Censoring model for evaluating intellectual capital value drivers

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Abstract

Purpose – The purpose of this paper is to examine the relationship between firms' value drivers and their intellectual capital (IC).

Design/methodology/approach – The health care sector (GICS 35) firms listed in the S&P500 were used to build a research censoring Tobit model by adopting financial data to determine value drivers.

Findings – The results of the study show that innovation capital, customer capital and human capital are significant positive drive factors for firms to create more IC and hence more intangible value. Process capital exerts moderating effects on IC; organizations with greater process capital must raise customer capital to enhance intellectual value.

Originality/value – This is the first empirical study that uses a censoring Tobit model and tests of the association between competitive advantage and the value drivers of firms. This research successfully combines management perspectives with financial data to describe the value drivers of firms.

Keywords Intellectual capital, Financial data processing

Paper type Research paper

1. Introduction

Market value is an appraisal based on an estimate of what a buyer would pay a seller for any piece of property. Book value is shareholders' equity shown in a firm's financial statement and reflects the value of corporate reported assets less liabilities. Recently, financial statements do not present relative market value, and the gap between firms' market and book value is increasing, (Table I) with market value exceeding book value by up to 15 times.

Why is it that financial statements do not always reflect the relative market value of corporations? This question has been heavily researched. Over the last two decades of the twentieth century, many probes into this disparity between market value and book value appeared in journals or in the news. In the new economy, value creation relies on the transformation from tangible assets to invisible assets. The difference between market value and book value is intellectual capital (IC) which improves the market value of firms. IC is firms' intangible assets or non-financial resources that underpin

future growth. These resources are the main source of sustainable competitive advantage, and are rare, imperfectly imitable, and substitutable. Therefore, designing a useful value creation model to describe value drivers is very important for the research field of IC.

In 1982, out of every $100 invested in stocks of US manufacturers and mining concerns, an average of $62.30 (62 percent) was spent on tangible assets. By 1999, the investment dipped to only 16 percent (Figure 1) (Lev, 2000). Nowadays, the intangible portion of the world economy can equal or exceed that of the tangible. This situation has occurred in the USA and can be observed in developed economies worldwide.

Businesses have to learn how to increase returns, not only by relying on tangible assets but also on intangible assets. Here, the authors require a new model to find value drivers of IC, which is adapted to new intangible driver factors rather than traditional finance-based accounting.

This study reviews the relevant literature and demonstrates that IC has been extensively investigated in industrialized nations like the USA (Bassi and van Buren, 1999; Stewart, 1997), Canada (Bontis, 1998; Miller *et al.*, 1999; Ng, 2006), the UK (Brooking, 1996; Roos *et al.*, 1998), Germany (Bollen *et al.*, 2005) Sweden (Edvinsson and Malone, 1997; Johanson *et al.*, 1999) and Australia (Bornemann *et al.*, 1999; Guthrie *et al.*, 1999; Sveiby, 1997), as well as in a few target emerging economies such as Taiwan (Chen *et al.*, 2005; Tseng and Goo, 2005; Wang and Chang, 2005) and Malaysia (Bontis *et al.*, 2000). This research explores the connections between IC and corporate value in industrialized nations.

Corporation	Status	Market[a]	Book[a]	Market-to-book ratio
Bristol-Myers	December 31, 1998	$132,952.36	$7,576.00	17.55
Coca-Cola	December 31, 1998	165,161.91	8,403.00	19.66
Dell, Inc.	July 31, 1998	127,225.30	2,321.00	54.81
Glaxosmithkline	December 31, 1998	125,110.84	4,485.00	27.90
Lilly (ELI)	December 31, 1998	97,735.84	4,429.60	22.06
Microsoft	June 30, 1998	267,043.69	16,627.00	16.06
Pfizer, Inc.	December 31, 1998	162,224.25	8,810.00	18.41

Note: [a]In millions of US dollars from compustat files

Table I.
Comparison of market value and book value
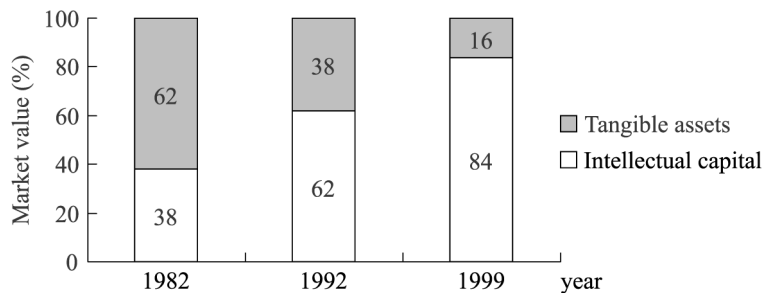
Figure 1.
Development of the value of intellectual capital as a percentage of market value of S&P500 companies between 1982 and 1999

