ANALYTICS-BASED MANAGEMENT OF INFORMATION SYSTEMS

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ABSTRACT

Information technologies penetrate virtually every division in contemporary organizations. Organizations deploy a spectrum of information technologies with aim of alleviating operating efficiency. Knowledge workers increasingly depend on deployed information systems to accomplish their tasks. Well-deployed and managed information systems have a potential to increase effectiveness and efficiency in organizations; whereas poorly deployed and managed systems may have significant negative impact. Strategic deployment and management of information systems play the key roles in attaining beneficial impacts for organizations. Conventionally, information technology managers have relied primarily on tacit knowledge. Such knowledge and experiences have been accumulated over a number of years. However, information technologies progress at a rapid pace and early adopters gain considerable strategic advantages. Information technology managers cannot afford spending years accumulating tacit knowledge. Viable solution to this problem is to adopt an analytics-based management. We explore pertinent aspects of analytics-based management of information systems in organizations.

JEL: M15; M21; O32; O33; O22; O43; L15; L21; L25; L86

KEYWORDS: Information Technology Management, Analytics-Based Management, Information Systems, Actionable Knowledge, Tacit Knowledge, Explicit Knowledge.

INTRODUCTION

Organizations deploy a variety of information technologies ranging from communication infrastructures, through computing hardware, to software systems. Different technologies have different lifecycles (Lehmann et al., 2010). Generally, internal communication infrastructures have the longest lifetimes, followed by computing hardware, and software systems with the shortest lifetimes.

Progress in information technology development has been exhibiting shortening lifetime with each successive technology generation (Devarajan, 1996). New generations of technologies are being developed and marketed at an increasing pace. Organizations are under pressure to innovate and deploy novel technologies faster. Older technologies often need to be replaced before the end of their originally projected lifetime. Early adopters of new technologies are able to gain strategic advantages over late adopters (Droge et al., 2010). Organizations cannot afford to ignore information technology progress. Late adoptions of progressive information technologies result in various losses for organizations. They are generally reflected in operating inefficiencies, lower productivity and loss of strategic advantages.

Information technologies provide operational support without which many contemporary organizations would be unable to function. They are among the core assets of many knowledge-intensive organizations (Alvesson, 2004). Knowledge workers increasingly rely on information systems and services (Davenport, 2005). They often incorporate essential business processes that have been transferred from their former forms into digital ones. Transformation of business processes into digital forms facilitates improved working efficiency, productivity, automation of tasks, as well as accessibility of information, documents and resources. Proper management of information technologies is crucial (Turban and Volonino, 2011). Inappropriate management of information systems may have numerous adverse effects.

Conventionally, management of information systems relied on valuable experience accumulated by managers over a number of years (Hunter, 2007). Years of management experience have led to accrued tacit knowledge. When progress in information technology development was slow, this experience-based management style was adequate. Experience and tacit knowledge gained by managers were sufficient to achieve a suitable level of management efficiency and extract a satisfactory value from deployed information technologies. After sufficient value had been extracted and novel technologies have become available, new information technologies have replaced older ones. This practice has been repeated for several generations of technologies.

With gradually faster technology progress, the traditional experience-based management style has been met with challenges. Increasing pace of development and availability of novel information technologies has led to shortening lifetimes of successive technology generations (Devarajan, 1996). This trend presented new challenges for managers of information systems. If managers maintained lifetimes of older technologies, the gaps between availability of new technologies and their deployment in organizations have become gradually greater. On the other hand, if older technologies have been replaced by new ones before their projected lifetimes, the conventional experience-based management faced difficulties with extracting sufficient value and utility. In both cases, the experience-based management has led to losses for organizations. Needs for better information technology management have emerged.

A viable solution to the problems associated with the experience-based management has been to employ analytics and transition to analytics-based management (Davenport et al., 2010). Analytics permit more effective transformation of tacit to explicit knowledge and extraction of actionable knowledge from data in a timely manner. Unfortunately, majority of organizations have neither viable analytical capability nor a detailed plan to develop one (Davenport and Harris, 2007). Absence of analytical capabilities presents missing opportunity and inability to employ analytics-based management.

