Intellectual Capital in Tech Industries: a Longitudinal Study

Scott Erickson[1] and Helen Rothberg[2]
[1]Ithaca College, USA
[2]Marist College, Poughkeepsie, USA
gerickson@ithaca.edu
hnrothberg@aol.com

Abstract: This paper reports on data collected over time on intellectual capital levels in three high-tech industries. Data are also presented on competitive intelligence activity in the same industries. These data shed light on the idea that knowledge management is more strategic than is commonly portrayed, with the level of development and sharing of knowledge depending on circumstances at the national, industry, and firm level. Similarly, competitive intelligence offense and defense also vary according to environment. Given the evidence here that knowledge assets vary widely by industry and by firm, as do competitive intelligence efforts, organizations should scan their environments and adopt knowledge strategies appropriate to their circumstances.

Keywords: strategy, knowledge management, intellectual capital, competitive intelligence, technology

1. Background

Empirical work is beginning to take a central stage in the field of intellectual capital (IC), as we move from case studies and conceptual work to broader industry-wide or nationwide work. For a long time, IC studies concentrated on a single firm or a small group of firms in order to define terms and illustrate best practices. Increasingly, however, both practitioners and scholars are looking for more convincing evidence of the positive impact of knowledge management (KM) systems installed to better manage intellectual capital. This paper continues in that direction.

IC theory and practice has developed over the past twenty years, basically as a reaction to our inability to measure and manage intangible assets. As closely allied efforts to install knowledge management systems also gained momentum, IC was used to try to better define these softer knowledge assets, assess their levels, and obtain competitive advantage by applying them more effectively. Much of the early work had to do with human capital, specifically the skills and expertise of individual employees, be they on the line, in management, or in support positions. Peter Drucker's (1991) "knowledge workers" was one of the first suggestions that human capital would be a critical source of competitive advantage. This concept of a knowledge economy, in which individuals' unique knowledge and skills would confer marketplace advantages, fit well with burgeoning interest in the resource-based theory of the firm (Dierickx & Cool 1989, Nelson & Winter 1982). This concept, from strategic planning, suggests that sustainable competitive advantage comes from the unique resources of the firm, in this case its particular knowledge assets, which provide core competencies (Prahalad & Hamel 1990) and superior performance. The natural conclusion from IC and KM is that it is, indeed, knowledge that is the key resource in firms, and those organizations looking to effectively differentiate themselves should seek to better manage that knowledge through identification, assessment, and development (Zack 1999, Stewart 1997, Grant 1996, Quinn 1992).

With this conceptual foundation in place, much of the proceeding work in the field has focused on that issue of how to better manage knowledge assets (Choi & Lee 2003, Schulz & Jobe 2001, Nonaka 1994). On one hand, some efforts have emphasized defining knowledge assets and better understanding their makeup. The difference between tacit and explicit knowledge, for example, is important to the field. While tacit knowledge is individual and may be hard to express, explicit knowledge can often be codified and thus easier to share. As a consequence, the techniques for managing each type of knowledge are quite different (Nonaka & Takeuchi 1995, Boisot 1995). In fact, efforts to manage tacit knowledge may be more trouble than they are worth, something organizations should keep in mind before even attempting knowledge management installations. This again implies a more strategic approach to KM.

Another important conceptual distinction is between the different types of intellectual capital: human capital, structural capital, and relational or collaborative capital (Bontis 1998, Edvinsson & Malone 1997, Stewart 1997). These refer, respectively, to more job-related knowledge, organization-related knowledge, and external-related knowledge. This framework was important to incorporating all manner of intangible assets into the intellectual capital fold, allowing corporate culture and IT systems

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(structural capital) as well as brand equity and regulatory experience (relational capital) to be identified, valued, and managed in the same way as human capital. All are unique elements of the knowledge of the firm, and all can be better measured and managed if properly identified and understood.