Some firms can create more value than others due to competitive advantages. These competitive advantages can be transformed into value drivers. Which competitive advantages are important to firms is an interesting question. IC is accumulated through the possession of unique resources, which are competitive advantages of firms. Creation value is left censored data with censoring point of zero, and IC is its appropriate proxy variable. The purpose of this empirical study is to investigate which competitive advantages upgrade a company's value. In particular, combined financial and management perspectives via published financial data are advocated to examine value drivers.

This paper uses the concept of IC and applies a censored Tobit model to revalue important value drivers of firms. The remainder of the paper proceeds as follows: Section 2 lays down the theoretical foundation of IC measurement. Section 3 describes research design and variable measurements. This is followed by discussion of empirical results in Section 4 and conclusions in Section 5.

2. Theoretical foundations of intellectual capital measurement
Until the 1980s, business economics focused on competitiveness of the firm in a given environment. Such an advantage enables the creation of superior value and profits for customers and companies, whose resources and capabilities form distinctive competencies: customer responsiveness, ability innovation, efficiency and quality. In the 1980s, resource-based view (RBV) of firms gained importance. RBV focuses on resources and their deployment in organizations, leading to the development of value creation (Peppard and Rylander, 2001).

In 1992, Kaplan and Norton introduced the balanced scorecard (BSC), a notion for measuring company activities in terms of vision and strategy, to give the manager a composite view of business performance. The BSC became a measurable system and concept for grouping non-financial measures in a report in a way that allowed the reader to recognize how the organization is doing from a strategic point of view (Daum, 2003). Kaplan and Norton (1992) cited a BSC to split IC into four perspectives: internal, customer, learning, and financial. Most other classification schemes of IC distinguish between external customer-related or internal structures and human capital (Peppard and Rylander, 2001; Sveiby, 1997). External structure concerns customer and supplier relations; internal structure consists of patents, concepts, and computer and administrative systems. The corporate culture of a firm also belongs to the category of internal structure. Human capital pertains to a person's capacity to act in situations:, i.e. skills, education, experiences, and motivations.

Hall (1992) categorized intangible resources as assets or skills. Assets include trademarks, patents, copyrights, registered designs, contracts, trade secrets, reputations and networks (personal/commercial relationships). Skills are comprised of know-how or culture. Stewart (1997) defined IC as intellectual material (knowledge, information, intellectual property and experience) a company utilizes to create wealth. Edvinsson and Sullivan's (1996) definition of IC has two major parts: human resources and structural capital (including intellectual assets). Tseng and Goo (2005) also categorized IC as organizational, human, innovation and relationship.

As a pioneer in supplementary reports, Skandia (1997) began publishing its reports in 1997 and is now active in some 20 countries on four continents. Edvinsson and Malone (1997) extended the concepts of Skandia to point out that IC is comprised of

human, customer and structural capital. Roos *et al.* (1998) traced the theoretical roots of IC to two different streams: the strategic and the measurement. Most scholars in the field have identified three main constructs of IC: human, structural and customer (relational) capital. Process and innovation capital remain distinct from structural capital (Bontis, 1998; Bontis *et al.*, 2000; Brennan and Connell, 2000; Cabriata and Vaz, 2006; Edvinsson and Malone, 1997; Hendry and Brown, 2005; Petty and Guthrie, 2000; Prahalad and Ramaswamy, 2000; Roos *et al.*, 2001).

2.1 Human capital
Human capital is defined as the knowledge employees take with them upon leaving a firm, such as knowledge, skills, experiences, abilities, motivation and tasks (Hendry and Brown, 2005; Miller *et al.*, 1999; Roos and Ross, 1997). Wang and Chang (2005) suggested employee increment/decrement ratio as an appropriate indicator.

2.2 Customer capital
Customer capital is the knowledge embedded in the relationships with any stakeholder that affects the organization's life. Prahalad and Ramaswamy (2000) suggested that customers become a new source of competence for the organization by renewing its overall competence. Bontis (1998) pointed out that the essence of customer capital is the knowledge embedded in relationships external to a firm. Its scope lies external to both the firm and to human capital nodes.

