Exploring the Benefits of an Agile Information System

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Abstract

Information Systems (IS) agility is a current topic of interest in the IS industry. The study follows up on work on the definition of the construct of IS agility and attributes for sensing, diagnosis, and selection and execution in an agile IS. IS agility is defined as the ability of an IS to sense a change in real time; diagnose it in real time; and select and execute a response in real time. Architecting an agile IS is a complex and resource-intensive task, and hence examination of its benefits is highly desired and appropriate. This paper examines the benefits of an Agile Information System. Benefits of an agile IS were derived from related academic literature and then refined using practitioner literature and qualitative data. The benefits considered were the first order or direct benefits. These benefits were then empirically validated through a survey of IT practitioners. The results of the survey were analyzed and a rank order of the benefits was arrived at. An exploratory factor analysis was also done to find the common dimensions underlying the benefits. It is suggested that organizations can use the empirically validated benefits from this study to justify and jump-start their capital and labor expenditure to build agility into their Information System.

1. Introduction

Change is the rule of the game in the current business environment. Not only are the changes occurring at an increasing rate, they are becoming increasingly unpredictable. This unpredictability can involve when a known change will oc-

cur, what an unknown change will look like, or the combination of these. The rapid rate of change implies that an organization needs to become an expert at changing and morphing itself rapidly in response to a change. As per the ORACLE cloud agility survey [1] the ability of the competitor to launch innovative services more rapidly was identified as a top threat by 27% of the respondents. Also, as per the survey, a majority of businesses believe they are agile but cannot flexibly manage workloads or rapidly develop, test, and launch new applications, leaving them poorly prepared to deal with competitive threats. Retention of leadership and/or competitive position requires that an organization should be able to change at will in any direction, without significant cost and time, to counter a threat or capitalize on an opportunity. Such an organization may be characterized as an agile organization. For most of organizations the survival and/or retention of market share demands that the organization should be able to change faster than, or as fast as, new entrants and rivals. The ORACLE survey found that the impact of agility on competitiveness is critically important to businesses.

Information Systems (IS) pervade all aspects of modern organizational functioning and play an integral role in information processing activities of an organization. Information Systems are needed for organizational agility on account of their ability to provide shared, distributed and integrated, current, and fast-flowing information [2]-[8].

Modern business processes in organizations use IS as a core resource or component. In many and most of cases, IS may completely or significantly embed a business process (e.g., Internet banking). The pivotal role of IS in modern organizational business processes means that an organization (agile or striving to be) cannot change its business processes unless the IS changes as well. Thus an agile organization would need an agile IS. As per the ORACLE cloud agility survey, 81% of the respondents stated that the ability to rapidly develop, test, and launch new business applications is critically important or important to the success of the business. In particular 29% of the respondents believed that effective mobilization of applications and services is the most important factor in business success today [1]. What Brandt and Boynton [9] indicated in 1993 still holds true—current IS are not easy to change though several are getting better at it in some aspects.

So what is an agile IS? We arrive at the definition or construct of an agile IS based on prior work done by the authors in this area. Agility in general is defined [10] [11] as a formative construct comprised of the ability to sense a change, diagnose a change, select a response, and execute the response in real-time:

1) **Sense**: Ability to sense the stimuli for change (as they occur) in real-time;

2) **Diagnose**: Ability to interpret or analyze stimuli in real-time to determine the nature, cause, and impact of change;

3) **Respond**: Ability to respond to a change in real-time, further disaggregated

into *select* and *execute.*

a) Select: Ability to s*elect* a response in real-time (very short planning time) needed to capitalize on the opportunity or counter the threat.

b) Execute: Ability to *execute* the response in real-time.

Real-time is defined as the span of time in which the correctness of the task performed not only depends upon the logical correctness of the task performed but also upon the time at which the result is produced. If the timing constraints of the system are not met, system failure is said to have occurred [12].

Thus an Agile IS may be defined as one that has the ability to sense a change in real-time, diagnose the change in real-time, select a response in real-time, and execute the response in real-time. Due to the formative nature of the construct, several, or some, of these abilities might exist in the absence of others.

The IT industry over the last few years has made strides in enhancing IS agility. Perhaps the most important development has been in the area of Cloud computing with services like Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Storage as a Service, Security as a Service, Database as a Service, and Software as a Service (SaaS), amongst others. In the area of software development, methodologies like eXtreme Programming (XP), SCRUM, Feature Driven Design, Microservices, and others have been implemented to facilitate continuous change to the software by incorporating new requirements as opposed to the freezing of requirements in the Waterfall methodologies. In the area of continuous deployment, DevOps has made great strides into the industry. However the adoption of these technologies and frameworks involves some learning curve and is not as rapid as anticipated. As per the ORACLE cloud agility survey, only 32% of respondents state that they fully understand what PaaS is, rising to 37% in the US, while 29% admit that they do not understand it at all. For those that say they do understand PaaS, only 31% cite reduced time frames for application development as a main benefit [13].