Analytics-based management has a potential to reach higher management efficiency of information systems faster. Thus, greater value and utility can be extracted quicker and novel technologies can replace older ones sooner. Consequently, the formerly increasing gaps between availability and deployments of technologies do not increase, but may eventually decrease. Analytics-based management is new and lacks elucidation and proper attention from scientific and academic community (Hamel, 2007). Our work attempts to fill this gap and explore advantages of analytics-based management in light of issues with experience-based management.

The manuscript is organized as follows. The literature review section is followed by the 'Experience-based Management Challenges' section. It highlights the primary challenges associated with the conventional experience-based management of information technologies. The next section, 'Analytics-based Management Advantages', explains natural transition from experience-based management style to this novel management style and explores its benefits. The section 'Discussions' elaborates on several issues with analytics deployment and adoption of analytics-based management. The presentation finishes with a concise summary in of the essential points in the section 'Conclusions'.

LITERATURE REVIEW AND HISTORICAL PERCEPTION

Analytics-based management of information systems have arisen as a solution to issues inherent in experience-based approach. It extends the experience-based management with a new dimension of analytics. Effective utilization of analytics permits greater flexibility and leads to increase of management efficiency (Davenport et al., 2010). Extracted actionable knowledge by analytics is a potent tool in the absence of experience. It fills the information gap and lowers the level of uncertainty in managerial decision-making.

Analytics-based and experience-based management styles are not mutually exclusive. They are symbiotic. Managers can reasonably rely on actionable knowledge provided by analytics if they do not have proper experience with the difficulties they face. In such case, analytics have greater weight. On the other hand, if managers have a suitable experience, then analytics may still provide valuable additional information. However, greater weight is placed on experience. This balancing of analytics-based and experience-based approaches allows addressing a broader range of managerial issues with greater efficiency. To understand this symbiosis better, it is useful to explore how information technologies have been adopted by contemporary organizations.

Although adoption of information technologies by organizations has been varying–depending on organization–one can notice a prevailing pattern. In early days, each organization had its own way of building information technology capabilities, resources and infrastructures. This period is characterized by a relative absence of dedicated information technology departments. There was also absence of coordinated long-term strategy and planning (Butler and Murphy, 2007). Various departments within organizations implemented their own information systems—meeting only their local requirements (Palanisamy et al., 2010). However, information technology companies provided multi-purpose hardware and software. This has led to diversity of systems at various departments having overlapping functionalities and components, but lacking interoperability (Papastathopoulou et al., 2007). Information technology costs have been rising sharply.

A need to coordinate strategy, planning and deployment of information technologies within organizations has emerged (Georgantzas and Katsamakas, 2010; Boar, 2000). However, radical reengineering of systems would hinder operating efficiency of organizations. Solutions that could utilize existing legacy technologies have been favored. A viable solution has been a deployment of organizational portals providing single-point access to systems and services distributed over various departments (Oertel et al., 2010; Sullivan, 2004; Collins, 2000). Standardized network communication protocols, web, and service-oriented architecture and design have been the enabling technologies (Rosen et al., 2008).
Web servers have featured data logging capabilities that paved the way for web analytics. Log data analysis is capable of providing a reasonable level of detail on system functions and users' interactions with organizational portals and services (Kaushik, 2009). However, log data has disadvantages: it grows rapidly, is significantly contaminated, and requires substantial pre-processing. This has led to development of other data collection technologies using client-side scripts and tracking options. Data collection technologies expanded to specialized hardware tools that allow deep inspection of communication packets and system functions. While advanced data acquisition technologies are valuable for analytics, they also raise concerns about security and privacy (Anthes, 2010; Lanois, 2010).