2.3 Structural capital
Roos *et al.* (1998) described structural capital as what remains at a firm when employees head home for the night. It encompasses all non-human storehouses of knowledge in an establishment: databases, organizational charts, process manuals, strategy routines and anything else with value to a company that outranks its material value (Bontis *et al.*, 2000). Structural capital means an organization's capabilities to meet internal and external challenges. It includes infrastructures, information systems, routines, procedures and organizational culture (Cabriata and Vaz, 2006).

2.4 Process capital
Processes represent an activity-oriented expression of a number of business activities especially favored by the company:, e.g. investments in R&D, lead time, economy and productivity of administrative processes. These also express quality, error rate and waiting time towards the surroundings of the company (The Danish Trade and Industry Development Council, 1997).

2.5 Innovation capital
Romijn and Albaladejo (2002) designed an experimental innovation index and used it alongside conventional ones, such as patents granted or new products, to test relationships with indicators of internal sources of innovation capability. Their findings supported the importance of R&D, the key role played by the regional science base, and proximity to suppliers.

Edvinsson and Malone (1997) asserted that the difference between a firm's equity market price and book value is IC:

$$\Delta V = \text{MVE} - \text{BVE} = \text{Intellectual capital} \tag{1}$$

where ΔV is the value of IC, MVE denotes market value of common equity, and BVE represents book value of common equity. Equation (1) only calculates the amount of IC, but does not describe its components. ΔV are summary data that lack incremental information content and that cannot pinpoint value drivers of firms. By decomposing the driver factor of ΔV, the authors obtain the following benefits:

- accountants can offer more reliable financial reports; and
- managers can effectively exploit competitive advantage and alleviate weaknesses.

This study extended Edvinsson and Malone's (1997) premise and used the Tobit model to combine scholars' categories to explain the elements that create corporate IC and the resource-based competitive advantage (e.g. human resources, customer relations, organizational culture and innovative ability) that constitutes a value driver for corporate IC.
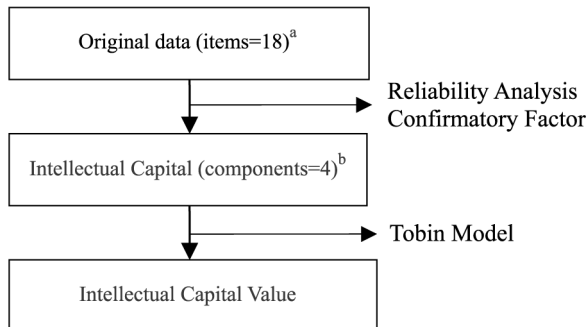
3. Research design and variable measurements

This study examines which value drivers create value for firms but that do not amount to value created. Companies can possess IC of zero or higher. Total assets were used to eliminate size effect, after which the ratio was left-censored at zero. Censored data violate the assumption underlying the ordinary least squares (OLS) estimator of a dependent variable as continuous and normal. Green (2003) stated that because it is not possible to obtain unbiased estimates from an OLS function, the Tobit estimator is the correct function.

This section describes the models and empirical proxy variables used to examine which value drivers are important to firms. Factor analysis was carried out to find a factor score representative of a component of IC, and the Tobin model was applied to link value driver with company IC. Figure 2 show the research design process.

3.1 Factor analysis

This statistical approach analyzes interrelationships among a number of variables and explains variables in terms of their common underlying dimensions (factors).

Notes:
[a] There are 18 items in which each component included four or six items in table 2.
[b] Intellectual capital (IC) is made up of four components: innovation capital, customer capital, human capital and process capital.

Figure 2.
Research design process

It involves condensing information contained in original variables into a smaller set of dimensions (factors) with a minimum loss of information (Hair *et al.*, 1998). Main applications of factor analytic techniques are:

- paring the number of variables; and
- detecting structural relationships, i.e. classifying variables.

Factor analysis is applied as a data reduction or structure detection method.

Factor analysis can be applied in order to explore a content area, structure a domain, map unknown concepts, classify or reduce data, illuminate causal nexuses, screen or transform data, define relationships, test hypotheses, formulate theories, control variables, or make inferences. Consideration of these various overlapping usages will relate to aspects of the scientific method: induction and deduction; description and inference; causation, explanation, and classification; and theory.

Assuming that X variables relate to a number of functions operating linearly:

$$
\begin{aligned}
X_1 &= \alpha_{11}F_1 + \alpha_{12}F_2 + \cdots + \alpha_{1j}F_j + e_1 \\
X_2 &= \alpha_{21}F_1 + \alpha_{22}F_2 + \cdots + \alpha_{2j}F_j + e_2 \\
&\vdots \qquad\qquad\qquad \vdots \\
X_k &= \alpha_{k1}F_1 + \alpha_{k2}F_2 + \cdots + \alpha_{kj}F_j + e_k
\end{aligned}
\tag{2}
$$

where: X_k, an observable variable of a financial item; α_{kj}, a pattern loading of variable X_k on factor F_j; F_j, an unobservable factor for intellectual components; e_k, a unique factor.