Having an agile IS is no simple task and needs a variety of abilities for sensing a change in real-time [14], diagnosing a change in real-time [15], and selecting a response and executing a response in real-time [16]. These abilities require a significant investment of resources in both the people and IT components of an IS. A relevant question then one may pose is what are the benefits of an agile IS? While many benefits may be apparent, it is still worthwhile to undertake an empirical investigation of this question. This is the research question addressed in this manuscript. It should be mentioned that there is literature specifically linking the role of IS to organizational agility [17]. The question explored here is specific to the benefits of IS agility, which may include both first order and higher order benefits.

2. Literature Review

Peer-reviewed academic literature alludes to several benefits of IS agility. While the authors clearly distinguish between flexibility and agility [11], the published

literature often does not make this distinction and hence pertinent literature from both areas is examined. Also literature from other areas like supply chain management and manufacturing (which was and is at the forefront of the agility phenomenon) is also examined.

Based on the Resource-Based View (RBV) of the firm, we consider IS as a key resource of a firm. Even though many systems can be purchased from the marketplace, the use and customization of these systems is recognized as anchoring the IS competencies of the firm. [18] [19] view IS infrastructure as an IS competence, because not all the firms can equally capitalize on information technology (IT) without using a flexible IS infrastructure. Firm competencies inherit the following properties: they are valuable, rare, inimitable, and non-substitutable. These attributes cannot be easily imitated by competitors in the short-run because capabilities are deeply rooted in the history of the firm, and some capabilities could arise just by being in the right place at the right time [20]. Agility of an IS would further enhance an organization's competitive advantage.

Traditionally IS planning was conducted on an ad-hoc basis, because IS was considered as a support system performing back-end service functions. Therefore, the main function of IS management was to choose those systems that could perform back-end functions efficiently. Since the 1980s, however, IS planning started playing an important role in business planning. However, both business planning and IS planning exercises were done in isolation. Even though business managers acknowledged the key role of IS, they did not take notice of IS competencies [20] [21]. Today, we look upon IS in an agile manner that can add benefit to the organization through sensing, directing, executing and diagnosing information in real time. A model proposed by [22] proposes to examine how IT capabilities (*i.e.*, flexible IT infrastructure and IT assimilation) affect firm performance through absorptive capacity and supply chain agility, in the supply chain context [22]. Their research shows that absorptive capacity and supply chain agility fully mediate the influences of IT capabilities on firm performance.

There are many examples of agile IS in the literature. For example, Shin *et al.* [23] explored the nature and role of agility as a strategic intent and its influence on operational and firm performance. [24] claim that agile development has now become a well-known approach to collaboration in professional work life. Yanan *et al.* [25] believe that there has been a significant effect that the design of a plant can have on its agile and dynamic performance. Sangari *et al.* [26] contend that supply chain agility is a key determinant of competitiveness and they developed a practical evaluation framework that serves to identify critical factors for achieving supply chain agility. Gilgor *et al.* [27] feel that traditionally, researchers have claimed agility as an attribute closely tied to the effectiveness of strategic supply chain management that is closely associated with customer effectiveness. Goldsby *et al.* [28] claim that the relationship between agility and cost efficiency is not clear due to limited empirical scrutiny from researchers and shed light on

the relationship between agility and efficiency. Narayanan *et al*. [29] demonstrate that several studies in the buyer-supplier relationship literature have addressed the impact of collaboration on agility performance and claim that some but not all studies have concluded that collaboration leads to beneficial effects while others have questioned the positive effects of collaboration on relationship performance. Chung *et al*. [30] examine how organizational workers improve their perceived job performance, while also investigating the impact of perceived organizational agility and location independence on technology acceptance. Sherehiy and Karwowski [31] believe that organizational agility requires development of an adaptable workforce that is able to deal with unexpected and dynamic changes in the business environment. They utilize an Agility Strategy Scale, Work Organization Scale, and Workforce Agility Scale to study autonomy at work as one of the most important predictors of workforce agility. Yang [32] developed and empirically tested a conceptual framework to investigate the antecedents of manufacturers' supply chain agility and the connection of their agility with performance. They postulated that technical (IT capability) and relational factors (information sharing and trust, and operational collaboration) are the antecedents of a manufacturer's supply chain agility.

Barthe-Delanoë *et al*. [33] propose that the modern business environment tends to involve a large network of heterogeneous people, devices, and organizations that engage in collaborative processes among themselves that lead to a high degree of interoperability between partner IS and that these processes need to be agile. Yusuf *et al*. [34] assesses the link between dimensions of an agile supply chain, competitive objectives, and business performance, and identify the most important dimensions and attributes of supply chain agility. Yusuf *et al*. [34] also researched the pressures that persist on organizations to master and profit from oil and gas energy. While most results suggest that clusters enhance and enable higher levels of agile practices, their findings indicate that there is no strong empirical basis to make a direct link between clusters and competitiveness. DeGroote and Marx [35] investigated the impact of information technology (IT) on supply chain agility measured by the ability to sense and respond to market changes, and the impact supply chain agility has on firm performance, and their results suggest that IT improves the supply chain's ability to sense market changes by improving the adequacy, accuracy, accessibility, and timeliness of the information flows among members of the supply chain. Balaji *et al*. [36] propose that Agility is perceived as the principal competitive medium for all organizations in an ambiguous and changing business environment and that enterprises are converging to a point where they need to be smarter, faster, flexible, and more reactive to changes in order to sustain in the demanding market. Seethamraju and Sundar [36] postulate that past research on the effect of ERP systems on agility is contradictory, and research on the post implementation effects of ERP systems on agility is limited and found that the inadequacies in implementation and poor process optimization prior to ERP implementation are

