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Discussion on Mediation of Innovation Capital toward Human Capital and Performance – A Case Study of the Industry of Integrated Circuit Design

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ABSTRACT

There are many studies of intellectual capital affecting enterprise performance, but no empirical research has been carried out by scholars on mediation effect of innovation capital between human capital and enterprise performance. This research selects Taiwan's listed and OTC companies in the industry of integrated circuit design are selected as a case study and with the Panel data model verifies their correlation. It is discovered from the research result that employee value added in human capital correlates positively with enterprise performance; employee productivity in human capital has positive correlation with R&D intensity in innovation capital; employee value added in human capital shows positive correlation with R&D productivity in innovation capital. Those verify and demonstrate innovation capital is the mediator between human capital and enterprise performance.

Keywords: Intellectual Capital, Innovation Capital, Human Capital, Mediation Effect, Enterprise Performance.
JEL Classification: C1; G2; M2

INTRODUCTION

For the information and electronic industry that stresses technical R&D and innovation, in the knowledge economy era, intellectual property is considered as a crucial factor in successful business operation. The value that enterprises rely on is changed from tangible resource to intangible resource. Therefore, intellectual capital which concerns successful future and long-term profit of enterprises emerges. Most of the literature reveals that "intellectual capital" is the force driving and creating the value of enterprises as well as brings them competitive advantage which has positive effect on enterprise performance (Amir & Lev, 1996; Edvinsson & Malone, 1997; Stewart, 1997; Sullivan, 2000; Johanson, Mårtensson & Skoog, 2001a, 2001b).

According to Wang and Chang's (2004) categorization and elements, intellectual capital is classified into Human Capital, Relationship Capital, Innovation Capital, Process Capital (Liebowitz & Wright, 1999; Horibe, 1999; Hou & Hsu, 2013; Chen, Hsieh & Chen, 2013; Hejazi, Ghanbari, & Alipour, 2016). The study took the listed and OTC-listed semiconductor companies as the subject, and discussed actual data through partial least squares (PLS). It was shown from the research result that the four elements not only, separately, directly affect enterprise performance, but have mutual correlation that then influences enterprise

performance. However, mediation effect or interference effect of four elements on enterprise performance was not discussed that motivates this study as Motive 1.

Taiwan relies greatly on knowledge-intensive electronic industry. Semiconductor is an essential part of electronic product, which indicates intellectual capital deeply influences performance. The semiconductor industry comprises Integrated Circuit (IC) design, wafer foundry and IC package testing. As business environment changes fast and product lifecycle rapidly shortens, IC design industry has to always develop new products. In addition to the cultivation of external competitiveness, the process of new product development requires internal knowledge integration and internalization of knowledge capacity. The studies by Wu, Tsai, Chang and Lai (2006), Chiou, Wang, Wei and Chien (2011), Huang, Wu and Tsai (2016), and by Wu, Chen, Chen and Chien (2019) pointed that IC design needs no expensive machinery or fixed assets, but has to center on R&D and innovation ability, which is a knowledge- and innovation-intensive industry of high value added. Intellectual capital and R&D team are crucial for IC design companies in competition. It is known from the above literature that the relationship between intellectual capital and performance in the IC design industry is worth a discussion that motivates this study as Motive 2.

Hence, the empirical study plans to investigate the correlation among the elements of intellectual capital and its effect on performance by taking the listed and OTC-listed IC design industry in Taiwan as the object. The purpose of the study is as below:

1. Does human capital in IC design industry affect its performance?
2. Does human capital in IC design industry influence its innovation capital?
3. Does innovation capital in IC design industry have mediation effect on human capital and performance?

LITERTURE REVIEW

High-tech industry needs innovation to make more profits, so companies have to keep investing a great deal of money in R&D to maintain innovation that makes profits. Thus, how high-tech companies create the value of enterprise in future products and services, enhance employees' coherence and creativity, and retain the superiority of R&D specialists is the priority. Taiwan semiconductor industry (includes design, manufacturing, package, testing) plays a very important role in global semiconductor industry. IC design needs no expensive machinery or fixed assets; R&D and innovation ability are important assets to companies. It is a knowledge- and innovation-intensive industry of high value added. Intellectual capital and R&D team are crucial for IC design companies in competition (Wu, et al., 2006; Chiou, et al., 2011; Huang, et al., 2016; Wu, et al., 2019).