Factor analysis assumes all rating data on diverse attributes can be reduced to a few crucial dimensions, made possible because attributes are interrelated. Rating of any one attribute arises partially from other attributes' influence. A statistical algorithm deconstructs the rating (raw score) into various elements, then reconstructs partial scores into underlying factor scores. Following factor analysis, all factor scores were stored. Each factor score represented a component of IC and was used in the Tobit model.

3.2 Tobit model

Creation value is zero for a nontrivial fraction of the population, albeit roughly continuously distributed over positive values. The Tobit model is adapted from the field of econometrics as a maximum likelihood estimator of parameters for data left censored or truncated. It is shown that the unbiased maximum likelihood estimator is efficient for the random variable with an unlimited dynamic range. This kind of limited dependent variable is left censored data. The Tobit model is an econometric proposed by James Tobin in 1958, to describe the relationship between a non-negative dependent variable y and a set of independent variables (or a vector) $\mathbf{x}$. The model supposes a partially unobservable variable y_i^* linearly dependent on an $\mathbf{x}$ via parameter (vector) β that determines the relation between independent variables $\mathbf{x}$ and latent variable y_i^* (as in a linear model). Moreover, there is a normally distributed error term ε_i to capture random influences on this relationship. The censoring point was assumed to be zero, although this is only a convenient normalization. The Tobit model is defined as:

$$y_i^* = \beta_0 + \mathbf{x}_i'\beta + \varepsilon_i$$
$$y_i = 0 \quad \text{if } y_i^* \leq 0,$$
$$y_i = y_i^* \quad \text{if } y_i^* > 0.$$

(3)

where random error ε has $N(0, \sigma^2)$ distribution.

The following censored regression or Tobit model framework was used to analyze whether innovation, customer, human or process capital is affected by firm value. Control dummy variables for year were added:, i.e. three dummy variables (D_{ij}) represented four years. The first year was coded (1, 0, 0), the second (0, 1, 0) and the third (0, 0, 1). Thus, baseline Tobit model is given by:

$$y_{it} = \beta_0 + \beta_1\text{INN}_{it} + \beta_2\text{CUS}_{it} + \beta_3\text{HUM}_{it} + \beta_4\text{PRO}_{it}$$
$$+ \text{dummy variables of year} + \varepsilon_{it}$$

(4)

where: y_{it}, the IC ratio of company, defined as difference between market and book values related to total assets for firm i in year t; INN_{it}, the composite index of original innovation capital items of firm i in year t; CUS_{it}, the composite index of original customer capital items for firm i in year t; HUM_{it}, the composite index of original human capital items of firm i in year t; PRO_{it}, the composite index of original process capital items of firm i in year t.

When the interaction effect for some independent variables is considered, the model in general pattern is given by:

$$y_{it} = \beta_0 + \beta_1\text{INN}_{it} + \beta_2\text{CUS}_{it} + \beta_3\text{HUM}_{it} + \beta_4\text{PRO}_{it} + \beta_5(\text{interaction term}_{it})$$
$$+ \text{dummy variables of year} + \varepsilon_{it}$$

(5)

3.3 Measurement of variables

Research data from prior IC research were divided into two streams: questionnaire and financial. Questionnaire data possess behavior perceptible perspective, which is an indirect method that investigates the relation between behavior and result (Baxter and Matear, 2004; Bollen *et al.*, 2005; Bontis and Fitz-enz, 2002; Bontis, 1998; Bontis *et al.*, 2000; Cabriata and Vaz, 2006; Chen *et al.*, 2004; Martinez-Torres, 2006; Tseng and Goo, 2005). Behavior perceptible perspective only explains the importance of research factors, but does not demonstrate their relationships with each other. The questionnaire perspective contains various questions about the purpose of the survey to which respondents indicate the extent of their agreement on a Likert scale. Behavior perceptible data are ordinal data. Another way to collect data are quantitatively, part of the financial perspective. It is a direct concept and investigates relevance (Chen *et al.*, 2005; Wang and Chang, 2005). This study used quantitative (non-)financial data amassed from financial reports and the SEC database to rate value drivers.