EXPERIENCE-BASED MANAGEMENT CHALLENGES

Contemporary experience-based management of information technologies relies extensively on tacit knowledge. Managers accumulate tacit knowledge concerning organizational information system management over several years of experience. Their management efficiency grows with accumulated experience.

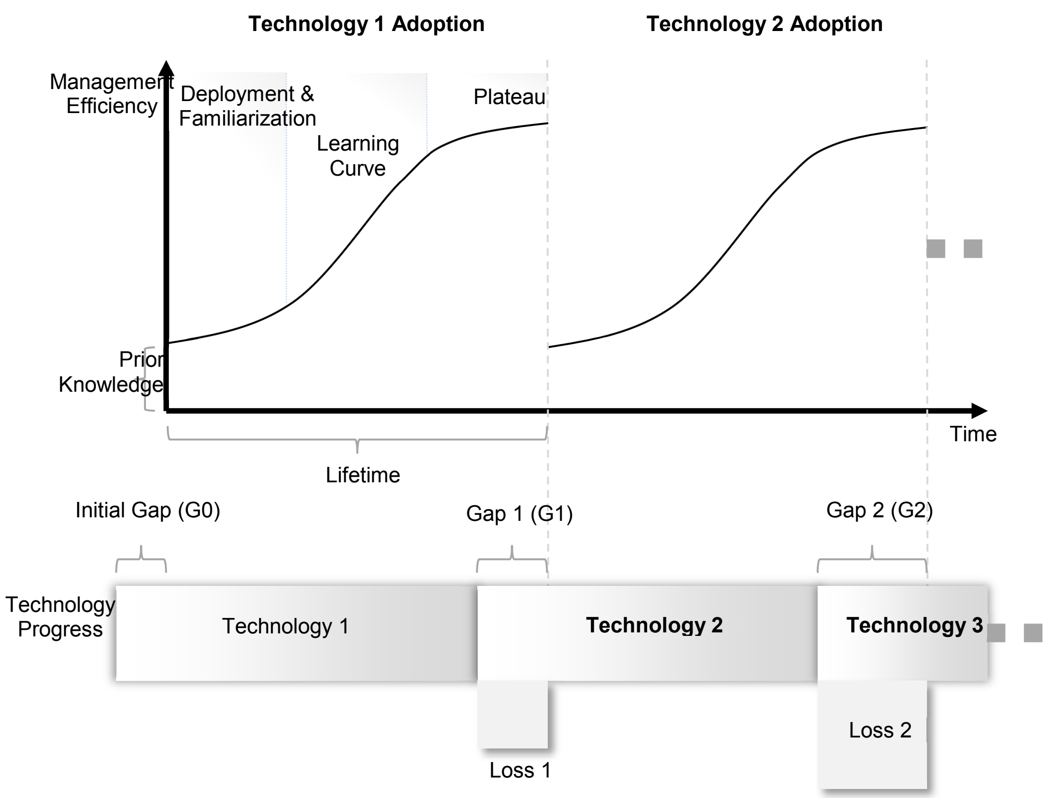
Overreliance on experience-based tacit knowledge has both positive and negative aspects. Positive side of experience-based management is experience. Managers gain hands-on experience with issues directly and/or indirectly related to organizational information systems. Negative traits of experience-based management originate from the nature of tacit knowledge and its acquisition time. Tacit knowledge is difficult to transfer into explicit form (Palanisamy, 2012). This causes difficulties in passing knowledge to other managers—whether substitute or subordinate. Acquisition time plays also imperative role. Rapid pace of progress in information technologies does not allow for extensive accumulation time. Hence, there is a pressure on managers to acquire valuable experience in a relatively short time.

Information technologies have been experiencing growing progress in complexity, usability and development (Resmini, 2012). Greater usability has a positive impact primarily for end-users. Growing complexity and shorter development times present challenges for managers of information technologies.

