Big Data and Knowledge Management: Establishing a Conceptual Foundation

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Abstract: The fields of knowledge management and intellectual capital have always distinguished between data, information, and knowledge. One of the basic concepts of the field is that knowledge goes beyond a mere collection of data or information, including know-how based on some degree of reflection. Another core idea is that intellectual capital, as a field, deals with valuable organizational assets which, while not formal enough to rate a designation as intellectual property, still deserve the attention of managers. Intellectual capital is valuable enough to be identified, managed, and protected, perhaps granting competitive advantage in the marketplace. So what do we make of current trends related to big data, business intelligence, business analytics, cloud computing, and related topics? Organizations are finding value in basic data and information as well. How does this trend square with the way we conceptualize intellectual capital and value it? This paper will work through the accepted literature concerning knowledge management (KM) and intellectual capital (IC) to develop a view of big data that fits with existing theory. As noted, knowledge management and intellectual capital have both recognized data and information though generally as non-value precursors of valuable knowledge assets. In establishing the conceptual foundation of big data as an additional valuable knowledge asset (or at least a valuable asset closely related to knowledge), we can begin to make a case for applying intellectual capital metrics and knowledge management tools to data assets. We can, so to speak, bring big data and business analytics into the KM/IC fold. In developing this theoretical foundation, familiar concepts such as tacit and explicit knowledge, learning, and others can be deployed to increase our understanding. As a result, we believe we can help the field better understand the idea of big data and how it relates to knowledge assets as well as provide a justification for bringing proven knowledge management strategies and tools to bear on big data and business analytics.

Keywords: knowledge management, intellectual capital, data, information, big data, business analytics

1. Knowledge

The value of intangible assets to the organization has long been recognized, going back to classic economists such as Schumpeter (1934) and management theorists such as Drucker (1991). The idea that such intangibles might be a key source of competitive advantage also has a deep history, including Nelson & Winter (1982). Sprouting from the resource-based theory of the firm (Wernerfelt, 1984), a more contemporary view has centered squarely on the key role of knowledge in obtaining and sustaining competitive advantage. Indeed, the knowledge-based view of the firm (Teece, 1998; Grant, 1996) suggests that knowledge may be not only a source, but *the* source of unique, sustainable marketplace advantage.

The fields of knowledge management (KM) and intellectual capital (IC) have to do with identifying and managing knowledge assets effectively in order to gain this competitive advantage. IC grew out of accounting and centers on identifying and measuring the knowledge assets of the organization (Bontis, 1999; Edvinsson & Malone, 1997; Stewart, 1997). KM is more about effectively managing these assets, through combination, sharing, and other methods leading to their growth (Zack, 1999a; Grant, 1996).

Both fields have always focused on the nature of the knowledge assets. In intellectual capital, there is a standard distinction between human capital, structural capital, and relational capital (Bontis, 1999). Human capital generally has to do with job-related know-how and learned expertise, structural capital with enduring knowledge existing within the organization (e.g. corporate culture, systems and procedures), and relational capital with knowledge concerning external relationships (e.g. customers, suppliers, regulators). KM has focused on aspects of knowledge that can make it easier or harder to capture and/or share it such as tacitness vs. explicitness (Nonaka & Takeuchi, 1996; Polanyi, 1967), complexity, and stickiness (McEvily & Chakravarthy, 2002; Zander & Kogut, 1995; Kogut & Zander, 1992). In addition, the field has also focused on tools and techniques that can be employed for KM purposes, especially those tools that may be more or less appropriate given the nature of the knowledge to be managed (Choi & Lee, 2003; Schulz & Jobe, 2001; Boisot, 1995). Given full awareness of the circumstances and likely approach, techniques such as communities of practice, IT-based knowledge markets, or other options can be applied (Brown & Duguid, 1991; Matson, Patiath & Shavers, 2003; Thomas, Kellogg & Erickson, 2001).

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Organizational variables also matter, including absorptive capacity of the firm (Cohen & Levinthal, 1990) and its degree of social capital (Nahapiet & Ghoshal, 1998). The full range of knowledge characteristics and organizational capabilities can poses their own issues with workability, including how matters such as motivation and trust can influence participation. It's really a matter of choosing the right approach for the circumstances of the firm and can be a complex decision.