According to Stewart (1997), intellectual capital generally refers to a combination of knowledge and ability used to create competitive advantage by every employee in a company, which is categorized into Human Capital, Structure Capital and Relationship Capital. Human capital is even considered as the power of company development. Intellectual capital is not specifically defined because its elements vary from features of an industry and a company (Edvinsson and Malone, 1997). As intellectual capital is extensively discussed, its categorization has been consistent with Bontis' (1998) framework including basic elements such as human capital, structure capital and relationship capital. Analysis of intellectual capital with the three elements including human, structure and capital is not to make them completely separated, but to identify their correlation. Nicholson and Kiel (2004), in the study on how to control a company's intellectual capital, categorized intellectual capital into human capital, structure capital and relationship capital. Besides, they expanded its meaning by incorporating

any behavior helpful to organization in relationship capital of company. A resource owned by employees within an organization is "human capital", which contain trait, experience, know-how, technique, etc. equipped by the management and employees in addition to culture, philosophy and innovation of an organization. A resource that enhances the operational efficiency within an organization is "structure capital", namely, a system and procedure for a company to solve problem and create value. It contains overall process of an enterprise, design of organizational structure, ability of using information technology, intellectual property management and information system framework and so on. Interaction between organization and environment is "relationship capital", that is, relationship deposit between organization and all interested parties such as customer, supplier and strategic alliance. Wang and Chang (2004) categorized intellectual capital into human capital, customer capital (or relationship capital), innovation capital and process capital (Liebowitz & Wright, 1999; Horibe, 1999; Roos, Bainbridge & Jacobsen, 2001; Hou & Hsu, 2013; Chen et al., 2013; Hejazi et al., 2016). They pointed out in the research result that human capital affects innovation capital and process capital. In addition to direct influence, human capital even indirectly affects process capital through innovation capital. Process capital helps increase in customer capital which brings greater performance.

According to Stewart (1991), human capital indicates a combination of employees' knowledge, technique, capability, experience, virtual ownership, community of practice and tacit interaction in an enterprise. Edvinsson and Malone (1997) indicated that human capital should include capability, technique, knowledge and experience of all enterprise employees and managers. Besides, an organization must be aware of the changing competitive environment. Nevertheless, it is worth noting that human capital is not possessed by owners, but an asset belongs to employees. Owners only hire employees based on their capability in terms of usable part such as salary payment and remuneration (Brooking, 1996). Ulrich (1998) defined intellectual capital relevant to employees as a product of competence and commitment, who believed competent employees that are willing to make commitment to company are important asset of a company. It is discovered from the research by Lee and Witteloostuijn (1998) that fewer companies crash when they have longer duration, more experiences in the industry they are, more employees of higher education (percentage of employees with graduate school degree or higher), or closer connection with potential customers. If a company is equipped with such conditions, it has better business performance. Huang (2002) found the management of human capital and structure capital advances inner efficiency of an organization that then increases market performance and eventually helps financial performance. Many empirical researches verified human capital that includes knowledge, education, experience, technique, training and trait of employees has positive effect on performance of a company (Finkelstein & Hambrick, 1996; Chiou et al., 2011). It is known from the above studies that human capital directly influence performance. The inference and hypothesis are as follows:

H_1: Human capital directly affects enterprise performance positively.

Human capital, the fundamental component of intellectual capital, can be regarded as the core resource and ability of an organization that helps the organization obtain fair competitive advantage (Lepak & Snell, 1999). Stewart (1997) thought intellectual capital generally refers to a combination of knowledge and ability used to create competitive advantage by every employee in a company. Human capital is even considered as the power of company development. Sáenz, Aramburu and Rivera (2009) researched knowledge exchange and innovation achievement in innovation capital, compared the difference in value creation between high-tech companies and non-high-tech companies. According to the research result, innovation achievement utilized in high-tech companies shows greater influence. While

accumulation of innovation capital depends on encouragement and active investment by enterprise, cultivation and development of employees' ability such as creativity are also important as knowledge and ability of employees are the source of innovation and outlook (Stewart 1997; Edvinsson & Malone, 1997; Hauschild, Licht & Stein, 2001). Apparently, human resource activity makes positive impact on innovation performance (Darroch & McNaughton, 2002; Forrester, 2000). Snell and Dean (1992), Walton and Susman (1987), and Barney and Wright (1998) clearly indicated that organization is able to train preferable human capital through investment in human resource and related activities that facilitate innovation activity for organization. Therefore, it is assume that human capital correlates with innovation capital. Accumulation of human capital shall be contributive to improvement in innovation capital. A relevant hypothesis is established below:

H_2: Human capital positively affects innovation capital.

