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An Exploration of the Intellectual Capital of the Biotechnology Industry: The Experience of Taiwan

Hsiukan Lin

Associate Professor, Department of Finance, Overseas Chinese University, Taiwan

Tsangyao Chang

Assistant Professor, Department of Finance, Overseas Chinese University, Taiwan

Chuntsen Yeh

Assistant Professor, Department of Finance, Chang Jung Christian University, Taiwan

Abstract

The biotechnology industry is one of the six emerging industries in Taiwan. Taking listed on the Taiwan Stock Exchange (TSE) companies and over-the-counter (OTC) companies which form part of the biotechnology healthcare industry in Taiwan during the period 1996-2008 as the research object, this paper uses factor analysis and regression models to explore the critical intellectual capital (IC) factors influencing enterprise value, with the aim of providing relevant information regarding the biotechnology industry to the administering authority to use as a reference. According to the empirical research results: (1) human capital, process capital, internal innovation capital, external innovation capital and customer capital are five critical IC factors (dimensions) influencing the value of the biotechnology industry; (2) human capital, internal innovation capital and external innovation capital have a significant and positive relationship with the creation of enterprise value, while process capital and customer capital have a negative impact on the creation of enterprise value; and (3) Taiwan's biotechnology companies should improve their process capital and customer capital in order to create enterprise value effectively.

Keywords: Intellectual capital, Biotechnology industry, Factor analysis, Taiwan

Introduction

In recent years, the knowledge revolution in the fields of electronics, information, molecular biology and other areas has not only led to technological innovations, but has also become the main motivation behind the growth of the world's economy. People's lives have undergone a tremendous change with the

Corresponding author's details:

Name: Hsiukan Lin

email address: lkin@ocu.edu.tw

development of biotechnology, pharmacy and other technologies. In 2003, the Human Genome Project (HGP) finished decoding the human genome, which opened the gates to further exploration of the fundamental elements of life. The HGP has provided huge business opportunities to industries which are now unlocking the secrets of the human body and developing new medicines for incurable diseases. It has also provided opportunities for the medical care industry, encouraging biotechnology industry dealers to use biotechnology in relevant areas like biology and medical care in order to further improve people's lives.

Harvard Business Review predicted that biotechnology, the Internet, the modernization of Chinese medicine and mobile communication will be the four most important industries in the next 20 years. In 2009, Ernst and Young investigated the revenue of the biotechnology medical industries of the United States, Europe and the Asia Pacific Region between 2004 and 2008, the results of which show that: the revenue of the global biotechnology industry increased by 64% from 2004 to 2008; the revenue of the American biotechnology industry is comparatively higher than other regions, and shows a stable development trend; revenue in the European region has witnessed a dramatic increase of 114%; and the revenue of the Asia Pacific Region is comparatively lower than that of other regions, but has experienced significant growth of 138%, which makes the Asia Pacific Region the fastest growing region in terms of its biotechnology industry in the world.

In its report of 1996, the Organization for Economic Co-operation and Development (OECD) defined a knowledge-based economy as an economic pattern that possesses, allocates, produces and uses knowledge as its key point. The OECD believes that, in the era of knowledge-based economies, knowledge is the crucial factor in the allocation, production, means of labor and consumption patterns of resources. Individuals and companies which own knowledge and have significant knowledge management capabilities are more competitive in the market, and those who can create knowledge will possess a sustainable competitive advantage. As Machlup (1962) pointed out, the knowledge industry includes research and development (R&D), education, information equipment, information services and communications media. Thurow (2000) held that knowledge-based enterprise is the most valuable form of enterprise in the 21st century, and that the elements of production such as capital, natural resources and manpower which are discussed in traditional economics are no longer the basic economic resources; instead, knowledge has become the most important economic resource. In the era of knowledge-based economies, knowledge provides the best advantage in the competition between enterprises. The biotechnology industry is not only an industry with great potential, but also a knowledge-oriented industry. In order to enhance and promote the development and competitiveness of Taiwan's biotechnology industry, it will be necessary to develop and use knowledge-based economy.

