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Ehi E. Aimiuwu
Morgan State University, eaimiuwu@gmail.com

Sanjay Bapna
Morgan State University, Sanjay.bapna@morgan.edu

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Ehi E. Aimiuwu
Morgan State University
Ehaim1@morgan.edu

Sanjay Bapna
Morgan State University
Sanjay.bapna@morgan.edu

ABSTRACT

The objective of this research is to identify the factors that are the drivers of innovation and to propose a means of measuring firm-specific innovation within a nation. Innovation leads to competitive advantages, as well as maximizing profits for a firm, so it is imperative that the firms have tools that measure how innovative they are compared to other firms within the same industry. The emergence of Business Intelligence dashboards provides such capabilities to firms and allows firms to track their innovative capability. Such innovative capability tracking is advanced by a proposed Innovation Score. Innovation is measured by factors such as the size of firm, market power, motivation to innovate, availability of resources, as well as decentralization. The role Business Intelligence plays towards tracking innovation by means of gathering and analyzing appropriate data efficiently is central to our paper.

Keywords

Innovation, business intelligence, dashboards, motivation

INTRODUCTION

"This is our generation's Sputnik moment," declared US President Barack Obama in his state of the union speech in January 2011. Interest in innovation is particularly high in the USA since the nation is perceived by many to start lagging behind other nations in terms of overall quality of life and wealth measures. Business leaders are aware of Business Intelligence as a tool of driving business effectively and innovatively (Watson & Wixom, 2007).

With the advent of information technology, it is now possible to measure innovation on an ongoing basis across the enterprise while taking a holistic view of innovation. Moreover, nascent technological tools such as Business Intelligence dashboards and alerts provide tools that upper level management can utilize to measure their firm's innovative capability. The rudiments of exactly such capabilities for a firm are developed in this paper.

Business intelligence as a concept is quite new compared to many strategic software approaches (Negash & Gray, 2008). Early adopters of IS management technology built decision support systems, expert systems, and initiated the data-warehousing domain. Each technology evolution, has attempted to improve a firm's decision-making ability. Performance management software, such as Business Intelligence (BI), has the goal of systematically gathering, evaluating, and dictating the actions necessary to ensure the host's financial success (Melchert, Winter, & Klesse, 2004). BI encompasses several information technologies including data warehouse management, data mining, analytics, statistics, end-user visualization, alert systems, etc. Norton and Kaplan (1996) in their popular Balanced Scorecard framework suggest that measuring learning and innovation, amongst other factors, is a requisite for enabling a firm track the strategic options. Tracking of innovation capabilities across a firm can be enabled with BI tools providing the strategic users with capabilities to take appropriate actions to enhance the innovative capabilities.

Based on a systematic literature review, four firm specific factors that capture a majority of the variance in a firm's innovative capability are identified. These four factors are employee motivation, firm characteristics, industry characteristic, and resources expended towards overcoming the innovation obstacles.

The role of government policies towards firm innovation capabilities are not examined in this paper because they could be perceived as both a factor and an obstacle towards a firm or industry depending on the specific policies towards the industry (Wallsten, 2000).

The rest of the paper is organized in the following manner. The literature on innovation is discussed in the next section. Based on a reading of the literature, four factors that largely determine the innovative capability of a firm are identified. In that same section, an innovation model based on the literature review is introduced. The important concepts related to Business Intelligence are discussed in the section following that. In section four, the measurement of the factors are described and a design of a BI dashboard that can track the innovative capability of the firm is proposed. Finally, in the concluding section, the importance and limitations of the work is described.

LITERATURE REVIEW ON INNOVATION

Stahl (2004) defines innovation as making ways of doing things simpler and better. Kuczmarski (1996) defines innovation as the appreciation of risk as well as a pervasive attitude and mindset that enables businesses to create a future vision. Kuczmarski insists that innovation is not cutting cost, but rather, the engineering, structuring, organizing, and examining of ourselves to beat industry competitors, increase our profit margin, and enhance future earnings from various streams.