2. Beyond knowledge

One characteristic present in all of this research on knowledge, knowledge assets, and knowledge development is a clear emphasis on the nature of knowledge itself. A distinction between knowledge, information, and data is quite apparent and very deliberate (Zack, 1999b), flowing from Ackoff's (1989) data, information, knowledge, and wisdom (DIKW) hierarchy. Data are simply observations, information is data in context, and knowledge is information subjected to experience, reflection, or some other practice providing a deeper understanding. The KM field, in particular, has always been quite clear about its subject matter being more difficult to manage knowledge, or know-how, particularly since data and information are by definition explicit and easily exchanged through information systems. And development of even higher level "wisdom" or intelligence beyond basic knowledge has generally been left to other fields, as we'll discuss.

But there is a recognized relationship in KM between data, information, and knowledge, principally the potential for data and information to turn into knowledge upon reflection, experience or learning, providing good reason to term these undeveloped observations "preknowledge" (Rothberg & Erickson, 2005). But there is still reluctance in the field to study any phenomenon not rising to the level of knowledge.

One early exception to this view came from competitive intelligence (CI). CI evolved during the 1990's, at much the same time as KM scholarship and practice was growing. At heart, the field is also about collecting knowledge, though it also includes data and information about competitors that is then organized, processed, and analyzed for key strategic and tactical insights (Prescott & Miller, 2001; Gilad & Herring, 1996; Fuld, 1994).

If one reviews CI scholarship, it often focuses on sources of information and related applications (Fleisher & Bensoussan, 2002; McGonagle & Vella, 2002). As just implied, this is often information or even raw data in addition to knowledge (e.g. financial reports or regulatory filings). The true value of CI, seen as CI operations mature within a firm, is in the range of intelligence-gathering sources and networks, combined with the growing analytical skills of team members (Wright, Picton & Callow, 2002; Raouch & Santi, 2001).

So KM and CI have readily apparent similarities (Rothberg & Erickson, 2005; 2002). Collection and distribution of key knowledge or information are critical to both, and methods differ by the nature of the application. The broad strategy of seeking competitive advantage from knowing something the competition doesn't (about your company or theirs) is identical. Where we begin to see differences, however, is in the nature of the inputs and what is done with them. As noted earlier, CI operations will often draw bits and pieces concerning a competitor from a variety of sources, and those inputs could include data, information, or knowledge.

But it is in directed analysis and purposefully drawing insights from the information and data that CI begins to separate itself further. The objective of CI is actionable intelligence, so CI teams typically review all available resources to discern patterns or ideas about competitor behavior. Such operations are responsible for understanding competitor actions, uncovering the strategies behind the actions, and, at the highest levels, anticipating strategic and tactical moves (Gilad, 2003; Bernhardt, 1993). This attitude is rare in KM circles, but, as we'll see, is a major driver behind the big data and business intelligence trend. Indeed, we believe it would be very surprising if KM scholarship and practice doesn't also move in this direction.

In some ways, the field has already started to shift. The rapid growth of various analytical and intelligence efforts in specific disciplines has shown that potentially valuable intangible assets are found in a variety of places inside and outside the firm. These assets may or may not fit within the traditional KM or intellectual capital frameworks, though most treatments of big data or business intelligence at least nod to KM or related systems (Bose, 2009; Jourdan, Rainer & Marshall, 2008). Andreou, Green & Stankosky (2007) developed a List of Operational Knowledge Assets (LOKA) to identify the wide variety of areas now contributing data, information, knowledge and/or intelligence to the organization. These include:

- Market capital

    - Competitive intelligence
    - Enterprise intelligence
- Human capital
- Decision effectiveness
- Organizational capital, and
- Innovation & customer capital

While one could squeeze these items into the traditional intellectual capital categories of human, structural, and relational capital, the richer description adds greater context to the discussion (and brings in the competitor element). The LOKA approach also makes clear that information and data might be part of the intangible asset mix, albeit at a lower level than most knowledge assets. But it is clear the discussion is starting to expand beyond our traditional definitions of knowledge.