Chiou et al. (2011) as well as Wang and Chang (2004) believed researchers with more resources are likely to endeavor to propose and realize new idea and opinions, who reveal positive contribution to performance. Hall and Bagchi-Sen (2002) took 74 Canadian biotech companies as the object of study to investigate correlation among their R&D intensity, innovation and performance during 1994-1997. R&D intensity was measured with patent. The result of the study shows more patent applications increase the profits of a company. The study by De Carolis (2003) found the number of patents and cited patents positively influences business performance. According to Kuo's (2009) research, it is discovered that human capital and innovation capital owned by parent companies of Taiwanese entrepreneurs directly affect business performance of their subsidiaries in China. Wang and Chang (2004) stated human capital is the most fundamental component of intellectual capital. Empirical researches reveal the influence of human capital on innovation capital, and the correlation between which affects enterprise performance. However, the present literature does not test the mediation effect of innovation capital on human capital and performance. Discussing from each dimension of intellectual capital, in human capital, knowledge and ability of employees are the source of innovation and outlook as well as the foundation for creating organizational value. Structure capital is accumulated through cultivation and development of employees' creativity (Hauschild, et al., 2001; Bontis & Serenko, 2009). Due to devotion of researchers along with fund investment and introduction of overseas technology, innovation achievement is finally transformed into performance and goal of a company (Wang & Chang, 2004; Chang, Lu & Wu, 2010; Hsieh & Chen, 2013). It can be seen that dimensions of intellectual capital correlate, that is, each dimension is influenced by another dimension (Huang, 2002). Taking the above literature as reference, it is considered in the study that innovation capital is a crucial mediator with assumption as below.

H_3: Innovation capital is the mediator between human capital and enterprise performance.

METHODOLOGY

Source of sample material

The study aims to investigate with actual data the correlation between the elements of intellectual capital and performance. Taiwan listed and OTC-listed IC design companies are selected as the object of study. The samples to be studied are obtained from the database of Taiwan Economic Journal in addition to company's annual report and prospectus. The studied samples refer to data during 2006-2012, 7 years in total. Delete the annual data of the companies if they are of error or missing. Thus the data in this study are "Balanced".

Measurement of variables

Empirical researches into the effect of intellectual capital on enterprise performance adopted few variables, so the selection of variables in this study will include message from annual report and public information as many as possible. The appropriate pointer variables are selected from the elements such as human resources, innovation capital and performance. Human capital is technique, ability, knowledge and experience owned by individuals, which is helpful to organizational productivity (Stward, 1997; Lynn, 2000; Sânchez, Chaminade & Olea, 2000). Accumulation and utilization of human capital increase one's income and productivity (Lazear, 1998; Kaufman, 1994). Hence, employees' productivity, operation income/employee, employee value added of the case study companies are applied in the study to reflect employees' ability and value that show the level of human capital in the company.

Canto and Gonzalez (1999) indicated innovation activity in a company mainly comes from internal investment such as R&D activity which has a complete and crucial contribution to future development of innovation in company. Innovation activity also comes from external resources through purchasing or cooperation by technology acquisition or license agreement. How to effectively obtain external knowledge or technology is important for competitive advantage. The variables selected for innovation capital include: R&D productivity that reveals investment of innovation resources brings concrete benefits, and R&D intensity that shows respect for R&D by investing greater resources in R&D. Return on asset (ROA) represents enterprise performance in the study.

According to Weir and McKnigh (2002) and Haniffa and Cook (2002), enterprise on a smaller scale is creative, innovative and of change mechanism, which enhances the value of company more quickly. The research result also revealed that the scale of company negatively correlates with performance, i.e. enterprise on a smaller scale makes better business performance. Therefore, an organization on a smaller scale gets superior innovation performance through prompt innovation activities. Accordingly, negative correlation is supposed to exist between the scale of company and enterprise performance as well as between human capital and innovation capital. According to the study by Huang, Huang and Chang (2011), higher capital expenditure indicates active investment by company, increasing investment in fixed equipment, reduction of product cost or offering of product quality to strengthen competitiveness in a market. The study by Su, Yu, and Yang (2013) considered that higher capital expenditure represents a company has faith in its future development and is willing to invest in R&D with a confidence in enhancing performance. Accordingly, positive correlation is supposed to exist between capital intensity and company performance as well as between human capital and innovation capital. The scale of enterprise and capital intensity are the control variables in the study. Table 1 has the variables for the study; Figure 1 shows the research framework.