Researchers differ on how innovation should be measured. Scherer (1965) sees innovation as measurement of input, such as Research & Development, while Mansfield (1968) states that innovation is a measurement of output, such as patents. According to Tellis, Prabhu, & Chandy (2009), the analysis on patents revealed that patents are not a driver of radical innovation. Moreover, other studies have indicated that the number of patents is correlated with the size of the firm (Wallsten, 2000). Mohr (1969) states that "innovation which brings forth something new into use rather than just creating it (invent), in public agencies, is the function of an interaction among the motivation to innovate, the strength of obstacles against innovation, and the availability of resources to overcome such obstacles". Some of the obstacles to innovation are cost, time, fears, traditions, social values, and self-esteem (Mohr, 1969).

Four key important drivers of innovation are identified based on a reviewing major works on innovation. These key factors are motivation, resources, firm characteristics, and industry characteristics. Where applicable, the factors are further sub-classified for the goal of creating a BI system that incorporates these factors.

Motivation

Motivation is one of the critical factors of innovation. Achievement motivation reflects the degree to which the organization or its subsystem attempts to excel, where reward and achievement motivation are greatly related to the initiation of innovation (Abbey & Dickson, 1983). Motivation is more of an individual ideal at the early stages of innovation than the group (adoption) and organization (implementation) stages (Abbey & Dickson, 1983).

Motivation determines what people are going to do willingly. Intrinsic motivation deals with passion and interest, which is an individual's desire to act or do a thing (Amabile, 1998). People are usually more creative when they are mainly motivated by the interest, the satisfaction, and the challenge of the work. Innovation is linked to creativity, which is actually how people will approach problems, utilize their expertise, and are motivated intrinsically (Amabile, 1998).

Amabile (1998) focuses on six critical factors of innovation that management must focus on in order to enhance creativity and innovativeness. Four of these factors of innovation which are motivation related are: challenge, freedom, encouragement, and support.

Resources

Resources are essential for innovative capabilities of a firm or organization to overcome the obstacles of innovation. According to Amabile (1998), "resources in terms of money, time, work teams, and senior management support are essential for increasing creativity and innovation through intrinsic motivation". The factors of innovation which are resource related are: human capital, time, and financial capital.

Organizational Characteristics

Organizational Size

Research shows that organization size, organization wealth, and organizational availability of resources are one of the highest predictors of innovation (Mansfield, 1963; Mytinger, 1965; Hage & Aiken, 1967; & Eisenstadt, 1963). According to Acs & Audretsch (1987), "large firms (above 500 employees) tend to have relative innovative advantage in industries which are capital-intensive, concentrated, highly unionized, and produce differential goods, while small firms (below 500 employees) have innovative advantage in industries that are highly innovative, utilize a large competent skilled labor, and tend to be composed of relative high proportions of large firms".

Market Power

Firms dynamic enough to achieve temporary market power usually chose innovation as a platform to maximize their profits (Kamien & Schwartz, 1975).