Indicators of each IC element (Table II) were gleaned from literature on the measurement of IC or determinants of business performance. Each component included four or six original items. Chen *et al.* (2004) showed that a company must provide mechanisms for the sake of effective innovation, which in turn need sufficient R&D allotment. Chen *et al.* (2005), Bollen *et al.* (2005) and Wang and Chang (2005) used R&D as proxy for innovative capital. This study accepted their ideas and considered R&D and total asset proxy innovation capital.

	Original items (variable denoted and measurement)
Innovation capital (INN)	$\text{INN1} = (\text{RandD}_t/\text{Sale}_t) \times 100$
	$\text{INN2} = (\text{RandD}_{t-1}/\text{Sale}_{t-1}) \times 100$
	$\text{INN3} = \text{RandD}_t/((\text{TA}_t + \text{TA}_{t-1})/2)$
	$\text{INN4} = \text{TA}_t/\text{Employees}_t$
Customer capital (CUS)	$\text{CUS1} = (\text{Sales of the major five customers}/\text{sale}_t) \times 100$
	$\text{CUS2} = (\text{Sales of the largest customer}/\text{sale}_t) \times 100$
	$\text{CUS3} = (\text{SGandA Expense}_t/\text{all cost}_t) \times 100$
	$\text{CUS4} = (\text{SGandA Expense}_t/\text{sale}_t) \times 100$
Human capital (HUM)	$\text{HUM1} = \text{sale}_t/\text{employees}_t$
	$\text{HUM2} = (\text{sale}_t/\text{employees}_t)/(\text{salary of five senior executives}_t/5)$
	$\text{HUM3} = \text{net income}_t/\text{employees}_t$
	$\text{HUM4} = (\text{net income}_t/\text{employees}_t)/(\text{salary of top five senior executives}_t/5)$
	$\text{HUM5} = \text{operating income}_t/\text{employees}_t$
	$\text{HUM6} = (\text{operating income}_t/\text{employees}_t)/(\text{salary of top five senior executives}_t/5)$
Process capital (PRO)	$\text{PRO1} = \text{Net Sale}_t/((\text{AR}_t + \text{AR}_{t-1})/2)$
	$\text{PRO2} = \text{Net Sale}_t/((\text{TA}_t + \text{TA}_{t-1})/2)$
	$\text{PRO3} = \text{Net Sale}_t/((\text{FA}_t + \text{FA}_{t-1})/2)$
	$\text{PRO4} = \text{COGS}_t/((\text{Inventory}_t + \text{Inventory}_{t-1})/2)$

Notes: RandD_t and RandD_{t-1}, research and development expense during years t and $t-1$; TA_t and TA_{t-1}, total assets for years t and $t-1$; Employees_t, number of company workers at year t; SGandA Expense_t, selling, general and administrative expense for year t; all cost_t, total (non-)operational expenses for year t; AR_t and AR_{t-1}, accounts receivable for years t and $t-1$; FA_t and FA_{t-1}, plant, property and equipment for years t and $t-1$; COGS_t, cost of goods sold during year t

Table II.
Definitions and
measurements of
variables

Customer capital has been classified into basic marketing capability, market intensity, and customer loyalty (Chen *et al.*, 2004). Bontis (1998) used market share as a proxy for marketing capability and market intensity. Chen *et al.* (2005) took advertising expenditures as a proxy for customer capital. In this study, SG&A expense was substituted for marketing capability and sales to major customers was adopted for market intensity. Chen *et al.* (2005) defined human capital as a combination of employees' competence, attitude, and creativity. Superior human capital will boost the worth of a company. The Danish Trade and Industry Development Council (1997) suggested value-added per employee as an indicator of human capital. In this study, productivity of employees was used as a proxy. Tseng and Goo (2005) proposed that operational processes represent process capital. The operational process, which ensures firms complete sundry operational tasks, is most effective (Chen *et al.*, 2004). Wang and Chang (2005) recommended turnover as a top indicator of process capital. Consequently, the concept of turnover was adopted to describe process capital.

Health care firms included on GICS 35[1] in the S&P500 were used to assemble a research model, sampling from a list of publicly traded firms in COMPUSTAT files. The supplementary data from 1,000 and proxy statements for each firm were collected. The sample period was from 2001 to 2004. Other inclusion criteria were:

- the company was missing no value during the sample period; and
- each company had 1,000 and proxy statements available.

This selection procedure garnered 224 samples from 56 health care companies during the 2001-2004 time period. The sample consisted of two sectors: health care equipment and pharmaceuticals. The average book value was \$12.332 billion, the mean market value was \$24.623 billion, mean net sales were \$11.273 billion and research and development expenses were \$0.84 billion over this period.