restricting process agility. Galster and Avgeriou [37] investigate how variability facilitates the design of software products that can be adapted for a wide range of customers or contexts. They found that in agile development, software products begin to be built before the desired product is fully understood. Sheffield and Lemétayer [38] believe that there is considerable debate among practitioners and researchers on the nature of software development agility and conditions under which it is linked to project success. They found that software development agility was indicated by the project environment factor of organizational culture and a project factor of empowerment of the project team.

Krotov, *et al.* [39] identify several ways in which mobile technology is used to improve operational, customer, and partnering agility. A flexible IS infrastructure, according to Bharadwaj [18], is an integrated shared system that is built piece by piece over time. That means, as a firm learns to work with a system and gradually becomes proficient in using the system, it continually works to add other pieces in the infrastructure that can set it apart from other firms. A flexible IS infrastructure allows sharing of data and applications through communication networks (Wasko and Faraj [40]. It pertains to the arrangements of hardware, software, and networks so that data and applications can be accessed and shared within and between suppliers, customers, and vendors [41]. A flexible IS infrastructure helps in integrating disparate and geographically distributed systems and make IS applications cost effective in their operations and supports, therefore, flexible infrastructure becomes a critical source of advantage to the firm [42]. Weber *et al.* [43] pointed out that in both academics and industry, companies increasingly adopt process-aware information systems (PAISs), which offer promising perspectives for more flexible enterprise computing. Seebacher and Winkler [44] believe that recent economic developments indicated that greater flexibility in manufacturing is more important than ever and they present an applicable approach that shows exactly how to evaluate the manufacturing flexibility and how to measure an improvement of flexibility in business practice.

The literature points to several benefits of agility and more importantly the need for agility, in general, to an organization in areas like supply chain, enhanced partnership with customers, timely information, etc. Though the unit of analysis-IS within an organization, in this manuscript is different, several of these benefits may be rolled into higher order benefits of an agile IS.

3. Research Approach and Objectives

IS agility is an area where practitioners have taken the lead. In the practitioner literature, IS agility is equated to a set of technologies that enable seamless interconnection and collaboration between the IT components to achieve rapid configuration changes. The conceptualization of IS agility used in this study is much broader and more comprehensive in scope. To arrive at the benefits of an agile IS, a comprehensive survey of the practitioner literature was done. This in-

cluded having Google alerts for the topic and continually refining the benefits. In addition, existing literature on agility was also examined to arrive at a list of benefits of an agile IS. Specifically, the following steps were taking to arrive at a list of benefits:

1) Arrive at a conceptualized set of benefits of an agile IS. Such benefits would arise due to the ability of an IS to respond to internal, organizational, and external changes through sensing a change in real-time, diagnosing the change in real-time, and selecting and executing a response in real-time (Pankaj, 2005).

2) Verify and refine the conceptualized set of benefits of an agile IS based on the feedback from practitioners and to arrive at a comprehensive set of benefits.

3) Validate the benefits through a survey.

4. Perceived Benefits of an Agile IS

As stated earlier benefits due to the ability of an agile IS to sense, diagnose, and select and respond in real-time are based on the comprehensive and continual review of the practitioner literature as well as published academic literature. The agility literature describes the benefits of agility as ranging from survival to enhancement of the competitive position. Since an agile IS contributes to the agility of an organization, the benefits of IS agility may span a similar range. The net effect of IS agility would be on the financial performance of the organization but it may have several other immediate or first order effects like reduction in the time needed for changing IS, etc. Table 1 gives a list of benefits of an agile IS from the classical agility literature. It may be noted that most of these are higher order benefits. For the purpose of this manuscript, the focus is on first order benefits to

Table 1. Benefits of organizational agility.

Description	References
Enhanced value to customers	Vokurka, Zank, & III, [54]; Christian, Govande, Staehle, & Jr., [55]
Advantage from the changing situation; benefit from change	Yoffie & Kwak, [56]
Competitive advantage and/or competitive performance	Bessant, Francis, Meredith, & Kalinsky, [57]; Schonsleben, [58]; Cho, Jung, & Kim, [59]; Bal *et al.*, [3]; Vernadat, [60]; O'Connor, [61];
Profitable operations	Sahin, [62]; Vokurka & Fliedner, [63]; Vokurka *et al.*, [54]; Devor, Graves, & Miles, [64]; Noaker, [65]
Survive unprecedented threats, viability	Sharifi & Zhang, [7]; Cho *et al.*, [59]; Dove, [45];
Growth in a competitive market	Y. Y. Yusuf *et al.*, [34];
Capture new market	Vernadat, [59]
Leadership	Dove, [45]

ensure that the effects of investments in an agile IS are observable and not confounded by other variables.