Big data, business analytics, business intelligence or whatever else one wants to call it will likely be a part of this discussion. By any definition, the advent of big data has been driven by the dramatic decrease in the cost of data storage and data processing. More power and decreased costs have led to an ability in many firms to store ever greater amounts of data and conduct more in-depth analysis on a regular basis, either through their own IT systems or in the cloud (Bussey, 2011; Vance, 2011b). Cloud services are available at reasonable costs by any number of big providers, including such well-known names as amazon.com, Google, and Microsoft. While surrendering the data to a second party gives away some level of control, security may actually be increased as the larger providers are usually more experienced at keeping data away from prying eyes.

Many of the big data applications have to do with operational and/or transactional data, shedding light on operations, supply chain, or distribution channel performance or on customer/consumer behavior (Vance, 2011a). Big data, in particular, has the potential to add value by providing transparency with immediate performance feedback, experimentation with quick results, more precise segmentation, more objective decision-making (algorithms rather than humans), and new products (Manyika, et. al., 2011). Big data and business analytics bring new capabilities to the party, and we need to discuss how they fit within the knowledge management/intellectual capital universe.

Big data has had only limited development in the literature. What exists has largely been based on the "3 V's" of data volume, velocity of input and output, and data variety (Laney, 2001). As volume, velocity, and variety have increased, along with dropping costs, they have allowed increased analysis of the new databases, enabling better strategic, tactical, and operational decision-making (Beyer & Laney, 2012). Big data has grown accordingly, bringing new metrics such as data storage into the mix (Liebowitz, 2013; Manyika, et. al. 2011) and the new buzz words we all associate with this important trend. It's important to remember, however, that the size of the databases is only one piece of the equation. As we know from knowledge and intelligence approaches, the information and data don't reveal their full value until insights are drawn from them. And so, big data becomes useful when it enhances decision-making. Decision-making is enhanced only when analytical techniques are applied and some element of human interaction is applied (Zhao, 2013).

With the blending of data and information vs. knowledge and intelligence, we see an opportunity for cross-fertilization between big data/business analytics and the fields of knowledge management, intellectual capital, and related disciplines. KM would certainly benefit from more attention to its pre-knowledge inputs. But the field also has an extensive history of developing tools and techniques for identifying, developing, and leveraging intangible assets. Further, KM has a focus not only on information technology and systems approaches but also on the more person-to-person and person-to-system issues affecting the actual operation and success of the systems (Matson, Patiath & Shavers, 2003; Thomas, Kellogg & Erickson, 2001). In a number of ways, what we know about KM and related disciplines both underscores the data vs. analysis divide and provides promise that organizations can be successful in effectively employing big data and business analytics.

3. Big data and business analytics

In order to provide a framework for discussion, we created Table 1 from two sources. Initially, there is information concerning big data, taken from a McKinsey Global Institute (MGI) report (Manyika, et. al., 2011). This is combined with industry categorizations based on levels of intangible assets and competitive intelligence activity as well as a market capitalization to assets ratio used to assess intangible assets (Erickson & Rothberg, 2013; 2012). From this table, we can begin to suggest some ideas concerning the relationship between big data and knowledge as well as what underlying concepts may explain differences present in the information.

Table 1: Big data, knowledge, and competitive intelligence, by industry

Industry	Stored Data per Firm (terabytes)	Stored Data, US Industry (petabytes)	Ease of Capture Factors (top factors, quintile)	SPF Category	Market Cap/Assets (μ= 1.02)
Security & Invest Services	3,866	429	Talent (1), data availability (2)	SPF 30	0.19
Banking	1,931	619	Talent (1), data availability (2)	SPF 30	0.14
Communications & Media	1,792	715	Not included	SPF 45	0.72
Utilities	1,507	194	Data-driven mindset (1), data avail (1)	SPF 5	0.54
Government	1,312	848	Data availability (4)	N/A	---
Discrete Manufacturing	967	966	Talent (1), data availability (1)	SPF 45	1.33
Insurance	870	243	Talent (1), data availability (2)	SPF 30	0.41
Process Manufacturing	831	694	Talent (1), data availability (1)	SPF 30, 15	1.39
Resource Industries	825	116	Data-driven mindset (1), data availability (1)	SPF 45, 30	1.04, 0.68
Transportation	801	227	IT intensity (1), data availability (2)	SPF 5	0.61
Retail	697	364	Data availability (4)	SPF 15	1.18
Wholesale	536	202	IT intensity (2)	SPF15	0.94
Health Care Providers	370	434	Data-driven mindset (1), data availability (1)		0.85
Education	319	269	Talent (2)	SPF 45	2.34
Professional Service	278	411	Talent (1), IT intensity (2)	SPF 30	1.00
Construction	231	51	All (3) or below	SPF 15	1.07
Consumer & Recreational Services	150	105	IT intensity (2)	SPF 30	0.91