Organizational Structure and Networks

Other researchers insist that innovation is also linked with ideology and leadership as well as decentralization. Thus, decentralization is another part of innovation. Innovation can be a destabilizing force and some degree of outsourcing can enhance a firm's creativity. To downsize, decentralize, and forge alliances can result in innovation (Chesbrough & Teece, 2002). It is possible for virtual companies to utilize the power of the marketplace for developing, manufacturing, marketing, distributing, and supporting their offering in methods that fully integrated companies cannot replicate (Chesbrough & Teece, 2002).
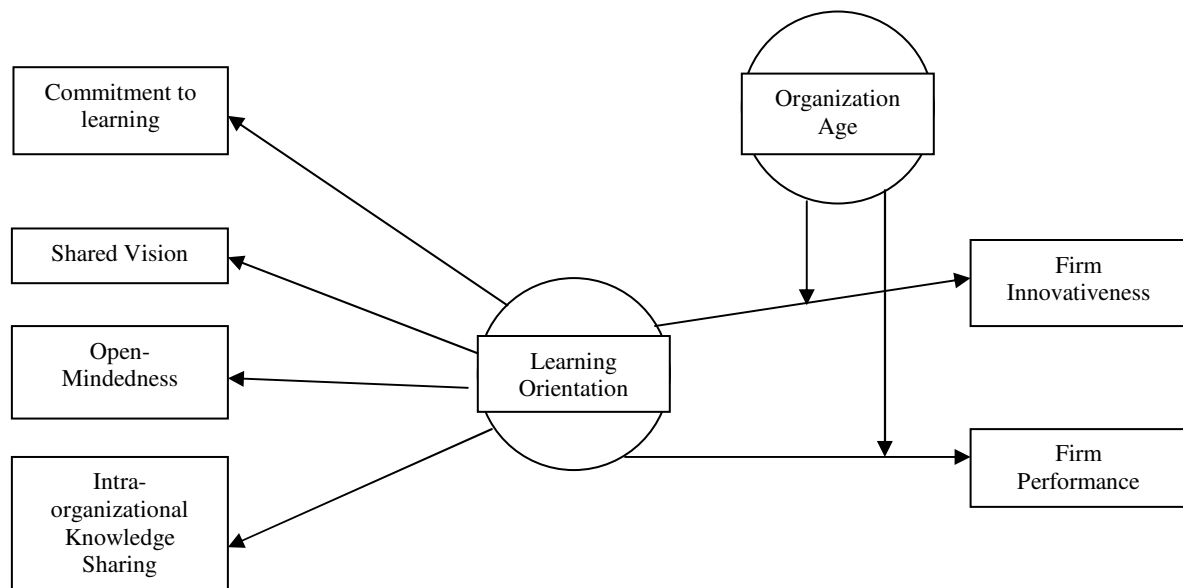

Figure 1. The Learning Orientation and Firm Innovativeness (Calantone et al., 2002)

Calantone, Cavusgil, & Zhao (2002), describe a framework that links learning orientation to firm innovation and performance (Figure 1). Learning orientation encourages knowledge sharing through systems and team-work, but this learning culture must be embraced by senior management thereby leading to increased firm innovativeness and increased financial performance. For firm performance and firm innovativeness to be very high, the age of the organization is also an important factor. The older a firm is, the more likely that it entered the industry first and therefore is established in terms of size, resources, time, market share, and financial capital.

Firm's Industry

"Organizations are usually more innovative in rapidly changing environments, such as changes in market conditions; technological changes; clientele needs; and the labor market, rather than steady environments" (Mohr, 1969). Acs and Audretsch (1987) measured innovation by using the four-digit SIC (Standard Industrial Classification) industry codes recorded in 1982 by the United States Small Business Administration. The innovation rate is usually measured as the number of inventions divided by the numbers of employees (thousands) or alternatively, the number of inventions divided by sales (ten-thousand dollars), since innovation rate may be affected by the bias of firm size (Acs & Audretsch, 1987).

Table 1 summarizes the factors identified above and a measurable firm innovative capability model is shown in Figure 2. Innovation score for firms within a nation's boundaries must include resources since adequate resources (human capital, financial capital, as well as the time to implement innovative strategies) must be made available to overcome the obstacles that impede innovation. The other three factors that directly contribute to innovation are motivation, firm characteristics, and the firm's industry, as described earlier.

Factors of Innovation	Sub-factors of Innovation	Description
Motivation	Challenge	Matching people with the right job & skills (Amabile, 1998).
	Freedom	Autonomy enhances intrinsic motivation, sense of ownership, & strength to meet challenge (Amabile, 1998).
	Supervisory Encouragement	Relying on intrinsic rewards, encouraging idea improvement rather than rejection of idea, evaluation impedes innovation (Amabile, 1998).
	Organizational Support	Mandate information sharing, collaboration, & minimize political problems (Amabile, 1998).
Resources	Financial Capital & Time	Money must be available so that workers can focus on work, discourage fake or impossible deadlines (Amabile, 1998). Market power & economic rents are necessary for innovation (Kamien & Schwartz, 1975).
	Human Capital	Team should support diversity; team must be excited about goal, willingness to help each other, recognize each others skills & knowledge (Amabile, 1998).
Organizational Characteristics	Organizational Size	Innovation depends on organization size, wealth, and resources (Mansfield, 1963; Mytinger, 1965; Hage & Aiken, 1967; & Eisenstadt, 1963). Large firm have innovative advantage in industries which are capital-intensive, concentrated, highly unionize, & produced differentiated good, but highly innovative & large skill labor for small firm (Acs and Audretsch, 1987).
	Market Power	Large firms with market power will use innovation to maximize profit (Kamien & Schwartz, 1975).
	Organizational Structure and Network	Innovation is linked to downsizing, decentralization, & forging alliances (Chesbrough & Teece, 2002).
Firm Industry	Changing Environment	Organizations increase innovation during rapidly changing market conditions, technological changes, changes in clientele needs, & changes in labor market (Mohr, 1969).