Benefits of having an agile IS come from a real-time response to internal, organizational, and environmental changes. Internal changes in IS that are geared for improvements, build spare capacity and enhance capabilities. Monitoring for internal changes enables the IS to predict outages and other potential problems and thus enables fast response by the IS to maximize the uptime and maintain desired levels of services at all times. In case of outage, the properties of an agile IS enable fast recovery and minimize downtime. An IS that changes easily in response to organizational changes ensures that the IS is aligned with the business processes at all times thereby increasing the efficiency, productivity, and effectiveness of the business processes and related information processing tasks. The efficiency and effectiveness may also lead to reduction in costs. An agile IS allows for rapid changes in the business processes thereby enabling the organization to maintain or enhance profits by countering the moves of competitors. The ability to respond to an actual or anticipated IS innovation (environmental change) in real-time enables an IS to provide the latest solutions for the business processes thereby increasing the effectiveness of the business processes. It also enables business process innovation through the use of the latest IS solutions, and protects against technology obsolescence. Being responsive to the environment also enables the IS to protect itself and the organization against unfavorable events like expensive licensing terms, security vulnerabilities, cyber-attacks, and viruses.

Overall, an agile IS will lead to a reduction in time for changing the IS. The resulting changes would also be more robust [45]. The benefits of having an agile IS for an organization are summarized in Table 2.

Table 2. Benefits of an agile information system.

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1) Reduction in time to implement changes in IS.
2) Increase in the robustness of the implemented changes.
3) Benefits from response to internal changes.
    a) Increase in efficiency and effectiveness of the existing business processes.
    b) Increase in efficiency and effectiveness of information processing.
    c) Build spare capacity.
    d) Build enhanced capabilities for future use.
    e) Maintain the desired levels of service as per the service level agreements for the IS.
    f) Enable fast recovery in case of outages to minimize the down time.
4) Benefits from response to organizational changes.
    a) IS is aligned to business process requirements at all times.
    b) Business processes can change rapidly (in real time).
    c) Higher financial benefits to the organization.
5) Benefits from response to environmental changes.
    a) Avoid technology obsolescence through provision of needed latest IT/IS solutions.
    b) Allow business process innovation through incorporating the latest IS solutions.
    c) Protect the IS and the organization against unfavorable licensing terms and
    vendor induced situations.
    d) Allow rapid response to security threats like virus attacks, cyber-attacks, etc.

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5. Improving and Refining the Benefits of an Agile IS

Ten executives were interviewed to elicit their opinions on the benefits of an agile IS. The interviews were comprehensive in the sense that they were introduced to the definition of IS agility, asked to validate it, comment on it, and discuss it, and then asked to comment on the attributes of an agile IS (published elsewhere). Subsequent to that they were asked about the benefits of an agile IS outlined in Table 2. They were requested to modify, add, and delete to and from the list. They were also requested to give a balanced perspective on different aspects of an agile IS ranging from organizational rules and policies to IT components. As per Bonoma's verification guidelines [46], multiple interviews were proposed for purposes of literal replication. The interviewees selected were participants in a discussion round table for a research center in a major university. The participants' organizations/companies were examined by the participating researchers and were deemed to have a need for IS agility based on an informal assessment of the antecedents of IS agility for these organizations [10].

The interviewees' demographics demonstrated diversity (industry and size; diversity in role and responsibilities; and diversity in organizations in terms of their approach to developing and managing IS). The interviewees' roles spanned from strategic, to a mix of strategic and technical, to more specialized technical roles.

Content analysis was done on the interviews [10]. Interviewees commented on the benefits of an agile IS but only the first order benefits of an agile IS were considered. Some of the first order benefits of IS agility mentioned were better recoverability, faster development of products and services, better responsiveness, higher availability of IS and conformance to Service Level Agreements (SLAs), cost savings on IS changes, use of IS as a strategic tool, targeted information for various tasks, increased problem resolution, better utilization of IS, availability of needed functionality in IS, process improvement, quick changes to operational processes, and alignment of IS with the business needs. Of these benefits, faster development of products and services and the use of IS as a strategic tool was not included in the original list of benefits and so these were included as a benefit of responding to organizational changes. Interviews also mentioned burnout effects resulting from changing too fast and too often. Changing fast and trying to be on the cutting edge of the technology may leave the organization with IS that use technologies that do not become mainstream, and a lot of new IS that stretch the IS staff. Poor vendor support for these cutting-edge technologies and their lack of maturity further aggravates the situation. As such, being agile does not necessarily mean that the IS should always use a cutting-edge technology. This aspect is stressed in the work that details the theory behind the definition of agility [10], where it has been mentioned that that a reconfiguration of an IS in response to change should result in a stable configuration. The criterion of stability will often preclude technologies that are not mature and proven, and are difficult to maintain. Most new and cutting-

edge technologies share these characteristics, and so being agile may not necessarily mean being on the cutting-edge of technology, though such new technologies may often facilitate higher levels of IS agility.