Within the activities of enterprise operation, knowledge management includes aspects like strategic planning, R&D, product design, information technology, human resources, production and marketing and operational performance. Every aspect includes the distinct criteria of process, operational systems, professional knowledge and external information. These complicated, interactive activities are not only the source of the enterprise's intellectual capital (IC), but also the main factors which enable the enterprise to retain its competitive advantage. Guthrie (2001) stated that a successful enterprise not only utilizes its intangible assets in order to create profitability, but also regards intellectual information and knowledge creation as critical conditions for business success. Ghosh and Wu (2007) indicated that, after controlling for the effect of financial performances on firm value, measures of IC are still significant explanatory variables (of firm value). Chang and Hsieh (2011) found that a company's IC is general has a negative impact on its financial and market performance. As most scholars pointed out, IC is significantly correlated with knowledge, experience, capability, intelligence and innovation. IC has the characteristics of non-depreciation and maximal value creation, which occupies a critical position in the innovation performance of the organization. Thus, it is necessary to know the effects of IC

on enterprise value creation. There are comparatively few studies on the IC of the biotechnology industry and enterprise value, which provides the motive for this study.

Hansson (1997) and Lev (2001) pointed out that the market value of knowledge-intensive industries is far more than the book value of their return on equity, and that its spread appears to be enlarging. The spread of market value and book value is generally related to intangible assets (Lev, 2001). Tangible assets like land, raw materials and equipment are losing their importance in the era of knowledge-based economies, and intangible assets like competence, knowledge and technology, which do not appear in financial reports, have taken their place. The biotechnology industry occupies a crucial position in the promotion of integral national development and competitiveness, and IC has become a critical factor [2] which influences enterprise evaluation. Suraj and Bontis (2012) collected from 320 managers in 29 telecommunications companies in Nigerian. They found that Nigerian telecommunications companies have mostly emphasized the use of customer capital, exemplified by market research and customer relationship management to boost their business performance. The purpose of this study is to explore the correlation between IC and the value of Taiwan's biotechnology industry, which differs from the purpose of previous studies which have explored the factors influencing enterprise value or performance from the perspective of corporate governance or financial indicators. Studies voicing different opinions can enrich the discussion in this field.

[2] Read et al. (2001) explored the multiple of net assets' market value to book value from the perspective of industry, and discovered that the market value of the technology industry is more than tenfold the net assets' book value. In addition, the media industry surpasses twentyfold, and the manufacturing industry exceeds thirtyfold.

This paper is organized as follows. Section 2 covers the literature review and establishes the hypotheses. Section 3 lays out the research design and describes the sources of data, empirical models and variables. Section 4 provides the analytical results of the hypotheses testing. The paper then concludes with a final statement and the limitations of the research.

Literature Review and Research Hypotheses

The OECD indicated that IC plays a critical role in enterprise value and that it effectively improved the labor productivity in the US between 1995 and 2003. The OECD and the European Union (EU) lay great emphasis on the importance of IC. Since the 1990s, there have been relevant articles discussing issues relating to IC, and many private enterprises (especially Research and Development intensive enterprises) began using all kinds of IC indicators, such as job satisfaction, process efficiency and customer satisfaction, to measure enterprise value, from which we can see that IC has received increasing amounts of attention.

McConomy and Xu (2004) pointed out that the development of the pharmaceutical industry is a long-term process, and that its success depends on continuous positive clinical testing and government permission. Therefore, the establishment of biotechnology industry value and the achievement of virtual profits is a long-term process. Although the development of Taiwan's biotechnology industry has been underway for more than 20 years, it is still at the embryonic stage. Its development model follows the model of countries such as the United States, Canada, Europe and Japan, which first laid the foundations for biotechnology R&D, and then promoted large-scale biotechnology projects, cultivated talent and accumulated R&D power. Over the past 20 years, the information industry has become "a trillion industry" for Taiwan; on the other hand, the development of the biotechnology industry has not experienced a breakthrough because of its high-risk characteristics and the long process from R&D to the successful development and commercialization of products. In this case, the government listed

the biotechnology industry as one of the six emerging industries[3] and passed the "Act for the Development of the Biotech and New Pharmaceuticals Industry" on June 15, 2007. This act offers rewards and preferential measures in order to encourage biotechnology practitioners to invest. Practitioners can enjoy rewards including R&D, investment credit for stockholders, postponed tax on technology investment income and tax incentives until 2021. This new act will help to develop Taiwan's biotechnology industry.

The White Book on the Biotechnology Industry in Taiwan (2009) illustrates the situation of Taiwan's biotechnology industry from 2006 to 2008. The data indicate that the turnover, the number of companies, employees, export and import value and domestic market demand all increased. In addition, in order to promote the competitiveness of the biotechnology industry, the government is continuously adjusting its industrial policy, increasing reward measures and has listed the biotechnology and new pharmaceuticals industry as the only one to enjoy tax exemption. Meanwhile, the government has also established Biotechnology Parks in order to encourage businesspeople to register or enlarge their biotechnology companies, hoping to successfully reproduce the cluster effect of Science Parks so as to improve dealers' willingness to invest in the biotechnology industry.