The first three columns are taken straight from the MGI report, including the industry definitions, though sorted according to Stored Data per Firm for our purposes. Stored Data by US Industry was sourced from research firm IDC by MGI and is an estimate of the total data held by firms with more than 1,000 employees in each broadly defined industry. This number is then divided by number of firms to get the per firm figure in the second column. Per firm obviously provides a much different number as number of firms varies dramatically between concentrated industries like those in financial services and dispersed industries such as manufacturing. Figures are from 2008.

The MGI report also provides an estimate of "Ease of Capture" of the value potential of big data for each industry. The estimate is based on four indicators, most of which have some relation to common knowledge concepts.

- **Talent** would be closely related to our common understanding of human capital. In particular, human capital with a tacit emphasis as individual talent or know-how may be difficult to share.
- **IT intensity** has a connection to structural capital. Although the latter term has other facets (corporate culture and other enduring common knowledge of the organization), the IT structure of the firm for managing data, information, and knowledge is also a substantial part of structural capital. Another aspect of this indicator would be that the firm has a good amount of explicit knowledge (capable of management with IT systems) and/or data and information, making it easier to leverage and share.
- **Data-driven mindset** goes back to human capital, specifically the knowledge of the firm's managers and leaders. As this is likely very personal knowledge, it is likely highly tacit and extremely difficult to replicate.
- **Data availability** is the one indicator that is not really knowledge-related but has to do with the knowledge precursors, data and information.

The SPF column relates to a Strategic Protection Factor framework for analyzing the level of knowledge development in an industry (need for and use of KM) contrasted with the level of competitive intelligence activity (need for protection of knowledge assets) (Rothberg & Erickson, 2005). Developed as an explanation for why aggressive investment in KM may or may not be an appropriate strategy, it also considers whether CI offense and defense are worth investment and effort. The categorizations in this table are based on concrete numbers from a large database constructed to validate the SPF framework (Erickson & Rothberg, 2012) and additional analysis linking the SPF's to big data (Erickson & Rothberg, 2013). Conditions for each SPF can be summarized as:

- **SPF 45: High KM, High CI.** A high level of knowledge development in industry and a high degree of competitive intelligence activity both exist. Investment in KM and in protection from CI are recommended for competitive success.
- **SPF 30: Low KM, High CI.** Knowledge development is at a lower level but competitive intelligence activity remains high. Aggressive investment in KM may be unwise but protection measures are very important.
- **SPF 15: High KM, Low CI.** Knowledge development is again high but now competitive intelligence activity is low. KM can be actively pursued without great worries about protection.
- **SPF 5: Low KM, Low CI.** Neither knowledge development nor competitive intelligence is present to any significant degree. Investment in either knowledge development or knowledge protection is probably unnecessary.

The associated Market Cap/Assets column reports on the metric used to estimate the KM score used in the SPF's. Measuring knowledge assets, as noted earlier, is the main point of the field of intellectual capital. Not surprisingly, quite a number of approaches exist, more than forty with some degree of credibility, according to Sveiby (2010). Some are well-known, such as the Balanced Scorecard (Kaplan & Norton, 1992) and the original Skandia Navigator (Edvinsson & Malone, 1997). One important difference between the methods, however, is whether they use readily available financial data from firms or they need to add up aspects of capital from the bottom to the top of the organization. The latter approach is useful for understanding a single company or small group of firms. The former approach, while not providing as much detail, is much more useful for comparing large numbers of companies at the same time—and might be considered more objective given the use of financial statement data. Whichever is chosen, the field has an extensive history of assessing the level of intellectual capital in a firm in order to determine impact (Tan, Plowman & Hancock, 2007; Chen, Chang & Hwang, 2005; Firer & Williams, 2003).