Table 1 Definition of variables

Variables	Manipulated variables	Variables definition and description	Relevant literature
Human capital	Employees' productivity	Net sales/Total employees	Tsai, Yang, Wu & Huang, 2008; Chiou et al.,2011
	Operation Inc./Emply	Net operating income/ Total employees	Ou, Chen & Lee, 2004
	Employee value added	Net income/ Total employees	Wang and Chang, 2004
Innovation capital	R&D productivity	Net income/R&D expenses	Aboody and Lev, 2000
	R&D intensity	R&D expenses / Total asset	Liu, Lin & Chin, 2005
Performance	ROA	Net income /Total asset	Chen, 2004; Kuo, 2009
Control variables	Scale of enterprise	Total asset	Weir and McKnigh, 2002; Chiou et al., 2011
	Capital intensity	Fixed asset / Total employees	Su et al., 2013

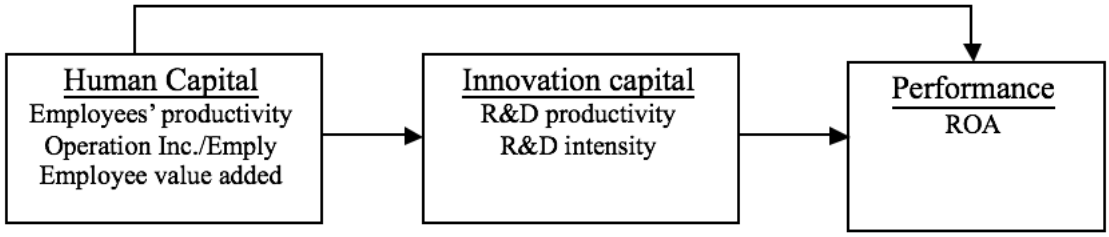

Figure 1 Research Structure

Statistical method and procedures

When data has characteristics of time series and cross-section, dependent variables are often heteroscedastic in analysis with Ordinary Least Squares Estimation (OLS), and time series has residual autocorrelation leading to inefficient result under OLS estimation (Kalton, Kasprzyk & McMillen, 1998). To settle the estimation error, Panel Data model is used. Information about cross-section and time series is introduced into metric model for effective estimation. If severe multicollinearity exists in explanatory variables for the model, estimation of regression coefficient may err. Thus it is necessary to understand if there is severe multicollinearity before regression analysis.

Each hypothesis in the study is estimated with Ordinary Least Squares Estimation (OLS), fixed effect model and random effect model. The suitable model is selected for an optimal fitting model to get correct estimation. However, among the three models, which is the most suitable has to be determined by F-test and Hausman test.

EMPIRICAL RESULTS AND ANALYSIS

STATA 11.0 software is applied to an empirical research into the research hypotheses.

Descriptive statistics

Table 2 has the mean, standard deviation, minimum and maximum of the studied samples. The total samples in the study are 140. The maximum of ROA is 38.08 and the minimum is –71.91. The maximum of employees' productivity is 45628 and the minimum is 1349. The maximum of operation income/employee is 10990 and the minimum is -2932. The maximum of employee value added is 11016.21 and the minimum is -13703.9. The maximum of R&D productivity is 10.86595 and the minimum is -24.9446. The maximum of R&D intensity is 0.369847 and the minimum is 0.005141. The maximum of enterprise scale is 2.10E+08 and

the minimum is 205630. The maximum of capital intensity is 2669.07 and the minimum is 49.42308.

Table 2 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ROA	140	4.562857	14.97156	-71.91	38.08
Employees' productivity	140	9595.9	7849.668	1349	45628
Operation Inc./Emply	140	1207.35	2407.82	-2932	10990
Employee value added	140	1019.759	2937.758	-13703.9	11016.21
R&D productivity	140	0.400379	3.299447	-24.9446	10.86595
R&D intensity	140	0.114285	0.068221	0.005141	0.369847
Enterprise scale	140	1.33E+07	2.96E+07	205630	2.10E+08
Capital intensity	140	1080.595	577.4051	49.42308	2669.07

Correlation analysis

To discuss collinearity resulting from the correlation among independent variables in this section, the study adopts Variance Inflation Factor (VIF) to test the level of collinearity among variables. If VIF < 10, collinearity among variables is not severe, otherwise variables in high collinearity have to be deleted in order to keep the study going. It is known from Table 3 that all relevant coefficients are lower than 10 showing no collinearity (Meyers, 1990).

