; under the alternative, the formerly more efficient one becomes inconsistent, while the formerly less efficient remains consistent. Thus if the null is accepted, the two estimators should be similar; divergence indicates rejection of the null.

The first test condition shown in Table 5 is that the Hausman test results did not reject the null hypothesis. If the test results reject the null hypothesis, it is not necessary to test random effects. Thus, Table 5 only lists the Hausman test results that do not reject the null hypothesis. As shown, the test results on *VAIC*, *VAIN*, *BATE* and *EIIC* are all the same as fixed effects. However, the R&D expense ratio has a significantly positive effect on operational performances, indicating that given the instant intercepts (i.e., without the consideration for the base

Table 5 Empirically Results of the Random Effect of Panel Data (2001–2008)

Symbol	*OCASH*	*ROA*	*MC*	*OCASH*	*ROA*	*MC*
Constant	0.062*** 18.55	7.68*** 25.88	1.728*** 22.78	0.06**** 16.99	7.672*** 25.39	2.095*** 9.72
VAIC (Value added intellectual coefficient)	–0.000 37* –1.695	0.016*** 8.38	0.001 78*** 7.772	–0.000 04*** –2.08	0.015*** 11.22	0.001 6*** 9.94
VAIN (Value added intangible coefficient)	0.000 004 0.266	–0.000 8 –0.623 6	–0.000 16 –1.033			
R_D%				0.004 6*** 4.93	0.016 0.202 5	–0.011 4 –1.17
BATE (Barriers to entry)	0.035*** 3.999	–8.205*** –10.967	–0.98*** –10.753	0.037*** 4.262	–8.05*** –10.73	–0.963*** –10.55
EIIC (Efficiency of investment in intellectual capital)	–0.000 006 8 –1.63	–0.01*** –3.179	–0.000 03 –0.173	–0.000 06 –1.624	–0.011*** –3.183	–0.000 088 7 –0.21
D% (Debt ratio)			–0.004 1 0.056 86			–0.01*** –6.487
Within variance	0.011 6	86.02	1.256	0.011	86.03	0.951
Between variance	0.000 00	0.4	0.02	0.000 005 8	0.415 9	0.016 6
Hausman test	7.044 0.133 6	0.27 0.992	9.06 0.11	0.97 0.914 5	0.23 0.994	5.1 0.177 9
Log-likelihood	3 741.25	–16 858.5	–7 164.333	3 754.45	–16 863.4	–7 134.98
Hannan-Quinn	–7 461.16	33 746.9	14 358.53	–7 487.56	33 760.3	14 299.82

period), each R&D expense has a positive effect on the operational performance. As shown, innovation capital has a significant effect on corporate performance. Moreover, this paper infers that the correlation between *VAIC* and *OCASH* is negative, but the correlation with other performances is positive, possibly due to *VAHU*. Firms often adopt the strategy of downsizing during economic recessions; however, this profit-oriented approach to maximize shareholders' benefits often jeopardizes the accumulation of human capital. If firms have growth opportunities, they would naturally invest more human resources; otherwise, they would reduce the expenditure on personnel. As a result, *VAIC* becomes negative, as a response to operational performance.

This paper found that the relationship between barriers to entry (*BATE*) and financial performance is statistically significant, so is relationship between *VAIC* with financial performance. The effects of *BATE* and *VAIC* on the financial performance are exactly opposite. It is very interesting that a higher *VAIC* will lead to less operating cash flow, and increase in *ROA* and market capitalization. But a higher *BATE* brings forth better operating cash flow, and decrease in *ROA* and market capitalization. This result supports the resource dependency theory that the knowledge creation can help companies increase their competitive advantages and strengthen barriers to entry. In addition, the efficiency of investment in intellectual capital (*EIIC*) only has a negative effect on *ROA*.

4.5 Robust Test

Many scholars believe that the intellectual capital itself has pre-post interaction in autocorrelation situations; Panel data is now widely used to estimate dynamic econometric models. Its advantage over cross-section data in this context is obvious: we cannot estimate dynamic models from observations at a single point in time, and it is rare for single cross-section surveys to provide sufficient information about earlier time periods for dynamic relationships to be investigated.

This result holds, regardless of the number of cross-sections observed in the sample. To tackle this problem, applied economic research usually follows the practice of differencing the data and then using an estimator based either on instrumental variables (such as the Anderson-Hsiao estimator, 1981), or on the generalized method of moments (GMM), proposed by Arellano and Bond (1991), Arellano and Bover (1995), Ahn and Schmidt (1995) and Blundell and Bond (1998). We have emphasized that large finite sample biases when the instruments available are weak, and when using the basic first differenced estimators with series that are highly persistent.