4. Empirical analyses

Table III summarizes descriptive statistics on IC components: innovation capital, customer capital, human capital and process capital, individually shown in Panels A-D. The standard deviation in Panel C is lower than in other panels. It appears that each firm respects human capital with only small differences in human utility. All descriptive statistics in Table III are positive except for the minimum values of HUM5 and HUM6. This situation may emanate from a net loss to the firm. Cronbach's (α) tests the reliability of a measure, as suggested by Nunnally (1987), and should be used to assess instrument quality (Churchill, 1979).

Panel A: innovation capital (INN)

	INN1	INN3	INN3	INN4		
Mean	5.711	5.770	3.774	0.476		
Median	0.238	0.193	0.304	0.334		
SD	9.373	9.942	6.182	0.518		
Min	0.000	0.000	0.000	0.008		
Max	75.297	75.297	45.972	2.834		
Cronbach (α)	0.8189					

Panel B: customer capital (CUS)

	CUS1	CUS2	CUS3	CUS4		
Mean	4.988	8.855	30.932	43.057		
Median	0.000	0.000	33.559	44.001		
SD	10.928	19.889	16.844	25.376		
Min	0.000	0.000	0.756	0.907		
Max	92.925	92.104	71.991	89.932		
Cronbach (α)	0.8434					

Panel C: human capital (HUM)

	HUM1	HUM2	HUM3	HUM4	HUM5	HUM6
Mean	0.583	0.544	0.095	0.092	0.040	0.039
Median	0.354	0.284	0.079	0.056	0.039	0.027
SD	0.689	0.685	0.077	0.094	0.077	0.078
Min	0.048	0.039	0.005	0.077	−0.730	−0.651
Max	0.407	4.227	0.603	0.005	0.428	0.382
Cronbach (α)	0.6020					

Panel D: process capital (PRO)

	PRO2	PRO3	PRO4	PRO5		
Mean	10.239	18.515	1.199	9.173		
Median	3.104	5.902	0.853	6.540		
SD	17.132	32.464	1.051	7.365		
Min	0.696	0.895	0.117	0.856		
Max	102.600	162.700	4.885	45.080		
Cronbach (α)	0.5196					

Note: Variable definitions are shown in Table II

Table III.
Descriptive statistics of financial items

An important issue is how well the original variables relate to each component of IC measure. For this analysis, Cronbach's (α) statistic gauges the correlation of an item with the sum of other items of the component. Guilford (1965) mentioned that an α above 0.5 indicates reliability. All variables contributed positively and significantly to Cronbach's (α) of the individual component and were thus input for statistical analysis. Cronbach (α) measures for INN, CUS, HUM and PRO are 0.8289, 0.8434, 0.602 and 0.5196, respectively.

Factor analysis was applied to reduce one important dimension and to save all factor scores used in Tobit model. Each factor score represents a component of IC in Table IV. The minimum value of all four components is less than 0, with a maximum greater than 2. Human capital exhibits the greatest range. The mean values of innovation capital and customer capital are above zero, while the other mean values are below zero. A mean value greater than the median of the four capital components implies a distribution skewed to the right.

Table V presents the Pearson correlations among INN, CUS, HUM and PRO for the full sample. Relationships between each two types of capital are all significant. The correlations between PRO and other types of capital are negatively significant. High correlation between CUS and PRO ($\gamma = -0.613$) suggests that CUS and PRO possess a significantly negative relationship. From Table V, coefficient sign of PRO differs from other types of capital in the Tobit model.

Table VI examines the influence of value drivers on a firm's IC. It also records information criterion statistics, namely the Akaike information criterion (AIC) and Hannan-Quinn (HQ) statistics, both model selection criteria for non-nested models and pseudo R^2. Variance inflation factors (VIF) evaluate the correlation of each independent variable in the equation. If VIF $= 1.0$, no self-correlation exists; if it is in the range of 1.0-5.0, the related equation is acceptable; if larger than 10.0, the regression equation is unstable and rechecking is necessary. All VIF values of each

Component items	Mean	Median	SD	Min	Max
INN[a]	0.007	−0.402	1.009	−0.754	6.036
CUS[a]	0.016	−0.194	1.001	−1.684	2.639
HUM[a]	−0.001	−0.164	1.004	−5.328	6.213
PRO[a]	−0.005	−0.488	1.003	−0.908	3.279

Notes: [a]Variable definitions; INN – innovation capital; CUS – customer capital; HUM – human capital; PRO – process capital

Table IV. Descriptive statistics of intellectual capital components

Component items	INN[a, b]	CUS	HUM
CUS[a, b]	0.502***		
HUM[a, b]	0.130***	0.290***	
PRO[a, b]	−0.344***	−0.613***	−0.147***