Definition and Classification of Intellectual Capital

There is no consistent definition of IC in the literature. The concept of IC was first proposed by Galbraith (1969), as a form of knowledge, intellect and brain activity, which means that enterprises can use knowledge to create value. Therefore, IC is the spread of the enterprise's market value and book value. Roos and Roos (1997) defined IC as the logo, brand or operation process which results from the knowledge of all members of staff during the working process, and which can also include any intangible element which can create value or increase the enterprise's total value and financial value. Stewart (1994) defined IC as the total of the collective knowledge, information, technologies, intellectual property rights, experience, organizational learning and competence, team communication systems, customer relations and brands that are able to create value for a firm and to promote the firm's competitive advantage.

Edvinsson and Malone (1997) defined intangible assets as IC, knowledge capital, non-financial capital and invisible assets, and they held that IC will increase a firm's market value and its book value. Masoulas (1998) stated that IC is the combination of intangible assets, while Guthrie (2001) indicated that a successful firm not only uses intangible assets to create profit, but also treats intellectual information and knowledge creation as its main resources. Shaikh (2004) and Phusavat and Kanchana (2007) suggested that any knowledge capabilities stemming from manpower, creativity, knowledge structures or affiliated aspects can be classified as IC, providing that these capabilities can store and convert knowledge for value creation in the future or translate the implicit knowledge of employees into explicit knowledge for organizational structurization. Cheng et al. (2008) employed censored regressions and Linear Least Squares (OLS) regression models in order to analyze whether innovation, customer, human and process capital is affected by firm value. They found that innovation, customer and human capital have a positive effect on IC. Schiuma and Lerro (2008) regarded human, relational, structural and social capital as the four main knowledge-based constructs which constitute knowledge-based capital, and found that decision-makers were inclined to formulate strategies by using

[3] The six emerging industries are the tour industry, green energy industry, delicate agriculture industry, biotechnology industry, health care industry and culture creativity industry. Biotechnology is further divided into four categories: the biotechnology pharmacy national project, genomic medicine national project, biotechnology Silicon Island project and a development project for agricultural biotechnology industrialization.

this knowledge-based capital for the development of their innovation capacity. Walsh et al. (2008) indicated that the investments of companies in the enhancement of human capital, structural capital and customer capital would increase their organizational value. To sum up, the definition of IC which will be used in this study follows the viewpoint of Edvinsson and Malone (1997) and Cheng et al. (2008), which suggests that IC comprises intangible assets, which include a combination of identifiable intangible assets and non-identifiable intangible assets.

Previous studies divided IC into three dimensions: human, structural and customer capital (Stewart, 1994; Cabrita and Vaz, 2006; Lynn, 1998; Johnson, 1999), or four dimensions: human, process, innovation and customer (relational) capital (Edvinsson and Malone, 1997; Joia, 2000; Cheng et al., 2008; Walsh et al., 2008; Schiuma and Lerro, 2008). This study follows the classification method used by other scholars, and divides IC into four parts: human, process, innovation (include external and internal innovation) and customer capital. This study generates hypotheses which are relevant to enterprise value creation.

Assessment Method

There are five methods for assessing IC: (1) Tobin's Q (Tobin and Brainard, 1968) is measured by the market value of corporate assets divided by the replacement cost; (2) Edvinsson and Malone (1997) suggested that the net market value difference can be measured by subtracting financial costs from the enterprise market value; (3) value-added IC (VAIC): Pulic (2000) pointed out that VAIC = VACA + VAHU + STVA[4]; (4) calculated intangible value (CIV), a method of valuing a company's intangible assets, which was put forward by the subsidiary body of Northwestern University's Kellogg School of Business: CIV = {(1-tax rate) x excess return}/discount rate; and (5) economic value-added (EVA), which uses the concept of residual income in order to transform accounting information into economic reality, and holds that value is created when the EVA is a positive value and that the return on the firm's capital employed is greater than the weighted average cost of capital (WACC). The measurement is EVA=(r-WACC) x K. Due to the convenience of obtaining data, this paper used the second method in order to evaluate IC.

[4] VAIC (Valued Added Intellectual Capital); VACA (Valued Added Capital); VAHU (Valued Added Human Capital); STVA (Valued Added Structure)

Key Elements and the Establishment of Hypotheses

This section illustrates the relationship between the various elements of IC and enterprise value creation, and establishes relevant hypotheses regarding enterprise value creation.