Table 2 illustrates the perceived benefits of an Agile Information System. A refined set of attributes for sensing is presented in Table 3. New attributes have been italicized. These changes are meant to demonstrate how our study leads to improving and refining the original perceived benefits of an Agile IS. These refinements make a contribution to the literature and increase our understanding of the Agile IS construct. The benefits of an Agile IS will lead to optimization of enterprise performance with improved organizational knowledge, memory and learning. Our improved model leads to enterprise-wide intelligent information management principle adoption.

6. Survey Development & Administration

Survey development and administration was performed using the well-documented steps for survey development, administration and analysis [47] [48] [49] [50]. The development and validation of the survey was performed as per the guidelines by Churchill [51]: generate sample items, pilot test, and develop final measures.

The survey contained 18 items for benefits of an agile IS along with other items relating to sensing, diagnosis, selection and execution [14] [15] [16] [52]. The survey contained 6 items pertaining to demographics. There, demographic items were based on a sample of ten surveys designed by peer researchers. The demographic information collected included the title and department of the re-

Table 3. Post interview benefits of an agile information system.

1) Reduction in time to implement changes in IS.
2) Increase in the robustness of the implemented changes.
3) Benefits from response to internal changes.
    a) Increase in efficiency and effectiveness of the existing business processes.
    b) Increase in efficiency and effectiveness of the information processing.
    c) Build spare capacity.
    d) Build enhanced capabilities for future use.
    e) Maintaining the desired levels of service as per the service level agreements for the IS.
    f) Enable fast recovery in case of outages to minimize the down time.
4) Benefits from response to organizational changes.
    a) IS is aligned to business process requirements at all times.
    b) Business processes can change rapidly (in real time).
    c) Higher financial benefits to the organization.
    d) *Faster development of products and services.*
    e) *Ability to use IS as a strategic tool.*
5) Benefits from response to environmental changes.
    a) Avoid technology obsolescence through provision of needed latest IT/IS solutions.
    b) Allow business process innovation through incorporating the latest IS solutions.
    c) Protect the IS and the organization against unfavorable licensing terms and vendor induced situations.
    d) Allow rapid response to security threats like virus attacks, cyber-attacks, etc.

spondent, industry, the number of IS personnel, annual IS budget, and annual revenue. The draft survey was pilot-tested with four practitioners and three MIS researchers for assessing the understandability of the questions, clarity of the instructions, unambiguity in the wording of the items, and the overall format of the questionnaire. Though the questionnaire was a long, pilot-testers agreed that the survey could be completed within a reasonable time, and without extensive effort. It was suggested that items be grouped together. For example, items relating to personnel may be grouped together and items relating to the IT components may be grouped together. Additional changes suggested included the rephrasing of five items and the layout of the balloon graphic providing the definition of agility on the second page.

The pilot test for the web questionnaire was done using students and was oriented towards visual appeal, layout and design, and not content. The survey was tested on different browsers to verify that all the buttons and scripts worked and there were no run-time errors. The pause-and-resume functionality; clarity of the images and fonts; visual appeal of colors; amount of scrolling at standard resolution of 800×600; and download times were tested. Some changes in fonts and layout were done as a result of the tests.

Survey Administration

The survey was mailed to IS executives for self-administration. This list was purchased from a professional marketing company. The questionnaire was mailed to 2718 executives (IS staff strength of between 100 - 1500). The survey included a cover letter, a paper copy of the questionnaire and a prepaid return envelope. The only incentive for responding to the survey was to share the results of the survey. The cover letter specified that the survey could also be completed online if desired by the respondent. A reminder for the survey was mailed approximately three weeks after the original mailing. After mailing the questionnaires, emails were sent to about 30 potential respondents using referrals from IS executives known to the researchers. The emails contained an executive summary of the research concepts, a copy of the questionnaire, and a link to the web-based questionnaire. A second mailing of the survey was done. The survey was mailed to 2448 addresses and a reminder postcard was mailed approximately three weeks after the mailing.

7. Survey Analysis & Results

A total of 154 responses were received (105 paper and 49 web responses). 11 responses were likely from referrals. There were a total of 2539 solicitations (accounting for incorrect addresses). This gives a 5.7% response rate. This response rate was considered acceptable considering the questionnaire had 112 items (pertaining to sensing, diagnosis, selection, execution, benefits, and self-assessment), budgetary constraints on the survey, and the fact that these executives likely receive several surveys with some financial incentive (gift card) for com-

pletion.

All the data was entered into SPSS for analysis. The demographic data item categories (except for the title and department) were assigned numerical codes. The rating for all items for benefits and attributes were entered as marked on the questionnaire except for "Not Applicable" which was assigned a code of 0 (zero). To verify the correctness of data entry from the paper survey, a random sample of 20 questionnaires was selected and checked by a fellow researcher. No data entry errors were found. There were few missing values in the entire data set. Missing values were treated as pair-wise exclusive for correlational analyses like factor analysis. They were treated as list-wise exclusive otherwise, e.g. for purposes like calculating descriptive statistics.

