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Abstract

Computer Based Information Systems (CBIS) have become pervasive in modern organizations. The MIS literature has always treated IS a support tool rather than a core requirement for a modern organization. But the latter is probably a more realistic picture of the role of CBIS in organizations today. This paper argues for this perspective. It argues that CBIS help organizations overcome cognitive limitations of human information processing and are necessary to meet the performance goals and assist in the decision-making processes of the organization. It points to the inherent complexity, fast rate of change, and uncertainty in modern environment and argues that the information processing requirements posed by these conditions precludes not using a CBIS if the information processing is to be done in an efficient and effective fashion. Given that a CBIS is necessary for organizations, it has important implications in areas like organization design, business process design, and CBIS development and deployment. It is hoped that this paper will put forward the idea that is explicated in the mainstream literature and create impetus and discussion for further research.

Keywords: CBIS, environment, organization, necessity

Introduction

Computer-Based Information Systems (CBIS)[1] pervade all aspects of organizational functioning and are found in most organizations. The term CBIS is defined here as a set of information technology (IT) and other inter-related components working together to collect, retrieve, process, store, and distribute information for purposes of planning, control, co-ordination, analysis, and decision-making. In this paper a CBIS means an information system that operates by using computers connected on a computer network. The MIS literature has traditionally treated CBIS as something that supports organizational/business processes rather than a necessary or core requirement for an organization. By contrast, CBIS in most modern organizations are tightly coupled with business processes. CBIS have shifted in role from being a support tool to being the core of many business practices and procedures (Edwards, Millea, et al., 1998). There are ample examples of IS being a necessary requirement for modern organizations. The banking industry is a prime example. The operation of a bank needs a CBIS implementing a core set of business functionality or the bank can not compete. This is primarily on account of the fact that the velocity of transactions is fast enough to preclude processing by humans owing to their cognitive and physical limitations.

Yet the recent survey of the MIS literature performed by the authors points to the lack of explicit acknowledgement of the fact that a CBIS is a core requirement for most modern organizations. While it may seem apparent that this may be the case, it may be argued otherwise as a result of the natural progression of the evolution of process-technology integration (Hyde and Pankaj, 2002). There is a need to acknowledge the necessity of CBIS and put forward a theoretical argument to support it. This paper presents a theoretical argument that the use of CBIS in an organization is a necessary and/or core requirement. Before proceeding on the argument, it should be pointed out that there would always be some exceptions to any thesis and this research recognizes that organizations operating in a niche market might form such an exception. For example, tourist resorts in a remote location

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[1]We use the term CBIS as opposed to IS to stress the role of computers and more so that of IT in information processing. We treat IS as a more generic term which will apply to any system that may or may not use IT.

may be one of these organizations. An organization that is targeting any sort of mass market will find it necessary to use CBIS for its operations.

Information Processing: Performance Requirements

Organization: Performance Requirements

An organization can be defined as people and groups of people that continue through time and exist to achieve some shared purpose through division of labor. The people and groups of people are integrated by information-based decision processes (Galbraith, 1977). An organization is purposeful and goal oriented, set up to do something. For most organizations, a primary, simple goal can be to maximize profits or to maximize the shareholder value. The reason for a collective effort in the form of an organization is to achieve its goal in a better way as compared to some other loosely coupled form.

The achievement of this goal invariably translates to an effort that is aimed to be more efficient and effective. The aim to be more efficient and effective in the current environment is mandatory or else the organization may be substituted by another organization that is more efficient and/or effective. To continue in time, an organization should meet its performance goals by being more efficient and effective in operations in all areas of interest of the organization. This extends to information processing and, thus, an organization seeks to perform information processing efficiently and effectively.