Human Capital

Human capital is the basis of any enterprise's competitive advantage, as it creates IC and combines with employees' competences, attitudes and intelligence (Roos, Edvinsson and Roos, 1998); Walsh et al. (2008) indicated that an increase in companies' investment in human capital, structural capital and customer capital would increase their organizational value. Snell and Dean (1992) and Heskett et al. (1994) put forward the same idea. This study predicts that human capital will have a positive impact on enterprise value creation. The first hypothesis (H1) is as follows:

H1: Human capital and enterprise value creation are positively correlated.

Process Capital

Joia (2000) pointed out that process capital includes the internal and external operational processes of the organization; the latter involves relationships between the organization and other related parties. Wang and Chang (2004) explored the correlation between IC and performance within the listed on the TSE and OTC companies of the Taiwanese semiconductor industry using the partial least squares approach. The results indicated a significant positive correlation between process capital and the performance

of enterprises. Considering the difference in the product life-cycle of the biotechnology industry and that of high-technology industries, process capital may have distinct effects on the performance of the biotechnology industry. This article expects process capital and the creation of enterprise value to be correlated. Hypothesis 2 (H2) is as follows:

H2: Process capital and enterprise value creation are correlated.

Innovation Capital

Hall and Bagchi-Sen (2007) used Americans biotechnology manufactures as the study object and discovered that R&D investment and innovation indicators such as patents are correlated with the enterprise's financial performance. Biotechnology in Taiwan has the potential to exploit innovative products[5], while enterprise innovation can be achieved through domestic R&D or by purchasing well-developed patents and technologies from abroad. Sougiannis (1994), Lev and Sougiannis (1996), Liu (2001) and Ou (1998) believed R&D expenditure and density to be a measurement of the innovational capacity of enterprises. This article measures internal innovational assets using R&D density and measures the proxy variable of external innovational assets using royalties and expenditure on technology. This article predicts a positive correlation between innovation assets and the creation of enterprise value. Hypotheses 3 and 4 (H3 and H4) are as follows:

H3: Internal innovation assets and enterprise value creation are positively correlated.

H4: External innovation assets and enterprise value creation are positively correlated.

[5] Taiwan has a total of about 6000 patents authorized by the United States, and is ranked at No.4 worldwide. Its patents for the biotechnology industry rank at No.13 and those for the manufacturing industry are also among the best. (The Liberty Times, 2009).

Customer Capital

Bontis (1998) pointed out that customer capital refers to the external intangible capital owned by enterprises, including their knowledge of the external relationships of other enterprises. Cheng et al. (2008) used America's healthcare industry as the study object and discovered that companies with more customer capital are able to create more IC. This article predicts a positive correlation between customer capital and the creation of enterprise value. The fifth hypothesis (H5) is as follows:

H5: Customer capital and enterprise value creation are positively correlated.

Methodology

Sample and Data

This research makes use of firm-level data from 1996 from biotechnology firms listed on the TSE and OTC. The industry code is 22. This led to a total of 257 firm-year observations after deleting non-calendar year companies and companies with incomplete information. The financial data were adopted from the database of the Taiwan Economic Journal (TEJ) and referenced against the annual financial statements and prospectuses of enterprises.

Empirical Model

Many variables are used to measure IC, and there are no unanimous measurement criteria. This study applied factor analysis method (the principle component method) to extract appropriate factor dimensions and multivariate analysis (MANOVA), and then used a regression model to analyze the relationship between IC and the creation of enterprise value.

The component factors of the IC dimensions are numerous, which may easily cause an issue if the variables present a high level of multicollinearity. Before the regression analysis was carried out, the variance inflation factor (VIF) was applied in order to test and examine whether or not it was in accord with

the basic regression conditions of the hypotheses. The regression estimation model is indicated in equation (1) and (2):

$$Y_{ij} = \beta_0 + \beta_1 HUM_{ij} + \beta_2 PRO_{ij} + \beta_3 INN_{ij} + \beta_4 CUS_{ij} + \varepsilon_{ij} \quad (1)$$

$$Y_{ij} = \beta_0 + \beta_1 HUM_{ij} + \beta_2 PRO_{ij} + \beta_3 INNI_{ij} + \beta_4 INNE_{ij} + \beta_5 CUS_{ij} + \beta_6 CUS_{ij} + \varepsilon_{ij} \quad (2)$$

where Y_{ij} is the intangible assets ratio of the firm i in year j, indicating the creation of enterprise value. Which is measured by the equation of that market value minus book value and then divided by total assets of the firm in year j. HUM_{ij} indicates the composite indicator of the original human capital items of firm i in year j, INN_{ij} represents the innovation capital comprehensive indicator for firm i in year j, including internal innovation capital ($INNI_{ij}$) and external innovation capital ($INNE_{ij}$), CUS_{ij} is the comprehensive indicator of customer capital for firm *i* in year *j* and ε_{ij} is an error term.