Table 3 VIF value

Variable	VIF	1/VIF
Employees' productivity	7.24	0.138158
Employee value added	5.76	0.173485
Operation Inc./Emply	3.34	0.299238
R&D productivity	1.83	0.546403
Capital intensity	1.45	0.692001
R&D intensity	1.4	0.714109
ROA	1.27	0.789826
Mean VIF	3.18	

Regression result

OLS, fixed effect model and random effect model are adopted in the study for analysis of information in the hope of obtaining firm result. For which model is the most suitable, F-test is used first to test the selection of fixed effect and OLS, and Hausman test is adopted to test the selection of random effect and fixed effect for final model selection. Table 4 reveals the suitable model selected for each Model in the study. In the study, model 2 is added with a control variable – the scale of enterprise, and model 3 is added with capital intensity. The study is mainly based on model 3.

It is known from Table 4 that employees' productivity has no remarkably positive effect on ROA (β= -0.1596, $p > 0.1$). Operation income/employee shows no significantly positive influence on ROA (β= 0.1687, $p > 0.1$). Employee value added has notably positive effect on ROA (β= 0.8777, $p < 0.01$). H_1 is partly valid.

Employees' productivity shows no remarkably positive influence on R&D productivity (β= 0.0165, $p> 0.1$). Operation income/employee shows no significantly positive influence on R&D

productivity (β= 0.1052, p> 0.1). Employee value added has notably positive effect on R&D productivity (β= 0.1052, p< 0.01). Employees' productivity has remarkably positive influence on R&D intensity (β= 0.3127, p < 0.05). Operation income/employee shows no significantly positive influence on R&D intensity (β= -0.4999, p < 0.01). Employee value added has no notably positive effect on R&D intensity (β= -0.0805, p> 0.1). H_2 is partly valid.

It is known from the testing of mediation effect in Table 4 that employee value added has notably positive effect on ROA and R&D productivity. The mediator R&D productivity remarkably influences performance ROA (β= 0.2252, p< 0.01). It is found from another testing that $|0.7134| < |0.8777|$, which shows R&D productivity has partial mediation on employee value added and performance ROA (Baron and Kenny, 1986). Employees' productivity shows no remarkably positive influence on ROA, but scholars think the step 1 of the mediation effect testing conducted by Baron and Kenny (1986) is unnecessary (Collins, Graham & Flaherty, 1998; MacKinnon, Krull & Lockwood, 2000; Shrout & Bolger, 2002). Employees' productivity in this study shows remarkably positive influence on R&D intensity. The mediator R&D intensity shows notably negative impact on ROA (β= -0.3028, p < 0.01) indicating R&D intensity has complete mediation on employees' productivity and ROA. Operation income/employee has significantly negative effect on R&D intensity. The mediator R&D intensity shows notably negative impact on ROA (β= -0.3028, p < 0.01) indicating R&D intensity has complete mediation on operation income/employee and ROA. H_3 is partly valid.

Table 4 reveals enterprise scale has no significantly negative impact on ROA (β= 0.2337, p > 0.1), which is completely different from the result of the study by Weir and McKnigh (2002) and Haniffa and Cook (2002). However, enterprise scale shows remarkably negative effect on R&D intensity (β= -0.4350, p < 0.01) indicating an organization on a smaller scale is with prompt innovation activities. Capital intensity negatively affects ROA notably (β= -0.2208, p < 0.05), which is different from the result of the study by Huang et al. (2011). Also, capital intensity has remarkably negative effect on R&D productivity (β= -0.7492, p < 0.01) and R&D intensity (β= -0.1513, p < 0.1).