7.1. Respondent Demographics

The demographics of the respondents are shown in Tables 4-7. Education, government, finance, healthcare, and information technology companies are prominently represented in the survey. 62% of the respondents had fewer than 250 IS personnel, 61% of the organizations had an annual IS budget between $1 million and $50 million, and 40% of the respondents had revenues between $1 billion and $25 billion.

Table 4. Industry distribution of survey respondents.

Industry	Frequency	Percent
Retail	3	2.0%
Finance & Insurance	23	15.0%
Government	24	15.7%
Information Technology	18	11.8%
Mining & Oil	1	0.7%
Manufacturing	9	5.9%
Education	32	20.9%
Recreation & Leisure	1	0.7%
Utilities	3	2.0%
Trading (Wholesale)	4	2.6%
Media/Publishing/Broadcasting	5	3.3%
Professional Services	3	2.0%
Healthcare	20	13.1%
Other	7	4.6%
Total Valid	**153**	**100.0%**
Missing	1	
Total	154	

Table 5. IS personnel distribution of survey respondents.

IS Personnel	Frequency	Percent	Cumulative Percent
1 - 100	39	25.3%	25.3%
101 - 250	56	36.4%	61.7%
251 - 500	29	18.8%	80.5%
501 - 750	12	7.8%	88.3%
751 - 1000	3	1.9%	90.3%
1001 - 1500	3	1.9%	92.2%
1501 - 2000	1	0.6%	92.9%
2001 - 5000	3	1.9%	94.8%
>5000	8	5.2%	100.0%
Total	**154**	**100.0**	

Table 6. Distribution of annual IS budget of survey respondents.

Annual IS Budget ($millions)	Frequency	Percent	Cumulative Percent
<0.5	11	7.2%	7.2%
0.5 - 1	10	6.5%	13.7%
1 - 50	93	60.8%	74.5%
50 -100	20	13.1%	87.6%
100 - 500 Million	15	9.8%	97.4%
500 - 1000	3	2.0%	99.3%
>1000	1	0.7%	100.0%
Total Valid	**153**	**100.0%**	
Missing	1		
Total	154		

Table 7. Distribution of annual revenue of survey respondents.

Annual Revenue	Frequency	Percent	Cumulative Percent
<$1 Million	8	5.5%	5.5%
$1 Million - $50 Million	18	12.4%	17.9%
$50 Million - $100 Million	9	6.2%	24.1%
$100 Million - $500 Million	25	17.2%	41.4%
$500 Million - $1 Billion	21	14.5%	55.9%
$1 Billion - $25 Billion	58	40.0%	95.9%
>$25 Billion	6	4.1%	100.0%
Total Valid	**145**	**100.0%**	
Missing	9		
Total	154		

In summary, the survey had respondents from various segments of the population and it captured opinions from a variety of organizations in different industries both small and large in terms of annual revenue, IS budget, and number of IS personnel.

7.2. Non-Response Bias

Since the survey was anonymous, it was not possible to test for differences between the respondents and the non-respondents. The respondents from the two mailings were, however, compared for differences. The number of responses for each medium and for each mailing is detailed in Table 8. The number of responses in the second mailing was about half of those in the first mailing.

Cross-tabulations on the demographic variables of industry, IS personnel, IS budget, and annual revenue were calculated and compared for differences. Chi-square tests were not conducted since many of the cells had an expected count of less than 5 and combining various categories led to mitigation of the differences with respect to the categories for the two mailings of the survey. There was no noticeable difference between the two mailings in terms of the demographic variables. The mean ratings of benefits of an agile IS from the responses of the two mailings were compared using independent sample t-tests. The means of the ratings were not different at a significance level of 0.01.

The 18 benefits of an agile IS were presented to the survey respondents for rating on a scale of 1 to 7, 1 being not important to 7 being very important. Table 9 shows the frequency, mean, and standard deviation of the ratings of the benefits of an agile IS.

Benefits of an Agile IS

The item with the largest mean rating of 6.54 was "Rapid response to security threats like viruses and cyber-attacks", and indicating the emphasis that IS executives attach to security and quickly taking remedial actions to alleviate the threat. Security has been a constant focus in mainstream practitioner and academic literature recently, and so the expectation of an agile IS to excel in the area of security is understandable. In the same vein, "Recovery from failure" was rated as an important benefit of an agile IS (mean rating of 6.32). The benefit with the second highest mean was "Information systems changes are made in a timely fashion". This is the reason for having an agile IS and is an obvious benefit. The fact that it did not score as the top benefit is somewhat of a surprise but

Table 8. Paper and web responses for first and second survey mailing.

| | | Mailing | | Total |
		First	Second	
Type of Medium for Survey	Paper	67	38	105
	Web	36	13	49
Total		103	51	154

Table 9. Survey ratings of the benefits of an agile information system.