When we consider the interaction effect of some of the independent variables, the model is as follows:

$$Y_{ij} = \beta_0 + \beta_1 HUM_{ij} + \beta_2 PRO_{ij} + \beta_3 INNI_{ij} + \beta_4 INNE_{ij} + \beta_5 CUS_{ij} + \beta_6 (\text{interaction term})_{ij} + \varepsilon_{ij} \quad (3)$$

Similar to Equation (2), in Equation (3), the definition of variable (interaction terms) means cross-relation of capitals.

Measurement of Variables

Dependent Variable

This article refers to the method used by Cheng et al. (2008), who subtracted the enterprise's book value from its market value and then divided the result by the total assets at the end of the year in order to measure the creation of enterprise value, in which market value is the result of the stock closing price multiplied by the amount of common stock outstanding at the end of the year, while book value is the total equity at the end of the year.

Independent Variable

In line with the opinions of Edvinsson and Malone (1997), Dzinknowski (2000), Wang and Chang (2005), Chu, Hsiung and Yang (2007) and Huang, Lin, Lin and Shih (2008), this study measured the IC of Taiwan's biotechnological industry using four dimensions, namely human capital, process capital, innovation capital and customer capital. The variable measurement included in each dimension is illustrated in Table 1.

Table 1: Variables Definition And Measurement

Variables	Measurement
Human Capital (HUM)	
Productivity per employee (HUM1)	$Sale_t$ / $employee_t$
Operating income per employee (HUM2)	operating $income_t$ / $employee_t$
Valued added per employee (HUM3)	net $income_t$ / $employee_t$
Fixed asset per employee (HUM4)	Fixed $asset_t$ / $employee_t$
YoY%-employee (HUM5)	($Employee_t$- $employee_{t-1}$ / $employee_{t-1}$)*100
Process Capital (PRO)	
Fixed asset turnover % (PRO1)	($sale_t$ / average fixed asset)*100
Total asset turnover % (PRO2)	($sale_t$ / average total asset)*100

Current asset turnover % (PRO3)	(sale $_t$ / average current asset)*100
Inventory turnover % (PRO4)	(costs of goods sale $_t$ / average inventory)*100
Administration expense % (PRO5)	(administration expense $_t$ / sales $_t$)*100
Ratio of administration expense per employee (PRO6)	(administration expense $_t$ / average employee) *100
Innovation Capital (INN)	
Current year R&D density (INN1)	(R&D expense $_t$ / sale$_t$)*100
Last year R&D density (INN2)	(R&D expense$_{t-1}$ / sale$_{t-1}$)*100
R&D intensity (INN3)	(R&D expense $_t$ / average total asset)*100
Current royalty and technology expense density (INN4)	(Royalty and technology expense $_t$ / net sale $_t$) *100
Last year royalty and technology expense density (INN5)	(Royalty and technology expense$_{t-1}$ / net sale$_{t-1}$) *100
Customer Capital (CUS)	
YoY%-sales (CUS1)	(sales$_t$ –sales$_{t-1}$ /sales$_{t-1}$)*100
Promotion expense% (CUS2)	(promotion expense$_t$ / sales$_t$)*100
Product acceptance % (CUS3)	1-(sales return and allowance$_t$/sales $_t$)*100
Advertising expense % (CUS4)	(advertising expense$_t$ / sales$_t$)*100

Note: YoY%＝year on year growth rate

Empirical Results

Description Statistics and Correlation Analysis

Table 2 reports descriptive statistics of the factors of the IC dimensions. In the human capital dimension, apart from the relatively low degree of volatility of the fixed asset per employee (HUM4), other variable statistics show significant differences. In the process capital dimension, there are significant differences in the fixed asset turnover rate, inventory turnover rate and ratio of administration expense between companies.