The presumed connection between better knowledge management and enhanced competitiveness (leading to superior financial performance) encouraged research on measurement and on KM techniques that could lead to measurable change (Marr & Schiuma 2001). Investment in information technology systems designed to better manage explicit knowledge, applications to deal with tacit knowledge such as expert systems or communities of practice, and other such installations were undertaken with an expectation that identifying, organizing, and distributing knowledge was the path to greater returns. The underlying assumption was that the more widely knowledge could be identified and shared, both throughout the firm and across its extended network, the better. At the same time as the increase of interest in KM and its practice, however, we saw a similar growth in the use of competitive intelligence (CI) operations. And given that a competitor's CI function was often aimed at precisely the valuable proprietary knowledge that a firm was carefully managing, there was a natural question as to whether those knowledge assets should be shared quite so freely. Could oversharing, especially outside the core firm, leave an organization more vulnerable to competitive intelligence incursions? Should the degree of KM employed be a more strategic decision, leveraging knowledge assets to a greater or lesser degree depending on competitive conditions, including both the potential from KM growth and threats from CI activities?

Although not a totally ignored question within IC/KM circles, neither is protection of knowledge assets widely recognized as a concern. A few researchers have raised the issue (Liebeskind 1996, Zander & Kogut 1995), but the number of scholars aware of the risks does remain limited. Should more attention be paid? Probably, as CI operations continue to grow (ASIS 1999) and effective competitive intelligence itself is increasingly seen as a means of competitive advantage by developing a better understanding of what competitors might be up to and acting appropriately. In a manner similar to KM, CI identifies knowledge assets (concerning a competitor), seeks out additional knowledge to close gaps, and develops actionable insights through analysis (Rothberg & Erickson 2005, Rothberg & Erickson 2002, Bernhardt 2002, Cappel & Boone 1995).

Sum it all up, and there is a great case to be made for employing KM to better manage the knowledge assets of the firm. In doing so, the organization clearly wants to make good use of its knowledge, leveraging it by putting it in the hands of as many affiliated individuals as possible. But that view is tempered by the CI threat. Not all affiliated individuals (and their organizations) are equally reliable, and lax security procedures may leave the core firm open to loss of its proprietary knowledge, watching all those precious assets leak to a competitor. Consequently, the KM decision may be far more strategic than what we typically believe. Depending on the benefits accruing from distributing the knowledge more widely balanced against the potential costs emanating from knowledge loss, a firm in given circumstances may decide to pursue less than full development and distribution of its knowledge. How much does it gain from extensive sharing? How much does it risk? Should distribution be limited to individuals inside the firm? To first-tier network partners? Or be totally unlimited? How aggressively should the firm conduct counterintelligence or enact protection measures?

Clearly, the answer depends on circumstances and becomes something of a strategic choice. But what environmental variables influence this choice? Natural candidates include national variables (IC reporting encouraged or required, strong intellectual property protections, etc.) and industry variables as we know conditions vary widely according to each. Consider the potential for KM in circumstances such as pharmaceuticals vs. motion pictures or the threat of CI in financial services vs. retail. In addition to these areas, the firm itself and the type of knowledge it employs (tacit vs. explicit, complexity, teachability) will matter. All of these variables, at the firm, industry, and national levels have the potential to be important to the strategic decision concerning KM development and protection (Rothberg & Erickson 2005).

Obviously, we would like to measure the circumstances as a start to providing practitioners with concrete guidance on how far to develop knowledge assets and how far to protect them. One of the issues is how much a firm would benefit from further KM development. That would seem to be at least partially dependent on the importance of intellectual capital within the firm's industry. How much

IC do it and its principal competitors, or whoever represents best practice, possess? The literature is full of attempts to measure IC, especially its details within the firm. Skandia Navigator (Edvinsson & Malone 1997) was one of the first systems and has been employed at a number of other firms as well, as has Pulic's (2004) VAIC method. Even the well-known Balanced Scorecard (Kaplan & Norton 1992) can provide something of a measurement of knowledge assets within a given firm. Related studies have sought to measure specific components of IC (e.g. human capital only or structural capital only) (Tan, Plowman & Hancock 2007, Chen, Cheng & Hwang 2005, Firer & Williams 2005, Lev & Radhakrishnan 2003). As with the other techniques mentioned, one can use these approaches to build up to an overall assessment of IC, essentially a micro to macro progression. All are fruitful and have yielded interesting results, helping to better identify and manage IC. But their very complexity makes them somewhat unreliable and difficult to apply beyond a single firm or small group of firms. The type of strategic approach we have been discussing would benefit more from cutting right to a macro (firm/industry) level measure.