Notes: Significances for two-tailed test are * < 0.1; ** < 0.05; *** < 0.01; [a]INN, CUS, HUM and PRO are factor scores extracted from their original data; [b]variable definitions: INN – innovation capital; CUS – customer capital; HUM – human capital; PRO – process capital

Table V. Pearson correlations for intellectual factor components

Independent variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.784*** (0.317)	0.867* (0.451)	1.249*** (0.358)	1.198*** (0.331)	1.024*** (0.403)	0.923** (0.416)
INN	0.435*** (0.153)	0.455*** (0.173)	1.214*** (0.455)	0.466*** (0.152)	1.231*** (0.281)	0.563*** (0.161)
CUS	0.593*** (0.216)	0.582*** (0.216)	0.550*** (0.211)	0.918*** (0.278)	0.596*** (0.195)	0.917*** (0.196)
HUM	0.551*** (0.149)	0.550*** (0.148)	0.505*** (0.146)	0.540*** (0.146)	0.479*** (0.130)	0.515*** (0.134)
PRO	−0.457* (0.261)	−0.452* (0.260)	0.251 (0.446)	0.248 (0.417)		
PRO × INN			1.322* (0.722)			
PRO × CUS				0.670* (0.353)	1.166*** (0.380)	0.537*** (0.199)
DUM_PRO					1.150*** (0.328)	1.062*** (0.330)
Pseudo R^2	0.107	0.109	0.112	0.112	0.132	0.129
Log likelihood	−297.850	−297.269	−296.128	−296.047	−289.595	−290.530
Akaike info. criterion	2.827	2.849	2.820	2.819	2.787	2.796
Hannan-Quinn criterion	2.865	2.906	2.864	2.863	2.850	2.859

Notes: $* < 0.1$; $** < 0.05$; $*** < 0.001$; dependent variable intellectual capital ratio equals intellectual capital (market value minus book value) divided by total assets. Tobit regression coefficient estimates, standard errors, and significance are reported. AIC and HQ are selection criteria for non-nested models. The smaller of AIC or HQ indicates preferred model. All models except Model 1 include the dummy control variable of year

Table VI.
Coefficients of Tobit
regressive models with
standard error in
parenthesis

model are below 5.0 (data not shown), inferring obvious statistical significance. Three dummy variables were designed to control for year. Years 2000-2004 display varied economic conditions. No influence on advantage over time was expected, regardless of fundamental advantage determinants of IC. Model 2 accounts for this by including annual indicator variables. Results for Model 2 include coefficient of INN of 0.455 with a t-statistic of 2.626; CUS of 0.582 with a t-statistic of 2.695; HUM of 0.550 with a t-statistic of 3.725 and PRO of -0.452 with a t-statistic of 1.734.

A comparison of Models 1 and 2 shows that coefficients for the four types of capital are almost unchanged. As expected, INN, CUS and HUM exhibit significant positive effects on IC. In Model 2, a one unit increase in innovation capital boosts predicted IC by 0.455. Such an increase in customer capital raises predicted IC by 0.582, and a one unit increase in human capital increases the predicted IC by 0.550. The results are consistent with prior research:, i.e. INN, CUS and HUM are essential to IC (Bollen *et al.*, 2005; Bontis, 1998; Chen *et al.*, 2005; Wang and Chang, 2005). However, PRO exhibits a weakly significant negative effect on IC. Table VI shows significantly negative correlations between PRO and other capital, implying that creation value and pay-out for creation value have a trade-off relationship. Different input level of process capital might create different value.

Owing to the negative impact of PRO on IC, the interaction of PRO with other components merits special consideration as defined in equation (5). Models 3 and 4 use interaction to adjust for this difference by PRO with innovation and customer capital, respectively. Association of PRO and INN (coefficient $=$ 1.322) is weakly significant in Model 3, and association of PRO and CUS (coefficient $=$ 0.670) is weakly significant in Model 4. After adjusting for interaction effect, PRO is positive (coefficient $=$ 0.251 and 0.284 in Models 3 and 4), similar to the findings of Tseng and Goo (2005), Wang and Chang (2005), Cabriata and Vaz (2006) and Martinez-Torres (2006). This situation illustrates that interaction of process and IC is critical. To confirm interaction effect as important in this study, PRO was classified into high- and low-input based on the median, and INN and CUS were divided into groups by quartile. A dummy variable was used to replace the quantitative data of process capital. The interaction term has high significance (all p-value $<$ 0.01) in Models 5 and 6, pointing to interaction effect as crucial once again. Figures 3 and 4 highlight interaction effect by PRO with INN, and more so with CUS.