Managers are required to efficiently manage information technology resources and innovate information systems in organizations. To do so, they must have appropriate knowledge and skills. Acquisition of such knowledge and skills through experience takes time. Increasing complexities of systems demand longer time. However, shortening technology development times do not allow expansion of time required for acquisition of proper knowledge and skills through experience—just the opposite.

These conflicting issues pose significant challenges for experience-based management. They result in increasing gaps between availability and deployment of novel technologies. Furthermore, they hinder innovation and lead to expanding losses. Interplay between experience-based management and technology progress is depicted in Figure 1 and elucidated in the following paragraphs.

Figure 1: Illustration of Relation between Technology Progress and Experience-based Management



Experience-based management of information systems builds on tacit knowledge accumulated by managers over extensive periods during the lifetime of technology adoption. Management efficiency progresses over time along a sigmoidal curve. There is a level of prior knowledge at the time of deployment. During the lifetime of technology adoption, there are three distinguishable stages. The first stage begins with slower progress in management efficiency after the initial deployment and during the familiarization. It is followed by a sharper learning curve in the second stage. The third stage culminates with a plateauing state. Technology development progresses at an increasing rate. Faster technology progress leads to increasing gaps between availability of technologies and their deployment. This results in losses for organizations.

Increasing gaps between developments of novel technologies and their deployments arise from shortening development times of new technologies while maintaining lifetimes of older technologies. This challenge is illustrated in the bottom part of Figure 1. Unless the organization is the early adopter of a new information technology or service, it starts with a certain initial gap, G0. After deployment of a novel technology, organizations have a tendency to maintain progressing along the same or related technology line for several generations; i.e. technology 1 → technology 2 → technology 3, etc. This is logical, since radical reengineering or complete system change is costly and resource demanding. Thus, organizations attempt to extract the greatest value from deployed technologies over their lifetimes.

Technology developers, on the other hand, strive to shorten development cycles in order to gain early-releaser advantage and expand market share. New technologies and services, that are superior to older ones, are released before lifetimes of older technologies expire. As a result, the gaps between technology releases and their adoptions by organizations tend to increase: $G0 < G1 < G2$. After several generations of releases, the gaps may widen to such an extent that managers may even decide to skip one generation release and adopt the next one. Increasing gaps between deployments of new technologies and innovations result in various losses for organizations.

While incremental technology improvements aim at smaller innovations and fixes, generational technology improvements present greater progressive shifts. For instance, software products, such as large-scale database or server systems, maintain incremental innovations and improvements via subversions and generational changes via new versions. Subversions are usually delivered as updates and new versions as upgrades. Although licensing agreements vary, updates are commonly a part of the version license. Transitions to new versions are normally associated with new licensing agreements and higher costs.

New generation of technologies generally provides notable utility improvements, novel and better functionality, and possibly improved integration with other organizational systems and other new technologies. These improvements translate to benefits for organizations. Improved utility and usability improve working efficiency of users and increase productivity. Novel functionality and improved existing system functions also positively contribute to efficiency and productivity. Enhanced integration improves overall functioning of organizational information systems and facilitates better management. Absence of these benefits translates to potential losses for organizations. Losses are reflected in lower user productivity as well as in greater management and overhead costs. Late deployments of new systems may result in losses that outweigh initial costs associated with transitions to new technologies.