This study continues our work attempting to better measure the level and success of knowledge management within a given industries, providing better guidance to practicing managers in determining how much they should pursue KM systems and practice. This study also adds a competitive intelligence perspective to the discussion. We look to directly measure IC in industries related to information technology, assessing both its importance and the relative success of participating firms. We also look to measure CI activity in the same industries, providing some sense of the threat posed by such efforts. Finally, we obtain a second measurement ten years later, allowing some perspective and some insights about how knowledge development and protection strategies may need to change over time. The results provide some guidance to firms as to what they might measure and how they might react in relation to their KM strategies.

2. Conceptual framework and methodology

In assessing a firm's need to develop KM, we need to measure the level of IC generally required to compete in that industry. In short, we need to measure IC by industry to determine how an individual firm in that industry compares and what it must do to remain competitive. Quite a number of potential measures are available (Tan, Plowman & Hancock 2007) though like some of those noted earlier, they are really meant to tease out the individual components of IC, building up to the overall measure. We are applying a variation on Tobin's q, a measure of intangible assets with a long history in the literature, widely accepted, easily available, and robust across different applications. It has been effectively used in industry comparisons such as these (Bramhandkar, Erickson & Applebee 2008). The measure is simply the difference between market capitalization and asset replacement cost, essentially value of the firm less tangible assets. The remainder are the intangible assets, essentially the knowledge assets of the firm. Since replacement cost can be hard to obtain, a common variation on Tobin's q is book value. A further choice is whether to treat the difference as a ratio or an actual difference. The former can yield misleading results if very small firms are included while the latter makes comparisons between different sizes of firms difficult. Our data set includes only large firms, so the ratio approach makes the most sense. With this measure, a high ratio indicates significant IC is apparent in the firms in the industry, suggesting that a certain aggressiveness in developing IC is probably necessary in order to compete. Alternatively, a low ratio indicates minimal IC exists and it may be either difficult or unnecessary to develop in that industry. Further, an individual firm with a higher ratio has presumably done a more effective job of developing its IC—it has more for a given level of tangible assets. Alternatively, a firm with a lower ratio than its industry is underperforming in terms of IC development and may be at a competitive disadvantage.

In assessing competitive intelligence, we used membership figures from the Society of Competitive Intelligence Professionals (SCIP). By obtaining an average number of members per firm for an industry, we can proxy the level of CI activity in that industry, essentially the incursion threat facing all the member firms. Even though the numbers are fairly small, the presence of just a member or two can be indicative of substantive CI operations as a SCIP member may have numerous other employees working under them.

We limited this study to related industries though with some potentially interesting differences. This is useful in this type of analysis since physical asset requirements of industries can vary dramatically, potentially skewing the denominator of our IC measure. Consider the different percentages of capital equipment, financial capital, labor, and intangibles across industries such as aircraft manufacturing, retail banks, and entertainment providers. Within an industry, those percentages will be similar,

eliminating the problem. While cross-industry comparisons would be useful in another context, they need to be done with some care. We eliminate some of the issues with the focus of this study.

Two data sets are present. The first is from 1993-1996 and is the more complete of the two. The second is from 2003-2006, is still under development and so is somewhat more limited. We used Compustat and StockVal to gather the financial data, organizing it by SIC code and NAICS code, respectively, for the two time periods. Market capitalization and book value were obtained and averaged across the four-year periods by firm, and then aggregated by industry. The four years helps to even out some of the influence of a particularly good or bad year while also illustrating trends. We also obtained SCIP membership data from 1993—1996. We are in the process of obtaining such data for the more recent period, but for now have only information for the current year.

3. Results

As illustrated in Table 1, we included three computer-related technology-oriented industries, all with substantive manufacturing components (even if much might be outsourced). As noted, the 1993-1996 database is more complete, including the Fortune 500 as well as a number of other large firms with a SCIP presence. The newer database is under construction and includes only select firms to this point. Consequently, the data in Table 1 represent 10-15 firms per industry for the earlier time period, with some illustrative individual firms broken out below. The later time period includes only those illustrative firms.