Table 1.Table of the Factors of Innovation

BUSINESS INTELLIGENCE

Business Intelligence is the process of turning data into information and then into knowledge about customer needs, customer decision making processes, the competition, conditions in the industry, economics, technology, and cultural trends (Golfarelli, Rizzi, & Cella, 2004). The purpose of Business Intelligence was to satisfy managerial demands for effective and efficient analysis of enterprise data in order to understand their business and make better decision processes (Golfarelli et al, 2004).

Business Intelligence combines operational data with analytical tool to present complicated and competitive information to decision makers in an attempt to improve the timeliness and quality of inputs to the decision process (Negash, 2004). Business Intelligence creates forecasts based on historical data, past and current performance, and estimates the future directions (Negash, 2004). Performance measurement, an outcome of BI, has been tackled by several means. Balanced Scorecard (Kaplan and Norton, 1996), a popular framework for performance driven organizations weigh both financial and non-financial information to achieve the best results for the organization. The four perspectives of balanced scorecards are the financial, customer, internal processes, and innovation & learning. Thus, based on the Balanced Scorecard framework, innovation itself is an important factor to measure. The architecture of BI solutions mandate development of well designed data warehouses which become the data source for firms to provide appropriate analytical tools to operational and strategic managers to track their business processes.
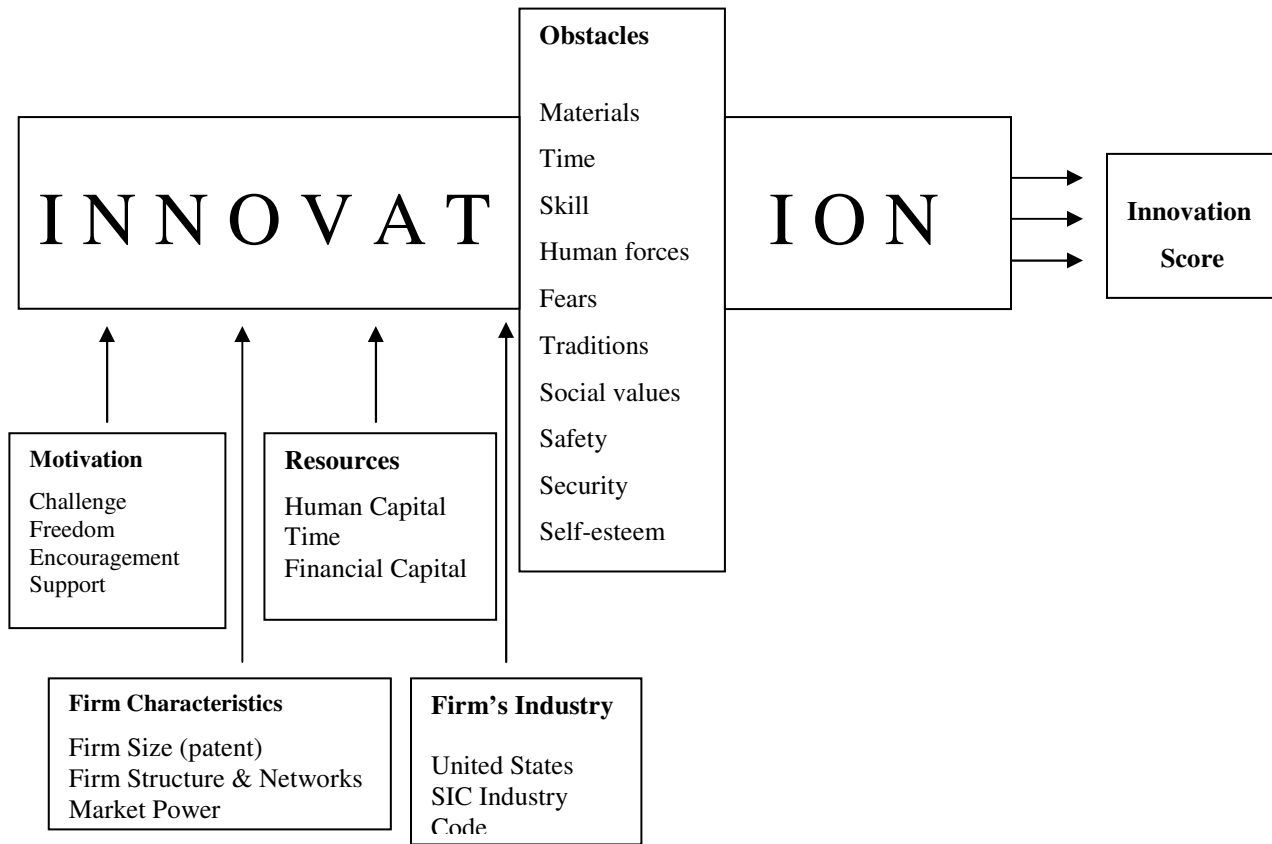
Figure 2. Model of Innovative Capability that can be measured