Table 2: Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
Human Capital (HUM)				
HUM1	0	53731.112	6012.092	7241.879
HUM2	-4893.762	10400.356	581.943	1611.311
HUM3	-6981.077	7379.268	448.815	1432.111
HUM4	32.794	7577.612	2173.461	1501.154
HUM5	-0.816	3.595	0.061	0.292
Process Capital (PRO)				
PRO1	0	217.178	6.012	18.712
PRO2	0	2.344	0.693	0.384
PRO3	0	3.521	1.351	0.658
PRO4	0	362.67	8.438	25.072
PRO5	0.013	4.283	0.192	0.507
PRO6	62.753	2220.619	414.931	357.254
Innovation Capital (INN)				
INN1	0	5.676	0.181	0.668
INN2	0	5.676	0.172	0.598
INN3	0	0.32	0.034	0.037
INN4	0	44025	1027.961	5064.556
INN5	0	44025	851.389	4330.811

Customer Capital (CUS)				
CUS1	-88.121	10780	57.655	675.531
CUS2	0	1.219	0.171	0.165
CUS3	0.204	1	0.927	0.129
CUS4	0	0.471	0.031	0.062
Number＝257				

The definitions of the variables please refer to table 1.

In the innovation capital dimension, the volatility of R&D density, royalties and technological cost is significant, for although enterprises fully understand the importance of R&D, the uncertainty of the results of R&D is obvious, which will influence the company's level of willingness to invest in R&D. In the customer capital dimension, the revenue growth rate is the most volatile, probably because enterprises focus on revenue growth that they ignore other factors which have a potential impact on customer capital and which may also have an effect.

The Pearson correlation matrix shows that the correlation coefficients of employee operating profit and employee added value, as well as those of working capital turnover and current asset turnover, were both higher than 0.8. In addition, the correlation coefficients of all of the other variables were less than 0.8[6]. The evidence shows that the levels of the correlations between variables were not high; there may be issues of multicollinearity in the explanatory variables. The evidence shown that the VIF values for all of the variables were less than 2, meaning that there was not a very serious multicollinearity issue among the variables[7], and that is an issue worth of further exploration .

Factor Analysis

This study tested whether or not the variable was appropriate for factor analysis according to the KMO[8] index and Bartlett's test[9] before conducting factor analysis. Table 3 reports the results of the KMO index and Bartlett's test; in Table 3, the KMO value was 0.722, and the p-value of Bartlett's test of sphericity was 0.000. Both results were under the level of significance of 1%, which means that both indexes suggest the appropriateness of factor analysis. The evidence shows that both indexes suggest the appropriateness of factor analysis.

Table 3: KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy		0.722
Bartlett's Test of Sphericity	Approx. Chi-Square	2275.569
	df	153
	Sig.	0.000

Table 4 shows a summary of the results of the factor analysis and reliability test. This article picked up on important dimensions with eigenvalues which were greater than 1; these were human capital, process capital, internal innovation capital, external innovation capital and customer capital. In addition, in order to verify the consistency of variables derived from the factor dimensions, this article performed a further reliability analysis, and the Cronbach's α values of the five factor dimensions were 0.894, 0.908, 0.810, 0.709 and 0.674. On the whole, there is a good level

[6] Hill et al. (2001) holds that when the absolute value of the Pearson correlation coefficient is larger than 0.8, it indicates that there is a strong linear relation, meaning a high level of collinearity.

[7] Hair et al. (1998) holds that there exists a collinearity issue as long as the VIF value is larger than 10.

[8] Kaiser and Rice (1974) pointed out when the Kaiser-Meyer_Olkin (KMO) is less than 0.6, it is inappropriate to perform a factor analysis.

[9] Bartlett (1951) pointed out that if the chi-square of the sphericity test reaches a significant level, which is an appropriate circumstance for factor analysis.

of internal consistency between the variables of the factor dimensions. The following are five major dimensional factors which influence the IC of Taiwan's biotechnology industry:

Human Capital

This is composed of employee operating profit, employee productivity and the added value of employees. Employees are enterprises' greatest source of capital, and their level of productivity not only helps to solve issues and promote productivity, but also benefits the external evaluation of enterprises' capabilities.

Process Capital

This is composed of two indexes, namely current asset turnover and working capital turnover. Highly efficacious application of capital can avoid idle assets and create enterprise value by promoting enterprises' operating capability.

Internal Innovation Capital

This includes the R&D density and intensity of the current year as well as the R&D intensity and management expense rate of the previous year. Innovation is a tool with which enterprises can maintain their competitive advantage, and enterprises should adopt appropriate management mechanisms in their R&D processes so that new and highly competitive products can be produced over a short period, thereby promoting the value of the enterprise.

External Innovation Capital

This includes the royalties and technological expense of the current year, and those of the previous year. The risk of internal R&D can be reduced by purchasing well-developed patents, producing technology directly or continuing R&D, which can improve the performance of enterprises.