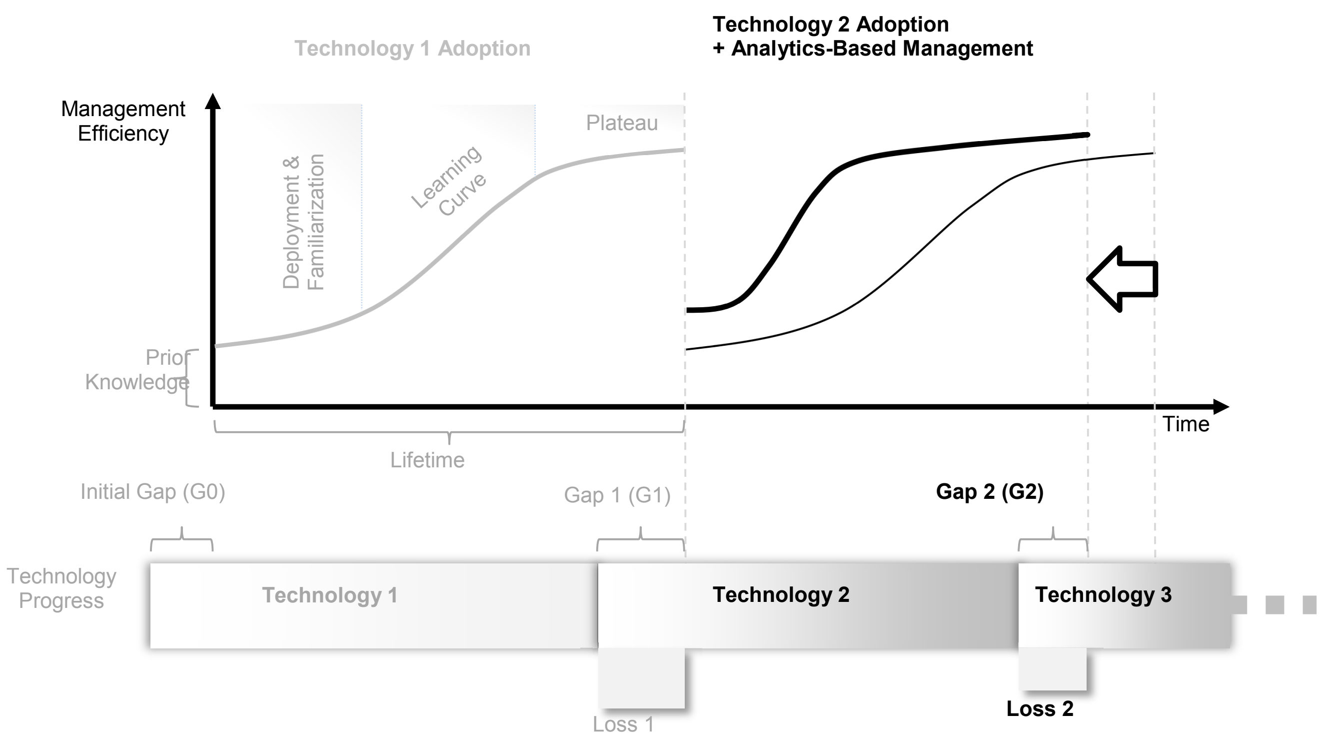
ANALYTICS-BASED MANAGEMENT ADVANTAGES

Analytics-based management approach adds a novel dimension to the conventional experience-based management: deployment and utilization of analytics. It enriches and progressively transforms the traditional experience-based management style rather than replaces it (Davenport et al., 2010). Deployment and utilization of analytics is a novel stage in evolution of information system management. It balances utilization of analytics and experience.

Analytics-based orientation has greater weight initially—in early stages of new technology deployment. This is natural, since there is an obvious absence of experience. However, as managers gain experience with the adopted technology, analytics-based management is beneficially balanced by experience-based insights. In this way, both analytics-based and experience-based management styles constructively complement each other. Unfortunately, majority of organizations do not take advantage of these opportunities (Davenport, 2007).

At the core of analytics-based management are analytics (Laursen and Thorlund, 2010). Deployment of analytics incorporates three major processes: data collection, analysis and actionable knowledge extraction. Analytics-based management necessitates persistent collection of reliable data about organizational systems, their use and performance. Data collection methods should be transparent to users, in order to keep natural interactions of users with systems undisturbed. Non-invasiveness of data collection methods also facilitates uninterrupted utilization of systems by members of an organization in carrying out their work related tasks. Collected data should be appropriately analyzed. Some data analysis should be performed on-the-fly while other may be performed later; e.g. during night hours when users are inactive and greater computing power is available. From suitably analyzed data, pertinent actionable knowledge should be extracted.