For Business Intelligence to be successfully implemented as an innovative strategy, it must be driven by senior management who believe in it, the use of information and analytics must be part of the organizational culture, have alignment between Business Intelligence and business strategies, there must be effective Business Intelligence governance, there must also be a strong decision support data infrastructure, and the users must have adequate tools, training, and support (Watson & Wixom, 2007).

BUSINESS INTELLIGENCE DASHBOARD FOR INNOVATION

As detailed in this paper in the section on Business Intelligence, accurate business requirements can be driven by frameworks such as Balanced Scorecards. Monitoring performance on an ongoing basis becomes imperative for the firm to succeed in the marketplace. Our goal in this paper is to develop such performance metrics related to tracking innovation and tools such as scorecards and dashboards provide such capabilities.

A dashboard is a visual display of the most important information needed to achieve one or more objectives which fits entirely on a single computer screen so it can be monitored at a glance (Few, 2006). Current dashboard tools are an evolution of executive information systems (EIS) user-interfaces that presented high-level summaries. Today's dashboards delivered on the web provide visual information of these high-level summaries and have user-interfaces such as gauges, dials, alerts, and provide interactive capabilities to drill-down and query the data, while presenting the results on the same screen. Where applicable, dashboards provide key performance metrics encoded in visual tools such as gauges. The design and layout of an economic dashboard has a direct impact on the understanding of the current business conditions by managers using that dashboard (Adam and Pomerol, 2002).

Since identifying key performance measures are an important characteristic of dashboard design, it is important to create measures of the drivers of innovation. Table 2 shows past research on measurement of the key drivers as proposed in our model (Figure 2). An organization can use similar measurement tools e.g., surveys and data analysis to track each of the drivers.

We now describe the rudiments of how these measures can be used to derive an innovation score. As can be seen from above, enough literature exists in order to measure each of the critical innovation drivers. However, the development of an overall trackable innovation score requires that each of the factors be weighted appropriately based on their importance. Tellis et al. (2009) proposed an industry fixed effect regression model that weighs factors that they considered to be important. A similar methodology can be used to generate the weights for each of the factors to arrive at the overall innovation score. However, incorporating these beta coefficients in a visual design is a challenging problem (Ivory & Hearst, 2001).