Customer Capital

This is composed of the advertisement expense rate and the sales promotion expense rate. Promoting products in an appropriate way can raise the prestige of products and enterprises, reduce stock and help to improve the performance of the enterprise.

Table 4: Factor Analysis and Reliability Test

Factors named	Variable code	Factor loading	Eignvalues	Cumulative variance explained	Cronbach's α
Human Capital	HUM2	0.875	2.066	35.906	0.894
(HUM)	HUM1	0.842			
	HUM3	0.783			
Process Capital	PRO2	0.892	1.698	49.257	0.908
(PRO)	PRO3	0.879			
Internal Innovation Capital (INNI)	INN1	0.832	4.696	19.472	0.810
	INN3	0.75			
	INN2	0.741			
	PRO5	0.689			
External Innovation Capital (INNE)	INN4	0.872	1.414	60.092	0.709
Customer Capital	CUS2	0.884	1.127	70.292	0.674
(CUS)	CUS4	0.829			

The definitions of the variables please refer to Table 1.

Regression Analysis

Table 5 reports the empirical results of the impact on enterprise value creation of five dimensional factors of IC. In addition to considering individual factors in this article, Models 2 to 5 take into consideration the effects of the interaction between different dimensional factors. With regard to the explanatory power of the total regression model, Model 1 is the basic model which includes all five dimensions, while Models 2 to 5 take into account the interaction between dimensions. The explanatory power of these dimensions (R^2) is 18.1%, 20.3%, 18.2% and 20.5% respectively, which are all higher than 15.8%, the explanatory power of Model 1. In addition, the F-test further confirmed that adding the interaction term does promote the model's explanatory power.

Model 1 is the basic model; the evidence shows that, with a significance level of 1%, the human capital dimension has a significant positive relationship with the creation of enterprise value. This means that H1 is supported, meaning that promoting the production abilities of employees in the biotechnology industry is beneficial for the creation of enterprise value. With regard to the aspect of process capital, with a significance level of 10%, an increase in process capital causes a significant decrease in the creation of enterprise value. The evidence supports H2: process capital and enterprise value creation are correlated. The test results of present study is contrast to the result presented by Wang and Chang (2004), which delineated a positive correlation between process capital and enterprise value creation.

Innovation capital is divided into two parts: internal innovation capital and external innovation capital. With a significance level of 1%, the empirical results support the idea that internal innovation capital and external innovation capital both contribute to enterprise value creation. H3 and H4 are supported, which is in line with the opinion of Edvinsson and Malone (1997), indicating that the enterprise value creation of Taiwan's biotechnology industry can be promoted using internal R&D and by purchasing patents. With regard to customer capital, with a significance level of 1%, the evidence shows that customer capital has a negative impact on enterprise value creation, and demonstrates that greater product promotion expenses will damage an enterprise's value creation efforts. The empirical results do not support H5: customer capital has a positive relationship with enterprise value creation, which is in direct opposition to the results provided by Cheng et al. (2008). One possible reason is that R&D in the biotechnology industry takes so long that an increase in customer capital expenses would not create immediate value for enterprises before the products are successfully researched and developed.

Table 5: Regression Results

$$Y_{ij} = \beta_0 + \beta_1 \mathrm{HUM}_{ij} + \beta_2 \mathrm{PRO}_{ij} + \beta_3 \mathrm{INNI}_{ij} + \beta_4 \mathrm{INNE}_{ij} + \beta_5 \mathrm{CUS}_{ij} + \varepsilon_{ij}$$

$$Y_{ij} = \beta_0 + \beta_1 \mathrm{HUM}_{ij} + \beta_2 \mathrm{PRO}_{ij} + \beta_3 \mathrm{INNi}_{ij} + \beta_4 \mathrm{INNE}_{ij} + \beta_5 \mathrm{CUS}_{ij} + \beta_6 (\text{interaction term})_{ij} + \varepsilon_{ij}$$

Variables	Expect sign	Mode 1	Model 2	Model 3	Model 4	Model 5
Constant		0.707***	0.707***	0.707***	0.707***	0.707***
		(11.355)	(11.513)	(11.673)	(11.522)	(11.688)
HUM	+	0.239***	0.228***	0.284***	0.207***	0.203***
		(3.837)	(3.704)	(4.597)	(3.317)	(3.303)
PRO	+/-	-0.130**	-0.124**	-0.100	-0.181***	-0.103*
		(-2.082)	(-2.015)	(-1.628)	(-2.833)	(-1.687)
INNI	+	0.215***	0.259***	0.231***	0.253***	0.276***
		(3.441)	(4.081)	(3.803)	(4.019)	(4.417)
INNE	+	0.197***	0.212***	0.149**	0.231***	0.247***