Limitations of Human Information Processing

Information processing by humans has cognitive and physical limitations. The information processing needed in an organization to achieve high performance levels is, at most times, beyond the human information processing capabilities. The human mind is limited in its ability to store and process information (Simon, 1977). Humans have limited power of computation and their decisions are impacted by their limited memory (Hogarth, 1980). Limitations in several other areas, especially related to increased volume and frequency of information processing, have also been identified. Humans acquire information based on their expectations and anticipations. Hence, there may be bias from sequence effect where recent information is given more weight, and simultaneous presentation of qualitative and quantitative information poses problems (Hogarth, 1980; Watkins, 1983). This bias may be linked to the limited storage capabilities and the absence of proper retrieval mechanisms for the stored information. Human thinking is asymmetrical (Laxar and Olson, 1978) since people have inherent biases in decision-making (Snapper and Peterson, 1971). When using information for decision-making humans are non-bayesian (Martin, 1985). They ignore prior probabilities and uncertainties in making predictions. Instead of putting observations into distributions, they put them into patterns that lead to a phenomenon similar to a gambler's fallacy. As humans gather more information, they become resistant to change (Pitz, et al., 1967). In situations that require multi-stage inferencing (most common in organizations), humans ignore the consequences of unlikely events and tend to base their decisions on most likely events (Martin, 1985). This best-guess effect is aggravated by the fact that often the events that have occurred in the recent past are assigned higher probabilities of happening than events that have not occurred in the recent past. People also need less information to predict a desirable event than to predict undesirable events. The amount of information available may not be related to the accuracy of the decision (Oskamp, 1965) but the confidence in the decision increases as more information becomes available. These are some of the pitfalls in human information processing. The psychology literature has studied other areas of human information processing and decision-making that could benefit from the support of a CBIS that is more objective and consists of an increased capacity.

CBIS to the Rescue

CBIS can provide support for information processing as they overcome many of the human information processing limitations, especially those related to capacity and those related to processing situations which can be modeled using mathematical techniques. While there are many situations, especially dealing with creativity, intuition, and innovation, where a CBIS is not of much use, even many of the most sophisticated information processing logic used in an organization can be embedded into a CBIS using advanced mathematical techniques. CBIS have provided support for information processing in organizations through automating information collection, processing, and dissemination for most routine tasks. For more non-routine, uncertain and/or unequivocal tasks, CBIS have provided support through decision support tools ranging from business intelligence suites to artificial intelligence based systems (Keen and Morton, 1978).

Additional Motivators for the Use of CBIS

Additional need for the use of CBIS for information processing has been dictated by high complexity, high rate of change, and uncertainty in the environment. These factors, along with the human limitations, present a strong case for the mandatory use of CBIS.

The Role of Complexity

Complexity in the environment faced by organizations has been continuously increasing due to globalization (hence, increased competition), the increased number of substitutes for a product, the obsolescence of technologies, etc. Complexity has been defined as the number of factors that must be taken into account by an organization in decision-making (Harvey, Palmer, et al., 1998). Complexity is defined here, however, as the work done in graph theory (from mathematics and computer science). Complexity is the multiplicity of cause and effect relationships between two given parameters of interest. The multiplicity of the cause and effect relationship can be through several other intervening variables. In addition, the relationships are bi-directional and contain cycles. In the presence of complexity, the information processing requirements faced by an organization increase several fold. Information about additional parameters of interest has to be collected and many more relationships have to be examined. The demand for computation and information storage increases as the necessary number of parameters increases. If the relationships are to be deciphered on a regular basis, this can only be accomplished economically and effectively using a CBIS. For example, to determine what stocks to invest in, a mutual fund not only has to look into the domestic stock market but also the major foreign stock markets. Using stock market data from various stock markets around the globe (increased complexity) significantly increases the demands on information processing.

Not only has the complexity in the environment increased, but many organizations have used the capabilities of CBIS to create complexity and use it as a competitive strategy. For example, through the use of CBIS, computer manufacturer, Dell, is able to continuously source parts at a much cheaper rate while ensuring that the parts with the latest technologies are used in the computers. The complex logistical system created by Wal-Mart is based on a CBIS. When an organization enters the market place and creates complexities through the use of a CBIS and is successful in using it as a competitive strategy, other organizations are forced to adopt and use a CBIS for similar purposes. In such cases, the use of CBIS becomes a necessity to successfully compete in the market. Most industries have reached such a state and the organizations operating in these industries cannot operate without a minimal level of CBIS in place. For instance, banks cannot operate without a teller CBIS and an ATM system in place that allows for completion of a transaction in a certain maximum time and allows for the real-time update of records among several other benefits.