We propose that each of the major factors (motivation, resources, firm, and industry) be normalized between 0-100 from a visual display perspective; with 0 and 100 being low and high end of a benchmarked scale and respectively. The size of each of the major visual display should reflect the importance of that particular factor and based on weights as obtained from a regression model. An overall Innovation Score is then computed and again normalized to 0-100, with 0 and 100 determined from the lows and highs of the benchmarked factors. Figures 3 and 4, shows a simulated BI dashboard for tracking innovation. Our design of innovation allows the strategic user to obtain information on the state of any of the factors by clicking on an appropriate tab. The first tab (Figure 3) is the overall Innovation Score tab which displays the history of the innovation score at the national level and the motivation, resources, and firm specific scores at the national level. Clicking on any state on the map where the firm has organizational units, displays the corresponding scores for that state. An example of an individual factor (motivation) is shown in Figure 4. In our design, the end-user is able to visualize the history of each of the sub-factors that comprise the factor. Caution must be used in interpreting the design elements since the dashboard is based on simulated data.
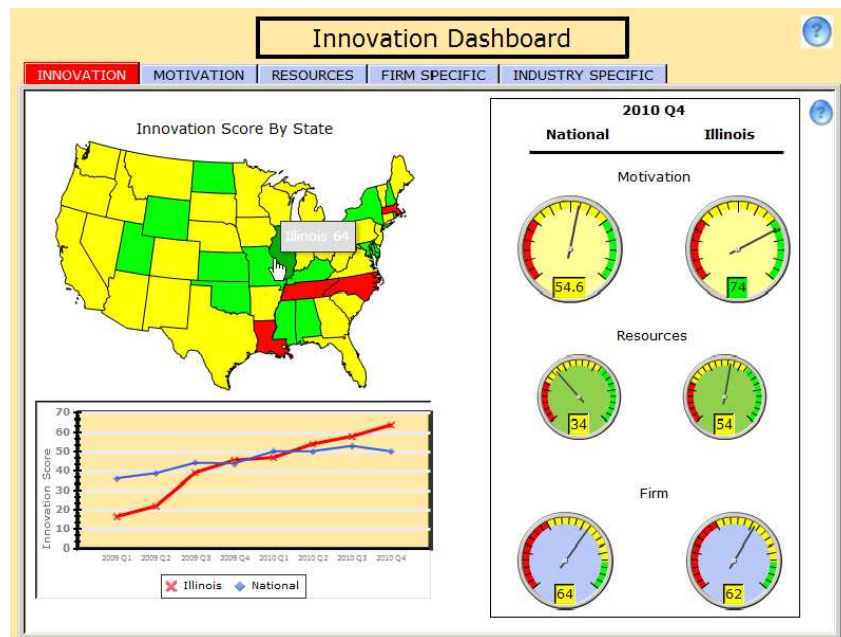

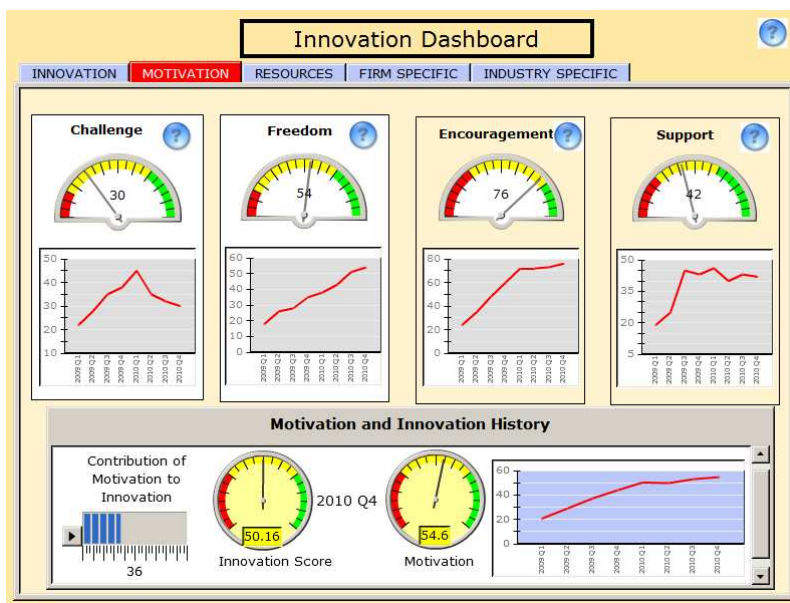**Figure 3. Innovation Tab of Innovation Dashboard**