		（3.155）	（3.434）	(2.408)	(3.695)	(3.990)
CUS	+	-0.217***	-0.220***	-0.193***	-0.198***	-0.289***
		（-3.474）	（-3.577）	(-3.158)	(-3.202)	(-4.569)
Interaction terms						
INNI *CUS	+/-		-0.105***			
			（-2.833）			
HUM*INNE	+/-			0.274***		
				(3.902)		
PRO*INNE	+/-				-0.421*** (-3.991)	
INN-E*CUS	+/-					-0.421*** (-3.991)
Adjusted R^2		0.158	0.181	0.203	0.182	0.205
F-value		10.584***	10.405***	10.085***	10.488***	11.999***

Note: The figures in parentheses are t value.

***, **, * represents statistical significance at the 1%, 5% and 10% levels, respectively.

Model 2 takes into account the interaction effect between internal innovation and customer capital, and the results indicate that interaction items damage the creation of enterprise value. The empirical results concerning other variables are in line with Model 1, suggesting that significant investment is needed in both the internal innovation of enterprises and in customer capital operation. However, a positive effect on value creation was still not found. Model 3 indicates that the interaction effect of process capital and external innovation capital is negative for enterprise value creation; the empirical results regarding the other variables are in line with Model 1. Model 4 indicates that the interaction term of human capital and external innovation management promotes value creation significantly and reduces the damage caused by process capital with regard to value creation. However, the effect is still not significant. It indicates that purchasing well-developed patents or technologies from external sources and using the productivity of employees effectively can enhance value creation.

Model 5 considers the interaction effects of external innovation capital and customer capital, and the empirical results are in line with Model 1. With a significance level of 1%, human capital and innovation capital significantly promotes enterprise value creation, but process capital provides weaker evidence; under the same circumstances, the interaction term of external innovation and customer capital has a negative relationship with the creation of enterprise value, indicating that with more patents and technologies being purchased and greater investment in sales and promotion, enterprise value creation is reduced. The main reason for this is that external innovation capacity accelerates the development of an enterprise through the purchasing of patent rights or technologies, while customer capital functions in a similar way by promoting products which require greater expenditure on advertisement and promotion. As a result, if the enterprise expects an immediate effect, a large sum of money has to be invested. Therefore, the value creation of the enterprise may be damaged. Due to the embryonic stage which the biotechnology industry of Taiwan is in, more resources should be invested in these two kinds of capital so as to establish the position of Taiwan in the market.

Conclusion and Research Limitations

The biotechnology industry features both high IC and high stakes. This article took Taiwan's listed and OTC companies which formed the biotechnology industry during 1996-2008 as the research objects. The study first extracted the proper factor dimensions using factor analysis, and then analyzed the dimensions using the regression method. Meanwhile, the

models considered the interaction effect of different capital-related factors, and then explored the correlation between the IC dimensions and the value creation of enterprises in the biotechnology industry.

The empirical results indicate that in Taiwan, human capital, internal innovation capital and external innovation capital are beneficial to the creation of value for enterprises in the biotechnology industry. However, process capital and customer capital have the opposite effect. One possible reason for this is the small scale of Taiwan's biotechnology industry, for although it has R&D capabilities and has successfully produced new drugs, it lacks the funding to continue clinical human testing. Therefore, the output value is low, and the employment of capital is ineffective. In addition, in terms of customer capital, investment in product promotion does not have an immediate effect on the creation of enterprise value, meaning that the creation of enterprise value is reduced.

Compared with the mature management of America, Japan and European countries with regard to biotechnology legislation, technology and funding, Taiwan is relatively immature in these areas, which is also one of the factors which hinders the development of its biotechnology industry. The government is now promoting six major emerging industries, and it passed the "Act for the Development of the Biotech and New Pharmaceuticals Industry" in 2007, hoping to encourage enterprises to invest in the biotechnology industry and to help enterprises to explore and sell products through R&D, investment credits for stockholders, deferring tax on technology investment income and other such reward policies, hoping to create the assistance which will be essential for the future development of the biotechnology industry in Taiwan.

Due to the embryonic stage which the biotechnology industry in Taiwan is currently in, some non-financial data are difficult to obtain, which may have influenced the empirical results of this study. Future studies could choose other dimensional variables to discuss in order to better understand the ways in which IC influences the process of value creation in Taiwan's biotechnology industry.

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