Table 4 Empirical result

		Model 1			Model 2			Model 3		
		Performance	Innovation capital		Performance	Innovation capital		Performance	Innovation capital	
		ROA	R&D productivity	R&D intensity	ROA	R&D productivity	R&D intensity	ROA	R&D productivity	R&D intensity
Human capital	Employees' productivity	-0.1561	-0.1503	0.073	-0.1726	-0.1337	0.2224	-0.1596	0.0165	0.3127 **
	Operation inc./emply	-0.0246	-0.2896 *	-0.2876 **	-0.0123	-0.2656	-0.5054 ***	0.1687	0.1052	-0.4999 ***
	Employee value added	0.9655 ***	0.9591 ***	-0.0485	0.9621 ***	0.9638 ***	-0.0316	0.8777 ***	0.1052 ***	-0.0805
Control variables	Enterprise scale				1.281 **	-1.07	-0.3979 ***	0.2337	0.1054	-0.4350 ***
	Capital intensity							-0.2208 **	-0.7492 ***	-0.1513 *
	F-test	0	0.7872	0	0	0.7988	0	0	0.0053	0
	Hausman	0.9183		0.5198	0.4158		0.0265	0.0437	0	0
	Model	random	ols	fixed	random	ols	fixed	fixed	fixed	fixed
	R-squared	0.6516	0.4208	0.1531	0.6547	0.4282	0.2130	0.6796	0.5156	0.2355
Mediation testing	Employees' productivity	-0.1259			-0.1540			-0.1406		
	Operation inc./emply	-0.0222			-0.0033			0.0098		
	Employee value added	0.7274 ***			0.7192 ***			0.7134 ***		
	R&D productivity	0.2399 ***			0.2416 ***			0.2252 ***		
	R&D intensity	-0.2803 ***			-0.2870 ***			-0.3028 ***		
	Enterprise scale				0.0875			0.0921		
	Capital intensity							-0.0546		
	F-test	0			0			0		
	Hausman	0.3186			0.9984			0.2525		
	Model	random			random			random		
	R-squared	0.7524			0.7546			0.7586		

CONCLUSION

In the knowledge economy era, intellectual property is considered as a crucial factor in successful business operation. Most of the literature reveals that "intellectual capital" is the force driving and creating the value of enterprises as well as brings them competitive advantage which has positive effect on enterprise performance 文(Amir & Lev, 1996; Edvinsson & Malone, 1997; Stewart, 1997; Sullivan, 2000; Johanson et al., 2001a, 2001b). Taiwan relies greatly on knowledge-intensive electronic industry. Semiconductor is an essential part of electronic product, which indicates intellectual capital deeply influences performance. The study takes IC design industry as the sample. As business environment changes fast and product lifecycle rapidly shortens, IC design industry has to always develop new products. In the course of new product development, intellectual capital plays a more important role. The research result reveals that human capital and innovation capital not only, separately, directly affect each other, but have correlation that then influences enterprise performance.

The result of the study responds to positive effect of human capital on enterprise performance that scholars believed (Darroch & McNaughton, 2002; Forrester, 2000; Snell & Dean, 1992; Walton & Susman, 1987). Meanwhile, the empirical result reveals positive influence of human capital on innovation capital in response to what scholars suggested that knowledge and ability of employees are the source of innovation and outlook as well as the foundation for creation of organizational value (Hauschild, Licht & Stein, 2001; Bontis & Serenko, 2009). The study also unveils that R&D productivity subordinated to innovation capital has partial mediation on employee value added and performance ROA. In addition, R&D intensity has complete mediation on employees' productivity and ROA as well as operation income/employee and performance ROA. The research result makes up a deficiency of discussing existence of mediation effect of innovation capital on human capital and performance in literature (Huang, 2002; Wang & Chang, 2004; Kuo, 2009).

In the knowledge economy era, the business performance of IC design industry is enhanced mainly because investment in human capital and innovation capital is increased. It is known from the result of the study that R&D intensity has remarkably negative effect on ROA, which indicates investment by IC designers in R&D resource does not positively affect enterprise performance. The result and the study by Chiou et al. (2011) show that the investment in innovation capital is mostly wasted. IC design industry invests considerably in innovation capital and products developed are not quite successful. However, disregard of investment in innovation capital may lead to loss of competitiveness. Thus, it is suggested in the study that IC designers properly invest in innovation and human capital to avoid wasting of resources.

Contribution of the study

According to the result of the study, human capital and innovation capital directly affect enterprise performance. Moreover, innovation capital is of mediation effect between human capital and enterprise performance, that is, human capital through innovation capital influences enterprise performance to further investigate the correlation among the elements of intellectual capital.

Limitation of the study and suggestion for following researches

1. As some IC designers are not listed and OTC-listed in Taiwan, data collection is constrained. It is hoped that scholars break such limit someday by discussing the materials of all IC designers to improve the accuracy of industrial analysis.

2. The study aims only to evaluate Taiwanese IC designers. If other researchers later are able to garner the materials of foreign IC designers, both of data can be compared.

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