Figure 2: Difference between Analytics-based and Experience-based Management



Analytics-based management style is contrasted with experience-based management in the right-hand side of the chart—in the stage of technology 2 adoption. Effects of analytics-based management are illustrated in the following features: greater initial management efficiency than prior knowledge, shorter initial familiarization stage, sharper learning curve, and faster plateauing at higher management efficiency level.

Benefits of analytics-based management of information systems are notable during early stages of new technology deployment. As the adopted technology approaches its end of lifetime these advantages are balanced by accumulated experience. Illustration of advantages is presented in Figure 2. The analytics-based management is compared to the conventional experience-based management. The following effects are distinguishable: higher initial management efficiency than prior knowledge, shorter initial familiarization stage at the beginning of technology adoption, sharper learning curve, and early plateauing of management efficiency at higher level. These benefits facilitate extraction of greater value from technology deployment and permit faster adoption of new technologies. Early adoption of new technologies brings strategic advantages and leads to lower potential losses.

Greater initial management efficiency at the point of adoption of new technology is a result of suitable mixture of prior knowledge and analytics. Analytics enable automation of some information technology management tasks. The automation can be partial or complete. Hence, managers may focus on other issues requiring attention. Adding automation of some management tasks to prior knowledge of managers results in greater management efficiency.

Shorter familiarization stage during the initial period of lifetime of adopted technology is a reflection of suitable extraction of actionable knowledge from viable analytics. Actionable knowledge extraction facilitates conversion of tacit to explicit knowledge. While experience-based management style relied primarily on tacit knowledge gained by experience, analytics-based management employs analytics for suitable extraction of viable knowledge from collected data. Hence, managers are provided with actionable knowledge in a timely manner, rather than needing to acquire it through experience.

Sharper learning curve is further reflection of tacit to explicit knowledge conversion coupled with appropriate management of information overload (Woolfson, 2012). Analytics are capable of providing insights into information technology operations to a considerable detail and with a notable speed. Excessive details contribute to information overload that decreases management efficiency. Thus, proper extraction of relevant knowledge at a suitable time is pertinent. Timely extracted actionable knowledge allows appropriate prioritization and targeting of management efforts. Proper prioritization places pressing managerial tasks before residual issues. A suitable dynamic prioritization positively contributes to faster knowledge acquisition.

Quicker plateauing of management efficiency at a higher level is a consequence of faster learning and timely experience acquisition. Sharper learning curve and faster knowledge acquisition provide more opportunities for exercising relevant managerial tasks at higher levels. Consequently, this leads to appositely acquired experience. Faster plateauing of management efficiency also facilitates greater utility extraction and faster adoption of new technologies.

DISCUSSIONS

Analytics-based management relies on appropriate analytics (Davenport and Harris, 2007). Deployment of analytics requires an initial investment. Majority of the initial cost of analytics deployment is distributed among the following domains: data collection systems, analytic and knowledge extraction tools, and computing power. Additional management information systems, or their extensions, may also be employed. However, they usually provide higher-level perspective and lack sufficient details.

Data collection systems may range from embedded functionality of already deployed systems to specialized hardware. For instance, a cost-effective way of acquiring data about users' interactions with organizational portals and services is to use web logs (and/or specialized scripts). Majority of web servers have logging capabilities. Managers and system administrators can readily utilize web logs for analyzing usability and interactions of users with web-based systems. On the other side of the spectrum are specialized packet sniffing and deep packet exploration tools. These tools allow significantly deeper inspections, but are also costly. While web logging functionality is embedded in web servers, it adds extra load. Packet inspection tools operate separately from web servers and do not generally influence their load.

Analytic and knowledge extraction tools are interrelated with computing power. Data acquisition tools accumulate extensive amounts of data about information systems and their users. Data may grow large rapidly. Table 1 shows basic statistics of real-world web log data collected from an organizational portal in our case study (Géczy et al., 2011). Data volume is in excess of sixty gigabytes.