Here, we have used a variation on Tobin's q (Tobin & Brainard, 1977), a metric with a long history that assesses intangible assets by comparing market capitalization to replacement value of assets—essentially, how much more is the company worth than its tangible asset holdings suggest? Since replacement value of assets can sometimes be a hard figure to obtain, a common variation on Tobin's q is market cap to book value. We take that one step further by using market cap to assets, essentially removing debt from the measure. We want to know intangibles generated for a given level of asset, whether those are borrowed or not. We also employ the metric as a ratio, removing firm size as a factor. The data presented here were drawn from the I/B/E/S database representing all listed North American firms and including all years 2005-2009 in which these firms had revenues of at least $1 billion. As a result, the database includes over 2,000 firms and over 7,000 observations from that period. Organized and analysed by industry according to SIC number, we present the metric drawn from industries that seem to best match up with the industries noted in the MGS study. Note that the average market cap/asset ratio for the entire database was 1.02.

4. Discussion

The market cap/assets metric is useful in identifying those industries with firms that have been successful in identifying, capturing, and leveraging their intangible assets. In some ways, a high number (above the 1.02 average) indicates that knowledge is important in that industry. In order to be able to compete, firms must possess some knowledge or related intangible assets. But it goes beyond. Not only is knowledge important, but the ability to effectively manage that knowledge is important. And that's what shows up in the data. If a firm has one or two key employees with critical tacit knowledge, that may be important but it isn't necessarily manageable knowledge and therefore won't show up as clearly in this metric. On the other hand, more explicit knowledge that is effectively captured in IT systems and spread throughout the firm will be reflected in the ratio. This is important for judging big data capabilities as the combination of big data stores and effective management techniques is where the most promise is likely found. This thought is further supported by considering the actual SPF results.

The nature of the SPF categories leads naturally into a discussion of how big data and business analytics fit into the standard KM and IC conceptual framework. Some of the SPF distinctions are counterintuitive, as we see in the middle categories (SPF 30, SPF 15) that knowledge has value to one party but not another. The extremes, where knowledge has value to everyone (SPF 45) or to no one (SPF 5) are more immediately understandable. But there are good reasons behind these results.

When examining the characteristics behind SPF results, potential explanations emerge. Variables from the literature include knowledge characteristics (tacit/explicit, complexity, specificity to application or firm), knowledge types (human, structural, or relational capital), stage of industry life cycle, value chain location of critical knowledge, visibility, competitive intensity and others (Erickson & Rothberg, 2012).

In SPF 45, for example, a mix of valuable tacit and explicit knowledge exists but the emphasis is more on explicit than what one sees in other sectors. Valuable knowledge is also often found at multiple places along the value chain, not just in operations, just in marketing, or just in logistics, and can be hidden from view. Industries are becoming mature but still in early stages with a high degree of competition, bordering on hypercompetition. In these industries it makes sense that knowledge management is active (taking tacit insights, making them explicit, and sharing throughout the firm and its network) but that competitive intelligence is needed and active, too.

This is seen in the MGI results as well, and would suggest big data would fit right into these industries as a valuable contributor. With the exception of education (which is for-profit in the SPF data, both for-profit and non-profit in the MGI data), big data is present in these industries, particularly discrete manufacturing (which would include industries like pharmaceuticals and semiconductors) and communications and media (with telecommunications and computers/software). We typically view these types of industries creating tacit learning from explicit knowledge assets, then turning the tacit learning into more explicit knowledge to be further distributed. Big data would add to this pattern, with tacit insights coming from big data and being turned into useful explicit knowledge. The pattern is already there to analyze intangible assets and turn them into something useful.

SPF 30 is a different animal. This category is one with different perspectives on the value of knowledge as KM does not have a high value but CI does. So knowledge development is of little interest to the originating firm but is highly desired by competitors. What we believe we see in this group is explicit knowledge that is well-known throughout the industry with very little new, proprietary knowledge being created. When a tacit insight does come along, however, it is highly individualistic. There is an originating individual more than an originating firm, though the originating firm obviously benefits from the creativity. But the extremely tacit and personal nature of insight makes it hard to manage and duplicate through KM systems. The knowledge is rapidly incorporated into products and made explicit but, again, the creative process is hard to share with others in the company.

CI in these industries is aggressive and significant precisely because creative insights are so rare, they are hidden, and competitor discovery is possible because of the explicit outputs. So competitors need to have a substantive operation in order to uncover the new insights, and payoffs are both possible and rewarding. The financial services industries are good examples of this group (investments, banking, insurance) as all have well-understood basic products, but new strategies or products (portfolio strategy, loan targets) can be a competitive advantage until uncovered and rapidly copied by competitors. Similarly, some natural resource industries, process manufacturers, and professional services (accounting, advertising) have industry-wide knowledge that is only slowly adjusted with new insights, incorporated into processes, and then vulnerable to competitor copying.