The Role of Rate of Change

The rate of change in the current environment has been continuously increasing. Not only are the changes occurring at an increasing rate, they are becoming increasingly unpredictable (Dove, 1995). A fast rate of change means that information needs to be collected more frequently to determine the state of the environment and this information needs to be processed rapidly so that the information and the analysis from processed information is current and relevant. Information also needs to be disseminated rapidly such that the decisions are made based on information that is current and relevant. Processing information quickly requires the use of CBIS. This is amply illustrated by the stock market where the price on various indices, prices, etc. have to be gathered and processed every few seconds to have a reasonable picture of the market. It is impossible to track the stock market today without the use of a CBIS. An empirical examination found that the financial performance of U.S. and foreign firms is contingent upon the extent to which information processing capabilities are congruent with the complexity and the rate of change in the business environment (Jones, Rockmore, et al., 1996). Similar to the case where an organization may create complexity, an organization may create a faster rate of change in the market it operates in, and use that faster rate of change as a competitive strategy. In this case also, the creation of a fast rate of change has to be accomplished using CBIS if efficiency and productivity goals of the organization are to be attained.

One may counter that, in the presence of change, the information processing logic used by the organization may itself change, thereby requiring changes in CBIS. Brandt and Boynton (1993) indicate that current CBIS are anything but flexible. Markets change but CBIS often do not. While one may argue that this makes a case for using information processing mechanisms other than CBIS (such as manual systems), the reality of the situation is that the concern for change is due to the fact that most organizations cannot operate without a CBIS. Hence, changes to CBIS are a major area of concern. Validation is provided by

people like Richard Pawson (Vice President of Research) from CSC who states that it has been the difficulty of changing the IS that has defined the pace at which business changes can be implemented (Pawson, 2000). The necessity of the CBIS also makes it a constraint as evidenced in the SIM Delphi study. The SIM Delphi (Brancheau, Janz, et al., 1996) survey of top executives found that building a technology infrastructure to respond to rapid changes in the competitive environment is a major theme for many businesses. Further validation is provided by the amount of research and efforts that are underway to enable quicker changes to a CBIS. The new developments in the area of SOAP, XML, and the Service-Oriented-Architecture that hold the promise of enabling fast changes to CBIS further supports the argument that CBIS are a necessity.

The Role of Uncertainty

Changes are inevitable. But changes in the current environment are getting more and more unpredictable. This unpredictability can be about when a known change will occur, what an unknown change will look like, or a combination of these. The unpredictability leads to uncertainty. Uncertainty may be defined as the amount of information needed to perform a task and the amount of information already possessed by the organization (Galbraith, 1977; Tushman and Nadler, 1978). The greater the uncertainty, the greater is the amount of information that needs to be processed among the decision-makers during the task execution to achieve a given level of performance (Galbraith, 1977). Studies by Spekman (1979) and Leblebici and Salancik (1981) also support this argument. A challenge facing most organizations is to develop information processing mechanisms to cope with variety, uncertainty, coordination and an unclear environment (Daft and Lengel, 1986). Galbraith proposes the establishment of vertical CBIS as a solution to meet the information processing needs of the organization in the presence of uncertainty. In the presence of uncertainty, an organization needs at least two capabilities. These are the capability to construct and evaluate alternate scenarios of the future and the capability to process information quickly, possibly in real time, as an event of interest unfolds. Fast information collection, information analysis, and dissemination in real time would require a CBIS. Consideration of more alternatives again would need more information collection, analysis, and storage that can be accomplished efficiently and effectively only with the use of CBIS.

The Interaction Effect

Complexity, fast rate of change, and high uncertainty do not usually occur singly in the current environment. More often than not, they are present at the same time. Even in cases where an organization deliberately creates complexity and fast rate of change, they are invariably intertwined. In most cases where these three factors occur together at the same time, information processing can not occur without a CBIS for performance considerations. For example, many manufacturing operations perform materials requirement planning (MRP) on a weekly basis to keep up with the changing market needs to maintain performance levels (low costs). The computational complexity, memory requirements, and time constraint for completion of the MRP process precludes its execution in the required time without the use of a CBIS. Another example that illustrates the necessity of a CBIS due to the combination of complexity, rate of change, and uncertainty posing heavy information processing requirements, is that of stock trading.