Table 1. Basic Statistics for Web Log Data Collected at Organizational Information System

Data Volume	~60 GB
Number of Services	855
Number of Log Records	315,005,952
Number of Resources	3,015,848
Time Period	1 Year

Six web servers collected data over the period of one year. The data contained over three-hundred-million log records. Organizational web-based portal contained significant numbers of services and resources—over three-million resources and eight-hundred-fifty-five services.

Large volumes of data may pose challenges for analysis and knowledge extraction tools. Data needs to be appropriately processed (Bernhardt, 2004). Processing incorporates several stages (Beydoun, 2013). For instance, the starting stage includes initial filtering, pre-processing, segmentation and databasing. After that, data is ready for analysis. Knowledge extraction follows the analysis. Depending on complexity and desired depth, analysis and knowledge extraction tools may be costly.

Processing of large data volumes demands notable computing power (Frischbier and Petrov, 2010). Thus, data processing and analytic tools should be supplied with adequate computing power. Although cost of computing power has been steadily decreasing, it is still significant—particularly for big data processing. Organizations may utilize computing power of their own, or that of external providers.

Contemporary cloud computing technologies provide solutions that enable efficient utilization of both organizations' own resources and those of external providers (Géczy et al., 2012). Cloud computing allows flexible utilization of computing power. Cloud systems are dynamically scalable according to demand. Private clouds are the most beneficial. They are owned by organizations and permit flexible use of resources. If private cloud resources are insufficient, organizations may employ external providers until they acquire sufficient resources to meet their needs. Presently, use of resources from external providers is economical in a short term (Mann, 2011; Morton and Alford, 2009). If organizations plan to use computing resources for longer term, it is advisable to invest in their own private cloud capabilities.

Running costs associated with deployment of analytics are relatively small in comparison to the initial costs. Utilization of private cloud technologies enables flexible use of computing resources. Further optimization of use of computing resources for analytics is possible by segmenting analytics into online and offline categories. The online analytics need to be performed on-the-fly, i.e. as soon as data is available in real time. The offline analytics may be carried out at later time; for instance, during night hours and weekends (or holidays). During night, users are mostly inactive and electricity is cheaper, so more computing resources may be provided for analytics.

CONCLUSIONS

The analytics-based management of information systems facilitates improved management efficiency over the traditional experience-based management. The experience-based management is largely dependent on experiential tacit knowledge accumulated over extensive periods. Tacit experiential knowledge is associated with several challenges in contemporary technological environments. Tacit knowledge is difficult to transfer into explicit form and extend to new managers in a timely and effective manner. These two primary aspects of tacit knowledge present complications for efficient management of information systems. They lead to knowledge deficiencies because increasing pace of technological progress does not allow sufficient time for gaining proper experience.

New information technologies are being developed at a quickening pace, hence, lifetimes of older technologies expire faster. Maintaining older information technologies to their expected lifetimes leads to increasing gaps in adoptions of novel technologies. Shortening lifetimes of older technologies, on the other hand, decreases returns—under experience-based management. In both cases, reliance on experience-based management results in losses for organizations. It is therefore desirable to achieve higher management efficiency quicker and to extract greater value sooner. This would permit faster adoption of novel technologies. Analytics-based management targets these desirable solutions by employing analytics.

The analytics-based management presents a new dimension in management of information systems that suitably complements experience. Actionable knowledge extracted by analytics from collected data substitutes the absence of viable experience—particularly in the early deployment stages of new technologies. Proper utilization of analytics facilitates transformation of tacit to explicit knowledge, permits automation of managerial tasks, and allows reaching higher management efficiency faster. These effects enable shortening of deployment times of technologies and earlier adoption of new technologies. Deployment of analytics requires proper data acquisition, processing, analysis and knowledge extraction. These requirements are associated with costs. Well-managed deployment of analytics aims at minimizing associated costs while maintaining benefits of analytics.

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