Table 1: Tobin's q, SIC 3571 electronic computers

	1996	**1995**	**1994**	**1993**	**Mean**	**Index**		**2006**	**2005**	**2004**	**2003**	**Mean**
Amdahl		1.29	1.44	0.46	1.06	0.42						
Apple	3.04	1.96	2.19	1.67	2.22	0.88		6.36	6.03	2.98	1.88	4.31
Compaq	4.78	4.78	3.81	3.81	4.30	1.71						
Dell	9.97	6.23	3.53	2.74	5.62	2.24			16.51	15.73	13.61	15.28
DEC	1.57	2.51	1.48	1.02	1.65	0.66						
HP	4.76	4.28	2.92	2.50	3.62	1.44		2.74	2.18	1.53	1.80	2.06
Sequent	1.59	1.76	2.35	2.84	2.14	0.85						
Stratus	1.39	1.57	2.08	1.61	1.66	0.66						
Sun	4.72	3.76	1.93	1.66	3.02	1.20		2.29	1.86	2.16	2.37	2.17
Tandem	1.46	1.57	2.66	0.95	1.66	0.66						
Unisys	0.71	0.43	0.59	0.83	0.64	0.25						
Means	**3.40**	**2.74**	**2.27**	**1.82**	**2.51**			**3.79**	**6.65**	**5.60**	**4.92**	**5.96**

Table 2: Tobin's q, SIC 3572 Storage, 3577 peripherals

	1996	**1995**	**1994**	**1993**	**Mean**	**Index**		**2006**	**2005**	**2004**	**2003**	**Mean**
EMC	6.53	5.31	10.52	17.49	9.96	1.88		2.80	2.71	3.10	2.93	2.89
Maxtor		4.85	1.61	0.87	2.44	0.46						
Quantum	2.83	1.90	1.74	1.55	2.01	0.38						
Seagate	3.51	2.49	1.31	1.61	2.23	0.42						
Storage Tech	3.16	1.22	1.33	1.30	1.75	0.33						
Cisco	16.20		9.80		13.0	2.46		4.37	5.27	5.20	4.78	4.91
Synoptics			3.45	7.89	5.67	1.07						
Means	**6.45**	**5.33**	**4.25**	**5.79**	**5.29**			**3.59**	**3.99**	**4.15**	**3.86**	**3.90**

Table 3: Tobin's q, SIC 3674 semiconductors

	1996	**1995**	**1994**	**1993**	**Mean**	**Index**		**2006**	**2005**	**2004**	**2003**	**Mean**
AMD	2.04	1.23	1.78	1.65	1.68	0.46		1.86	3.98	2.87	2.13	2.71
Analog Devices	4.97	5.35	3.88	3.21	4.35	1.20						
Intel	8.61	5.41	3.19	4.40	5.40	1.48		3.31	4.30	3.79	5.51	4.23
Intl Rectifier	1.86	3.63	2.67	1.51	2.42	0.66						
Level One	5.99	4.24	6.38		5.54	1.52						
Micron Tech	2.99	5.91	4.08	2.90	3.97	1.09		1.60	1.23	1.22	1.76	1.45
Motorola	2.97	3.99	5.18	4.95	4.27	1.17		2.65	3.65	3.16	2.67	3.03
Ntl Semi	2.14	1.88	2.04	2.33	2.10	0.58						
Siliconix	2.42	8.06	2.14	1.47	3.52	0.97						
Texas Inst	2.95	3.60	3.02	2.99	3.14	0.86		3.67	4.61	3.24	4.28	3.95
Means	**3.69**	**4.33**	**3.43**	**2.82**	**3.64**			**2.62**	**3.55**	**2.86**	**3.27**	**3.07**

The data provide some interesting insights. There is a very clear difference between industries in terms of the level of intangible assets/intellectual capital. There is also a very clear difference

between some of the firms within a given industry in terms of IC. Further, both of these circumstances can and do change over time. Consider each in more detail.

The Tobin's q ratio for computers runs between 0.64 and 5.72 with an mean of 2.51 over the early period in the database, considerably below the 2.10 to 5.54 (3.64 mean) of semiconductors and, especially, the 1.75 to 13.0 (5.29) of peripherals. This makes some sense as we remember that the mid-nineties generally saw a commoditization of computers. It was in the early to mid part of the new century that Dell started to practice its customization and low-price offensive that made it the largest player in the market for a number of years. Its burgeoning IC indicated not only manufacturing prowess and a highly efficient supply chain but also an ability to read customer needs and wants. Apple's design prowess and brand image brought it similar results beginning in 2005. Both firms possessed demonstrably higher levels of knowledge during this period and were rewarded in the marketplace. One could argue that Dell's more recent outsourcing of manufacturing and customer service, and the resulting loss of unique knowledge, is reflected in its more disappointing current results.