Benefit of an Agile IS	Frequency of Rating[1]								N	Mean[2]	Std. Dev
	1	2	3	4	5	6	7	N/A			
Rapid IS response to security threats like viruses and cyber attacks	0	1	0	2	13	23	114	1	154	6.61**	0.79
IS changes are made in a timely fashion	0	0	0	2	15	37	100	0	154	6.53**	0.73
Fast IS recovery from failures/outages	0	0	4	6	14	42	87	1	154	6.32**	0.98
Increase in efficiency and effectiveness of business processes supported by IS	0	1	0	6	22	54	71	0	154	6.21**	0.91
Effective information processing	0	2	3	9	23	54	61	2	154	6.02**	1.09
Alignment of IS with the business process requirements at all times	2	0	4	12	26	42	63	3	152	5.94**	1.23
Use of IS as a strategic business tool	0	1	7	10	26	54	54	2	154	5.89**	1.14
IS can meet the service level agreements (SLAs) for capacity and performance	0	1	6	8	42	52	42	3	154	5.75**	1.09
Quick building of capacity for handling peak loads and/or sudden loads	0	2	5	17	34	50	46	0	154	5.71**	1.78
Faster development of products and services	1	0	2	18	40	49	42	2	154	5.70**	1.10
Efficient information processing	1	2	4	18	38	43	47	1	154	5.66**	1.24
Increased financial benefits to the organization	2	2	6	12	33	52	44	3	154	5.68**	1.28
Rapid change in business processes	3	1	5	19	36	52	36	2	154	5.53**	1.29
Increased robustness of changes made to the IS	4	2	7	15	55	39	32	0	154	5.34**	1.34
Enhancement of IS capabilities	2	0	4	16	57	48	27	0	154	5.24**	1.11

Notes: [1]The shaded boxes show the rating with the highest frequencies. [2]Items are arranged in ascending order of mean rating. **Mean is significantly greater than 4 at 0.00 level of significance in a two-tailed test.

perhaps amply demonstrates the focus on security. Interestingly, "Quick building of capacity for handling peak loads and/or sudden loads" was not rated as one of the top benefits (it is 9th in the ranking) of an agile IS, yet this is the area where many IT providers are focused through various cloud initiatives like PasS, SaaS, IasS, etc. The low rating for "use of the latest technologies to avoid technology obsolescence", shows that the use of the latest technologies did not seem to be a priority for most IS organizations. Also, in spite of the trend towards applications service providers, off-the-shelf software products, outsourcing, and off-sourcing, managing vendor risk did not seem to be a major concern for most

IS executives, as denoted by the low rating on "protection of IS and the organization from vendor induced risks (bankruptcy, etc.)".

7.3. Exploratory Factor Analysis of Benefits of an Agile IS

An exploratory factor analysis (EFA) was conducted to identify possible dimensions underlying the benefits of an agile IS. Though broad categories were defined when arriving at attributes and it would be possible to do a confirmatory factor analysis, it was felt that an EFA is appropriate given the exploratory nature of the study. There were 18 items for benefits of an agile IS. Given the sample size of 154, the case-to-variable ratio is 8.55:1. This ratio satisfies the rule of thumb of 5:1 and thus the sample size was considered as acceptable for an EFA. Kaiser-Meyer-Olkin's Measure of Sampling Adequacy (KMO MSA) for the correlation matrix was 0.88. This is considered at meritorious level, signifying that the correlation matrix can be used for factor analysis.

An EFA was conducted using principal axis factoring since the objective was to identify underlying dimensions based on the common variance shared by the attributes. Varimax rotation was used to arrive at a simple factor structure. Other rotations including varimax, oblimin, quatrimax, and promax were tested. Varimax rotation provided the simplest and most interpretable structure. The number of factors to be extracted was based on a combination of the scree-test, eigen-value criterion, and simple structure. Simplicity of structure was given preference over parsimony. Initial factor extraction was based on the criteria of the eigen-value being greater than 1. Then, the scree plot was examined for a visible elbow such that all factors with an eigen-value of greater than 1 were included in the solution. The factor analysis was run again with the number of factors indicated by the elbow. Both solutions were examined and the factor structure that was simple and interpretable was chosen. The cut-off for factor loading was taken as 0.4. While no set criteria for the factor loading exist in the literature, guidelines suggest [53] loadings of greater than ± 0.3 to meet the minimal level while loadings of ± 0.40 are considered more important.

The criteria of eigen-values greater than 1 yielded four factors. The scree plot did not indicate a distinct elbow, though the slope seemed to decrease at factor 5. The five-factor solution was not superior in any sense to the four-factor solution and so the four-factor solution was retained. These four factors together explain 62% of the variance. Table 10 depicts the factors: The strategic benefits factor reflects a top down approach and provides guidance for all levels of the organization's managers.

The first factor was labeled as the "Technology Leverage" factor. Though "protection of IS and the organization" and "increased robustness of changes" may be seen more as mitigating risks, these benefits in recent times have emerged due to the use of new and better technologies. In some cases, the benefits have arisen due to leveraging existing technologies and using them in an innovative way. The item "faster development of product and services" cross-

Table 10. Factors for benefits of an agile information system.