This paper also conducted investigation on the time series properties of the individual series, and comparison of the consistent GMM estimators to simpler

Table 6 Dynamic Panel Data Analysis

Symbol	OCASH	ROA	MC	OCASH	ROA	MC
Constant	0.15*** 5.19	14.8*** 5.997	3.7*** 12.32	0.144*** 5.05	15.01*** 6.07	3.68*** 12.23
VAIC (Value added intellectual coefficient)	–0.000 04** –2.004	0.015 5*** 8.224	0.001 8*** 7.94	–.000 04*** –2.643	0.015*** 11.23	0.001 7*** 10.455
VAIC(–1)	0.000 01 0.49	0.002 45 1.303 3	0.000 32 1.384	0.000 006 0.37	0.002 67** 1.988	0.000 26 1.61
VAIC(–2)	–0.000 04** –2.052	0.000 245 1.067	0.000 245 1.067	–0.000 03** –2.1	0.002 3* 1.7	0.000 195 1.192
VAIN Value added intangible coefficient	0.000 003 0.183	–0.000 12 –0.726	–0.000 12 –0.73			
VAIN(–1)	–0.000 005 –0.328	–0.000 055 –0.34	–0.000 005 –0.34			
VAIN(–2)	0.000 001 0.814 2	–0.000 049 –0.31	–0.000 05 –0.31			
R_D%				0.002 1** 1.98	–0.157* –1.73	0.018 1.642 4
R_D%(–1)				–0.000 36 –0.35	0.045 5 0.5	–0.002 –0.186
R_D%(–2)				0.000 9 0.861	–0.033 –0.362	–0.007 8 –0.72

(*To be continued*)

(*Continued*)

Symbol	OCASH	ROA	MC	OCASH	ROA	MC
LCAP	0.004 8***	0.68***	0.012	0.004 8***	0.676***	0.012 5
(Firm size)	3.453	5.67	0.796 5	3.484	5.631	0.855 3
LCAP(–1)	–0.005 3***	–0.82***	–0.067***	–0.005 3***	–0.821***	–0.067***
	–3.737 5	–6.7	–4.49	–3.76	–6.69	–4.484
LCAP(–2)	–0.003 44**	–0.4***	–0.087***	–0.003 4***	–0.4***	–0.087***
	–2.504 5	–3.354	–5.989	–2.465	–3.374	–6.01
D%	–0.002**	–0.17***	0.000 34	–0.001 8***	–0.181***	0.001 4
Debt ratio	–8.08	–8.2	0.134 4	–7.18	–8.34	0.53
D%(–1)	–0.000 55**	–0.016	–0.001 7	–0.000 5**	–0.018	–0.001 53
	–2.27	–0.77	–0.67	–1.983	–0.822	–0.58
D%(–2)	–0.000 5*	0.017 8	–0.001 7	–0.000 35	0.013	–0.001 8
	–1.86	0.85	–0.666 7	–1.384	0.594	–0.69
R-square	0.028 7	0.065	0.085	0.03	0.066	0.085
Adj-*R*-square	0.024 7	0.061 5	0.081 2	0.025 7	0.062 2	0.082

Note: Log-likel. = log-likelihood estimates, Hann-Qu. = Hann-Quinn test, Dur.-Wats. = Durbin-Watson test. The table did not discuss random effect because Hausman test are significant, so discussing fixed effects is adequate.

estimators like OLS levels and Within Groups, The model was used to measure and estimate by using the GMM-DIFF estimator proposed by Arellano and Bond (1995) for the case of dynamic panel data models.

Table 6 only reports fixed effects. The results are consistent with the conclusions of the previous section, that is, *VAIC*, rather than *VAIN*, has an impact on financial performance, while R&D ratio has a partial impact on financial performance.

To further explore the intellectual capital of the time variation effects on the financial performance of. *VAIC* has a significantly negative related effect with operating cash flow. And *VAIC* has positive related to the *ROA* lagged by two periods. Here we can only explain that *VAIC* has the before-post periods influence to the financial performance, but is not each issue has the relatedness.

Other control variables, such as debt ratio and *LCAP* have time-lagged influence (two periods lagged) on financial performances. In other words, debt ratio affected financial performance only at the period of t and t–1, but all of the time effect is not significant. Another finding is that even if there is a time lag, the relationship between structure of capital and the impact of financial performance is not significant.

5 Conclusion and Discussion

The main contribution of this paper lies in its exploration of relationship between intellectual capital and financial performance. The proxy variables chosen for financial performance in the current paper include operating cash flow, *ROA* and market capitalization in 2001 to 2008 in Taiwan. Our results show that the impact of innovation capital on the financial performance is more significant than that of structural capital has a significant influence. It is an interesting feature of listed companies in Taiwan, for mostly as manufacturing enterprises, Taiwan companies prefer bulk orders to client marketing. Taiwan companies are also found to be prone to rely more on government subsidiary to conduct R&D activities and obtain technology advanced from developed economies.

Directions for future research include: First, in addition to financial reports, the authorities should promote the disclosure of intellectual capital reports consisting of intangible assets such as patents, trademark property, and company reputation and so on. As intangible assets bring forth competitiveness for enterprises, a report of intellectual property shall be important for more accurate valuation of companies in Taiwan. Second, the measurement of intellectual capital needs to be further improved; we found that the relationship between structural capital and financial performance remains insignificant. Thus it is necessary to redesign and further improve measurement for structural capital, say, we can integrate employee turnover as a possible proxy for structural capital.

Third, due to space limitation, this paper does not discuss the case of organizational restructuring such as mergers, acquisitions, spinoffs and carve outs. However, as organizational restructuring can influence significantly a company's intellectual capital, we need to pay more attention to the impact of organizational restructuring on intellectual capital in future research.

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