The big data implications are that these industries are significant users of data. And the MGI results reflect the previous conclusions as we see a combination of talent (tacit insights) and data applications (established explicit knowledge) present in many of these industries. Just like knowledge, much of the content of these databases is explicit and non-proprietary, except in the details. But these industries are exactly the type to benefit from a combination of big data, carefully managed KM (not necessarily major installations but perhaps more talent acquisition), and aggressive CI offense and defense. The vast amount of big data to be analyzed is the type of thing to lead into proprietary tacit insights. While there is little benefit to aggressive investment in KM systems, big data may provide a lower cost, lower risk (lost data to CI is much different than lost knowledge) approach to seeking those rare creative insights.

SPF 15 has a similarly bifurcated situation with knowledge now of great value to the originator but little apparent CI activity. Industries in this category tend to be more mature, with established processes, established brands, and a great deal of explicit knowledge. This lends itself to KM, with different parts of companies learning from one another, encouraging the regular exchange of explicit knowledge about sourcing, operations, logistics, or other aspects of running the firm. Knowledge is valuable and explicit but CI is muted. A number of reasons likely exist, but a couple of readily apparent ones are in the openness of many of these industries. Wholesale, retail, construction, and some of these process manufacturers don't have a lot of secrets—competitors can find out a lot about them by simply walking through or observing a facility and/or its outputs. So a full-bore CI operation might not be necessary to uncover competitor insights.

Another aspect of these industries is the concentration. In quite a number, as one looks into the specifics, there are dominant firms and/or strong brands. Such a situation may block any copying by a competitor, even if it fully understands the knowledge a firm employs. Everyone knows what Wal-Mart does, for example, but copying its state-of-the-art supply chain is another matter altogether given its size and installed base. The company can freely employ its accumulated knowledge without worrying overly much about competitors being able to duplicate its massive IT and logistics capabilities.

Once again, the fit of big data into this structure is fairly clear. These industries run on data and explicit learnings based on the data. They are heavily dependent on well-understood transactional, operational and logistical principles, and data and deeper analysis feed right into that. With established KM systems, they can readily take advantage of any new learnings. And, of course, with limited CI activity, they have little to fear from wide dispersion of new knowledge. The MGI data are a bit of a mixed bag but do show some emphasis on data availability and IT-intensity, which makes some sense in these types of industries running on established principles and efficiency.

Finally, SPF 5 shows little interest in knowledge on the part of the originator or its competitors. These are often highly mature industries with little new under the sun and possibly regulated. While any business can have a new, bright idea, they are few and far between in these industries and probably not worth aggressive investment to pursue. Here, they are illustrated by utilities and transportation. While there are some logistical complications to both, not much is proprietary or new, so KM is not actively pursued. Nor is there any reason to bother with CI if little can be learned from competitors.

These industries do show something a little different in the big data results. The MGI data show that substantial data are present and some potential for capture and to be put to good use. Analysis of the wealth of data available in some of these industries may provide some opportunities we haven't seen from a pure knowledge perspective. At the same time, managers should be aware of the seemingly limited payoff to come from tacit insights. New potential exists but should be seized with care as the ultimate impact may be limited.

5. Conclusions

A natural connection exists between KM, IC, and the burgeoning trend toward the application of big data and business analytics. All deal with some sort of intangible asset, be it data, information, knowledge, or intelligence. By focusing on the strategic aspects of developing and protecting knowledge, we can get a better sense of when and how big data might fit into our conception of how knowledge assets can benefit an organization.

By reviewing variables such as the nature of knowledge (tacit and explicit, in particular), we can get a handle of what types of knowledge is suitable to develop in various industries. From this perspective we can start to get an idea of when and where further contributions from big data may be helpful. Similarly, such variables can lend insight into the protection of intangible assets, and can give us guidance into whether data is at risk or not, and whether steps should be taken to protect it from competitive incursions.

The natural connection between KM, IC, and big data is clear. Both fields will benefit from initial steps such as this to find ways to arrange a meeting of the minds.

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