The New Order

With the advent of CBIS, more and more information is becoming available and accessible due to the computers residing on the network. The decreasing cost of storage means that more and more data and information can be stored. The decreasing cost of bandwidth means that these storage systems can be accessed from anywhere in the world. The decreasing cost of processing power (whether measured in teraflops or TPC rating) means that this information can be analyzed and more information can be generated economically. The implication is increasing intensity and velocity of information in the environment in which the business is operating. Modern organizations work in this information-intensive environment and, hence, need to be adept in collection, analysis, dissemination, and the storage of large amounts of information at a fast rate.

It is easier to manipulate information using a CBIS. It is also easier to handle information as compared to physical objects and goods. Due to the opportunities of cost-saving and speeding up business flows, more and more physical flows are being converted to information flows. These information flows are being implemented using CBIS. For example, retailers on the Internet provide information about a product instead of providing a physical product itself. More and more organizations are trying to minimize the physical flows and maximize the information flow while still being able to offer the same products and services. This is one of the reasons many small organizations outsource their logistics to UPS and are, therefore, able to do

business on a global scale. In this case, the small business retains control of the information flow from the time of marketing and point-of-sale through the process to the point of delivery and follow-up with the customer while allowing the physical flow to be outsourced to UPS. In addition, new developments in IT and organizational innovations in the use of IS to solve business problems and become more competitive are further working towards putting CBIS at the core of the organization. For example, an application being explored is that of real time enterprises (Anonymous, 2002) where automated sensors collect information and feed it through a CBIS to provide reliable information about the state of the organization and the environment. Through the use of CBIS a real time organization may also have the capability to operate in an automated self-correcting mode like an autopilot in an airplane.

Implications

Organization Design

There is no doubt that changes are underway that are making CBIS more and more entrenched into the organization. It is hard to envision a modern organization working without a CBIS. The real benefits of establishing the necessity of CBIS in organizations comes from its implications for organization/businesses as well as IS/IT. These implications are not explored in detail in the mainstream academic MIS literature. Several implications can be identified. The first, of course, is on the structure and design of the organization. Tushman and Nadler (1978) view the organization design problem as creating a fit between information processing requirements and the information processing capacity of the organization. Galbraith (1977) has defined the organization design task as an information processing task involving the coordination of the interdependent subtasks, that are created for performance considerations, into a whole. Efficient and effective coordination mechanisms for the performance enhancing subtasks are needed. Ramaprasad and Rai (Ramaprasad and Rai, 1996) define work in an organization as composed of logical and physical work with the logical work controlling all the physical work. The implication here, then, is that when considering organization design in the current times, the organization may be designed also to satisfy some of the constraints and requirements of the CBIS. Traditionally the literature in the area of organization studies has focused on hierarchy of responsibilities and authority and rules and procedures are the primary variables for organization design. In the presence of CBIS as a necessity these parameters have to be appropriately modified so as to reap the full benefits of the CBIS and more so to overcome the constraints posed by the technology and the CBIS. An organization design that ignores CBIS in the design considerations will still have to use a CBIS but cannot derive its full benefits. If an organization makes policies that are based on the use of a particular technology, then that technology will, most likely, become the mainstream method. An example of this is the use of web-enabled laptop computers used by sales forces that have been shown to significantly reduce the lead times of customer orders.

The proposal of designing organizations around CBIS will immediately come under attack from the purist that CBIS should follow the design and not the other way around. Each route has its merits and demerits and since mainstream thought is that CBIS should follow organization design, an argument for the opposite logic is presented. (The reality of the situation is that neither of these methods is preferred. In actuality, the design of the organization and the design of the CBIS should be fully integrated, rather than seen as two separate entities.) There are two parts of this argument. Firstly, many CBIS exist that incorporate the better, if not the best, business practices performed. These practices are designed to fully capitalize on the capabilities of the CBIS. This means that for most organizations of all sizes, CBIS already incorporates a better way of doing things. Secondly, technology, as it exists in its current form, is constrained in several ways. It is evident in higher order information constructs such as wisdom, knowledge, expertise, creativity, innovation, etc., that technological artifacts are based on determinism. Given the constraints in technology, performance and efficiency, considerations will be much better served if the human component of the organization can recognize them and work around. Humans, by redesigning the way they work, can better overcome the constraints rather than modifying the CBIS. There has been limited success in designing organizations around CBIS. Call centers and brokerages are example of the businesses that have successfully made the transition to such a philosophy. It is possible to start a call center of any size built around the CBIS existing in the markets for this purpose.