Figure 4. Motivation Tab of Innovation Dashboard

Factors of Innovation	Sub-factors of Innovation	Measurements
Motivation	Challenge	Seven-point Likert like scale was used to measure affect & self affirmation in terms of challenge and skill (Voelkl & Ellis, 1998).
	Freedom	Measured the ranking of variety of choice & non-restrictiveness in choice (Bavetta & Seta, 1999).
	Supervisory Encouragement	Employees graded supervisors on how supervisors related, communicated, motivated, managed goals, & rewarded employees with incentives (Ramus & Steger, 2000)
	Organizational Support	Eight-item questionnaire measured employees' symptom status, social function, physical function, emotional function in relation to confidant & affective support (Broadhead, Gehlbach, De Gruy, & Kaplan, 1988).
Resources	Financial Capital	Firm's stock market value to the book value of its asset ratio (Tellis et al, 2009).
	Human Capital	Revenue / total wages of R&D employees of a firm. (Jeong, 2002). Firm labor and capital as R&D spending as percentage of sales (Tellis et al. 2009), Gini Coefficient for Diversity.
Organizational Characteristics	Organizational Size	Large firms have over 500 employees while small firms have less than 500 employees (Acs & Audretsch, 1987).
	Market Power	Market power is price-cost margin (Corts, 1999).
	Organizational Structure & Networks	Ratio of firm's revenue from largest single business or ratio of revenue from its largest related businesses (Chatterjee & Blocher, 1992), Organizational network coupling using block interaction techniques (Knoke & Rogers, 1978)
Firm Industry		Measuring innovation with SIC (Standard Industrial Classification) code recorded by the United States Small Business Administration (numbers of inventions / number of employees (1,000) or (number of inventions / sales ($10,000)) - Acs and Audretsch (1987).

Table 2.Table of the Factors of Innovation and their Respective Measurements

CONCLUSION AND LIMITATIONS

In this paper, we propose the rudiments of a BI dashboard that allows strategic users to track the innovative capability of their firm. The actual development of such a system must be undertaken using an appropriate structured methodology and requires obtaining a rich data set. Surveying a myriad number of factors to obtain a final innovation score is challenging from a research objective due to large time commitments of survey respondents to fill several surveys, however, this is within the capability of a firm if a high-level champion endorses this concept.

From a research perspective, this becomes more daunting since several high-level champions must be identified in order to obtain a breadth of information. Other alternatives may be to incrementally obtain measures, but that may lead to spurious results due to longitudinal effects. However, this does not diminish the overall quality of this work since there may be a time and adequate funding available to obtain relevant measures and then creating these BI systems which are then integrated with existing ERP systems. The innovation score we propose can only be measured for publically traded firms since it relies on the financial capital measurement which uses the stock prices. Proxies for this measure must be developed in order for an innovation score to be derived for non-profits or small privately held companies. In this paper, we dwell on measurement of innovation and not on prescriptive means on what an organization should do if it is not faring well on these measures. Our interest is in providing actionable information and not on what an appropriate action should be. An appropriate action, based on the information is beyond the scope of this paper.

Our current design is based on traditional BI systems where data is obtained in a batch manner, however, with some modifications; the system can be tailored for real-time BI. This, however, requires forecasting capabilities so that even if the factors are measured at different points in time, they can be valued at an identical time. Meeting this capability is an interesting line of future research.

Productivity tools for dashboard development e.g., Cogos, BusinessObjects, are now been deployed across many firms, however, a tremendous gap exists in the knowledge for appropriate visual encoding of information and the toolset of such tools. Considerable research in this area is warranted. For instance, how are poor, average and good alert levels in gauges determined? How can alerts be communicated automatically? What criteria should be used for the BI user-interface objects to autonomously modify themselves and what and how should they be modified? These and other topics are prime candidates for research due to the explosion of interest in BI in the analytic organization. This paper also provides a reader with insights into this emerging area of information technology.

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