Benefit of an Agile IS	Factor			
	1 (Technology Leverage)	2 (Strategic Benefits)	3 (Cost Savings)	4 (Top Performance)
Use of the latest technologies to avoid technology obsolescence	0.795			
Business process innovation through use of latest IS technologies	0.719			
Protection of IS and the organization from vendor induced risks (bankruptcy, etc.)	0.663			
Increased robustness of changes made to the IS	0.569			
Enhancement of IS capabilities	0.483			
Alignment of IS with the business process requirements at all times		0.719		
Use of IS as a strategic business tool		0.652		
Faster development of products and services	0.449	0.541		
Rapid change in business processes		0.488		
Increased financial benefits to the organization				
Effective information processing			0.822	
Efficient information processing			0.717	
Increase in efficiency and effectiveness of business processes supported by IS			0.525	
Rapid IS response to security threats like viruses and cyber attacks				0.726
Fast IS recovery from failures/outages				0.551
IS can meet the service level agreements (SLAs) for capacity and performance				0.542
Quick building of capacity for handling peak loads and/or sudden loads				0.428
IS changes are made in a timely fashion				

loaded onto this factor. Faster development of product and services may be another benefit of leveraging technologies and hence the loading of the item could be considered appropriate. It must be understood that the technology leverage factor deals with improving the enterprise through technology attributes such as improved flexibility and expertise. This is often a bottom up phenomenon. The second factor was labeled as "Strategic Benefits". The item "faster development of products and services" that loaded on this factor and cross-loaded

on the first factor may also be considered as a strategic benefit to the organization. The strategic benefits factor reflects a top down approach and provides guidance for all levels of the organization's managers. The third factor was labeled as "Cost Saving" since the items that loaded onto it primarily dealt with efficiency and effectiveness of information processing which would lead to cost savings and increase in revenues. The fourth factor was labeled as "Top Performance" and included rapid response to various situations and sustaining performance levels.

The only cross-loading was of "faster development of products and services" on two factors, both of which appear to be relevant. It may need to be further investigated.

Two of the items did not load on any factor. The first was "IS changes are made in a timely fashion". In the rating of the benefits, this particular item was consistently rated high. It deals with changes that are undertaken in a planned or proactive fashion and may just not be attributable to agility but other factors like good project management and may be more related to planning related attributes. In hindsight, the item is an obvious benefit of IS agility and may easily apply to more than one factor or all the four factors. It may need to be worded more specifically; in which case, it is more likely to load on the "Strategic Benefit" factor. The item loaded on to "Top Performance" factor with a loading of 0.305. The second item in question that did not load on to a factor was "increased financial benefits to the organization". This item had a near 0.4 (0.379) loading on "Strategic Benefit Factor" and greater than 0.3 loading on the "Cost Savings" and "Technology Leverage" factors. It is more of a higher order benefit as compared to others. In hindsight, this item sounds fairly generic and may be split into at least two or maybe three distinct items. First would be cost savings, second would be an increase in revenue due to leveraging of technology and third may be increase in revenue by successfully keeping up with changes in the marketplace. The item "faster development of product and services" may also be split into two items: one that deals with innovation in products and services and the second that deals with maintaining competitiveness through emulating competitors or making incremental changes. These suggestions may be explored in future research.

8. Limitations

There are some methodological limitations to this study which have alluded to earlier for example in the EFA section. Some items may need to be further refined to avoid cross-loadings and non-loading items in EFA. The response rate for the survey was 5.7% and though this response rate was considered acceptable for the purpose of this survey there is still room to improve the response rate. This could be done, for example, through collaboration with some special interest groups and research groups with an interest in the area of IS agility.

In view of the rapid evolvement of new paradigms like the cloud model and

machine to machine communication the issues and benefits may shift since, like all research such as this, this research represents the state at a particular point in time. The research may need to be continually refreshed to be more meaningful with the times.

9. Summary and Comments

The survey data provides support to the hypothesized benefits of an Agile IS. The top benefit of an agile IS was "rapid IS response to security threats like viruses and cyber-attacks" and the third most important benefit was "fast IS recovery from failures/outages". Thus IS agility may be present in some form in most of organizations in the IS especially in the recovery area.

These empirically supported benefits may provide the justification for investment in initiatives to increase the agility of an IS. Specifically, investments in areas that enhance sensing a change in real time [14], diagnosing a change in real-time [15], and selecting a response and executing a response in real-time [52] may be undertaken.

It is unarguable that the current IT industry has come to accept the requirement for agility in the IS. The industry approach though is somewhat fragmented along applications, databases, infrastructure and so forth and may lack a holistic framework in line with what has been proposed in this study. This is somewhat understandable given the complexity and distributed vendor driven nature of these new paradigms. The empirically-justified benefits from this study may provide support for an organization to invest in these initiatives through both capital and labor expenditures. Over a period of time with the benefits that have been established in this study and other new benefits, agile ISs will become a mainstream in organizations.

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