Design of Work Processes

Known popularly as "IT enabled business transformation" we use the term "CBIS enabled business transformation" for consistency in terminology. The term implies transformation of business processes based on the capabilities of the new technologies. If CBIS is taken as a necessity, then the organization needs to continuously monitor and evaluate new CBIS developments. The new CBIS capabilities coming into the mainstream should be used in a proactive mode to design new

solutions and business processes. Such an action may not be a necessity and involves a risk, but the payoffs may be significant. An organization does not need to be a pioneer but it should devote enough resources in monitoring the CBIS developments such that it realizes when a technology is becoming mainstream and then takes steps to accommodate them.

The organization needs a set of manual and emergency work processes, as well as a disaster recovery plan, that work in the case of outage of the CBIS. When CBIS is a necessity and an outage occurs, the organization still needs to function though perhaps in a degraded mode. There should be alternate backup mechanisms to keep the organization functioning in the case of CBIS outage. The organization also needs a set of work processes to handle transactions where the rules and policies may have to be overridden and hence may not be accommodated by the CBIS, to ensure customer service. These are needed so that the solution is provided to the customer since at most times it is the impression that since the transaction has to be processed using the CBIS only, it cannot be carried out. Occasionally, because of the interaction with customers, it becomes apparent that rules and policies may need to change. This is all part of the essential feedback mechanism that is part and parcel of the CBIS.

Human Resources Implications

There is a severe paucity of experts who are experts in the technology that forms the basis of CBIS as well as in the business. Most IT experts do not understand business requirements well and the business experts often fail to understand the limitations of CBIS. This creates a peculiar situation where a CBIS may be able to support the business but is not used to do so. In other cases, the requirements posed by the business may be such that they cannot be implemented using a CBIS due to time and money constraints. In either case, it is the CBIS that is seen as the culprit—the confounding factor—rather than the other way around. Organizations and educational institutions should aim to train people to be experts in both areas. The training needed may be long and may need dedication on part of both the aspirant and the organization. For example, an undergraduate engineering degree in computer science followed by an MBA and some work experience will probably yield experts who are good in both technology and business.

At times, the users at the lowest level just interface with the CBIS and are not aware of the business logic, rules, and regulations that the CBIS embeds and blame the CBIS for being restrictive rather than understanding that the behavior may be by design. In addition, many users are not aware of the alternative solutions that work around the limitations imposed by the CBIS or that organizational policies do not allow such measures. An organization needs to train its users appropriately not only in the use of CBIS but also to explain the business logic, rules, policies that form the basis of the CBIS design.

Conclusion

CBIS are necessary and facilitative but restrictive at the same time. In the functional areas of the organization where CBIS have made inroads, they have become a necessity due to their capabilities. They are making further inroads into other areas of the organizations that were previously thought to be the exclusive domain of humans. It is time that the necessity of CBIS in organizations is realized and accepted. It is also time to realize that this necessity coupled with the constraints of the CBIS demands that they are put in the considerations of organization design and business process design right at the beginning rather than at the end. At the other end, the ever new, evolving capabilities of CBIS should also be a driver in the design of business processes and organizations since these capabilities, if found appropriate, may need to enter into the organization as a necessary component.

This paper argues for a point that may be obvious but still does not seem to have been acknowledged in the mainstream MIS literature. Its acknowledgement has important implications and can provide a different perspective on how one looks at the existence of CBIS in an organizational context. More than anything it will serve to ease the blame game where the CBIS and technology is often blamed for not delivering business results and performance.

This paper is an initial attempt to build up a different perspective on the role of CBIS in organizations. A more comprehensive and integrated approach that takes into account additional considerations like evolution of work processes through their interaction with technology, and coupled with an empirical investigation of the phenomenon, forms the agenda for future research work in this area. Explication of the necessity of CBIS in an organization leads to several other issues that may be investigated. For example, a related issue may be the correctness of the results of processing by CBIS, control of the CBIS, etc.

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