Semiconductors are more of a mixed bag, with some cutting edge chips being released regularly, some copies following close behind, and a number of commodity chips being produced for basic electronics goods. Intel's enduring success based on its R&D abilities, customer relationships with pc makers, and brand image isn't surprising, especially its consistent IC dominance of rival AMD. Texas Instruments, at one time a laggard to industry IC levels now exceeds them while Micron has gone in the other direction. In peripherals, the high amounts of IC possessed by both EMC and Cisco just prior to the tech boom are not as impressive now, though both continue to indicate possession of considerable knowledge assets.

The indices are presented to give an idea of the relative importance of intangibles relative to the physical assets (whatever their absolute level might be). In the case of computers, for example, Dell is 2.24 times above the average ratio while other competitors lag at 0.25 and 0.42 of the average intangible to tangible ratio. For peripherals, the story is much the same with Cicso at 2.46 times the average ratio vs. others with 0.33 and 0.38. In semiconductors, the results are much more bunched, from a high of 1.52 for Level One to a low of 0.58 for AMD. What this means is that the presumably higher performing firms in terms of IC development have built intangible levels much higher in the computer and peripherals industries than is the case with semiconductors. Again speculating, we can hypothesize that the former industries are more apt to have dominant firms with superior knowledge assets than is the case in semiconductors where numerous strong firms compete in quite a few niche markets (Intel and TI, for example, tend to make very different types of chips).

The critical point is that intellectual capital does wax and wane, as circumstances change. Further, firms need to be cognizant of the conditions in their industry and their place in it. If the industry average for Tobin's q, for example is around 4.0, and you have competitors substantially above that while you are below it (not identical to, but similar to HP's situation in the later time period in Table 1), you had better look to more aggressively manage your IC, closing that gap. Information on competitive practices, the areas of IC in which the gaps are present, would be useful in supporting this more strategic approach to knowledge management.

In Table 2, the competitive intelligence data tell a similar story. As noted earlier, these numbers reflect the average number of SCIP members per firm for the earlier time period (again, number of firms 8-15, depending on the SIC classification).

Table 4: SCIP Membership (average across industry and by firm)

	2008		**1996**	**1995**	**1994**	**1993**
SIC 3571: Computers	1.75		2.79	1.93	1.21	0.54
SIC 3577: Peripherals	2.00		1.55	0.90	0.64	0.18
SIC 367: Semiconductors	0.75		4.00	3.14	1.07	0.43

As with the IC results, we see quite a range of outcomes. All three industries saw substantial growth in CI activity over the four-year period in the 1990's. Further, there are definite differences between the industries, with semiconductors showing quite high levels of competitive intelligence compared to

each of the others, especially peripherals during that early time. CI actions also vary by firm. Although we can't reveal firm-specific from the current database for confidentiality reasons, computer firms range from 0 to 6 SCIP members (and both computers and semiconductors had firms with double-figure memberships during the 1990's.

What does this mean? Once again, one needs to be aware of circumstances and the implication for competition intelligence offense and defense. In an industry with extensive CI activity, an organization needs to guard its knowledge assets more carefully, perhaps not developing and sharing them as much through a KM system as it might otherwise. Further, if a specific competitor has very high levels of CI activity, that would be a real red flag for KM development. Finally, if the practice in the industry is extensive CI and the firm in question doesn't have an active team, it should probably look into doing something about that as well.

4. Conclusions

This study focuses on three specific, related high-tech industries and a number of individual firms within those industries. By examining levels of intellectual capital over time, it better establishes the strategic foundation for knowledge management practice. The potential and need to develop KM varies markedly by industry. In some cases, KM may be difficult to further develop and, if others in the industry refrain, the prudent firm might also. In other cases, aggressive KM may be a requirement to even participate. In such cases, a substantial and effective KM program needs to be quickly employed.

Similar conclusions can be drawn from the CI data. Limited knowledge sharing because of dangerous competitive intelligence activity can also be a critical strategic decision. Alternatively, if CI is not a threat, KM can be freely pursued, if worthwhile. The case for establishing one's own CI operation and/or incorporating counterintelligence procedures into firm practice can also be made depending on circumstances.

This and similar studies better establish knowledge development and protection as strategic options. It is not the case that KM should always be pursued to its greatest degree, collecting and distributing knowledge as widely as possible. It is also not the case that CI always should or should not be practiced, it really depends. Further explorations in this direction will help us to determine what variables help us to decide what makes sense in what circumstances.

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