A similar trait is the turning point in respective middle groups of Figures 3 and 4. A progressive increase in the ratio after the turning point is higher than before that point with a higher input of PRO. This implies a trade-off relationship between PRO and other types of capital. Given interaction by process capital, innovation capital more than doubles its effect on IC, versus that without interaction (ratio of 1.214 to 0.455 is 2.67). Models 2 and 4 show customer capital with more than a 150 percent effect (0.528 to 0.918) on IC.

5. Conclusions
This paper is the first empirical study to use the censoring concept for evaluating value drivers of IC. The censoring model describes the relationship between a non-negative dependent and independent variables. This study adopts financial data to find value drivers. The relevant literature on IC has adopted questionnaires (Baxter and Matear, 2004; Bollen *et al.*, 2005; Bontis, 1998), but few studies have used financial data. As questionnaires are mostly developed from the management perspective, methods have included SEM (Bontis, 1998; Martinez-Torres, 2006; Tseng and Goo, 2005) and regression (Chen *et al.*, 2005).
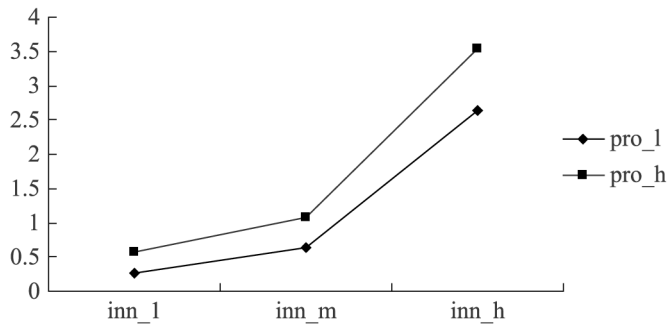
Note:
1. The process capital is classified into low and high groups (pro_l and pro_h) based on median.
2. The innovation capital is classified into low, middle and high groups (inn_l, inn_m and inn_h) based on the first and third quartiles

Figure 3.
Interaction between innovation capital and process capital
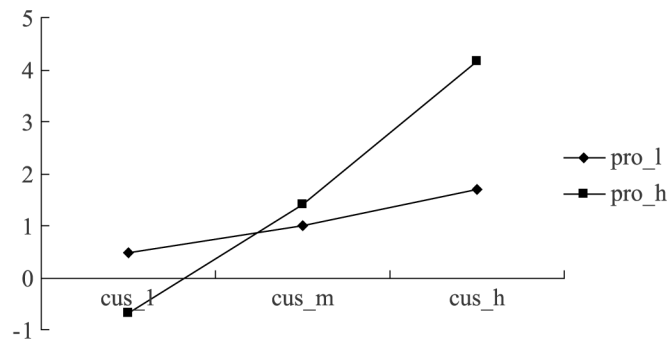
Note:
1. The process capital is classified into low and high groups (pro_l and pro_h) based on median.
2. The customer capital is classified into low, middle and high groups (cus_l, cus_m and cus_h) based on the first and third quartiles.

Figure 4.
Interaction between customer capital and process capital

A validated procedure to identify and revalue value drivers of IC in a knowledge-based industry was created. This entailed ferreting out the competitive edge of an industry as a means of identifying the IC needed to obtain a competitive advantage via the IC framework, a basis for building a censoring model of the firm's IC, validated by the Tobit model.

This study produced various findings useful to both researchers and practitioners. First, this study integrated two theoretical streams or perspectives. The management perspective was applied to examine components of IC. The financial perspective was used to select original financial items to gauge each intellectual component. Second, this study conducted one of the first empirical tests of association between competitive edge and value drivers of a firm. This empirical test expands competitive advantage

theory to seek elements of IC and to explain their association with value drivers. Finally, results of process capital not only illustrate interaction but also imply a trade-off between each component of IC. Process capital negatively correlates with IC, which is a more practical finding than in previous research (Bontis, 1998; Bontis *et al.*, 2000; Martinez-Torres, 2006; Tseng and Goo, 2005; Wang and Chang, 2005).

Note

1. The Global Industry Classification Standard (GICS) was developed by Morgan Stanley Capital International (MSCI), a premier independent provider of global indices and benchmark-related products and services, and Standard & Poor's (S&P), an independent international financial data and investment services company and a leading provider of global equity indices. GICS structure consists of 10 sectors, 24 industry groups, 67 industries and 147 sub-industries.

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