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REDUCING PERCEPTUAL DIFFERENCES IN END USERS: POTENTIAL AND POSSIBILITIES FOR CONTINUING TRAINING PROGRAMS

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ABSTRACT

Perceptions of two groups of end users were compared on importance of and satisfaction with support services provided by information technology (IT) personnel. Importance ratings of one group of users were significantly higher than the other group. Surprisingly, satisfaction ratings were virtually identical. In prior research, users who placed higher importance on IT support were less satisfied than the comparison group when those expectations were not met. Establishment of continuous training programs for end users is encouraged to reduce perceptual differences, improve end user satisfaction, job satisfaction for IT personnel, and meet organizational requirements.

INTRODUCTION

This research compares the perceptions of different groups of end users on two dimensions of information technology (IT) support.[1] One dimension is the level of importance of certain features (response time, follow through, etc.) associated with IT support. The second dimension is the users' reported level of satisfaction associated with these IT support features. If a particular feature is very important to the user it is expected that such user will not be satisfied unless his or her expectations are met.

Various aspects of end user satisfaction have been studied in prior research.[2] However, these issues continue to be important to researchers and to organizations. Indeed, Lee, Kim and Lee (1995) call for increased research into the personal and organizational impact of end user computing in an organizational context because of the use of end user computing as a "competitive weapon." To achieve competitive advantage organizations must ensure that IT support helps end users maximize use of information technology. The first step in designing effective IT support is to obtain an understanding of what end users believe are important services. Focusing resources on these IT support features can improve efficiency and satisfaction among end users. If IT support is able to meet end user needs in the initial contact, waiting time and callbacks can be reduced or eliminated.

Nevertheless, it is unlikely that all users have identical perceptions of IT support. Even within one organization, users are rarely homogeneous – they have different skills, use different software and hardware, and may have different expectations of what computers should be able to do. Shaw, Partidge and Ang (2003) referred to these differences as the user's technological frame of reference. They found that users reporting overall satisfaction with IT support were self-directed learners, viewed the computer's role as a "task completer" and typically used more complex applications. On the other hand, dissatisfied users were not self-directed learners, viewed the computer's role as a "task enhancer," and usually worked with less complex applications.

In the Shaw et al. (2003) study, IT personnel preferred to solve non-routine problems, displaying "little patience" with repetitive requests, and responding more readily to technical issue requests. This would imply that IT personnel are more responsive to users who use more complex applications and are more technologically sophisticated. Working with such users may provide greater professional job satisfaction for IT staff; however, it probably does not adequately address the overall needs of the organization.

To address the gap between individual and organizational needs, a separate function of IT support could be created to provide continuous training for users. In most organizations the skills and knowledge of users varies widely depending on the education, training and job function of the users. Improving the technological competency of all users could reduce the need for routine requests, allowing IT support personnel to focus on the more complex issues. This would improve end user satisfaction with IT support, job satisfaction for IT personnel, as well as benefit the organization.

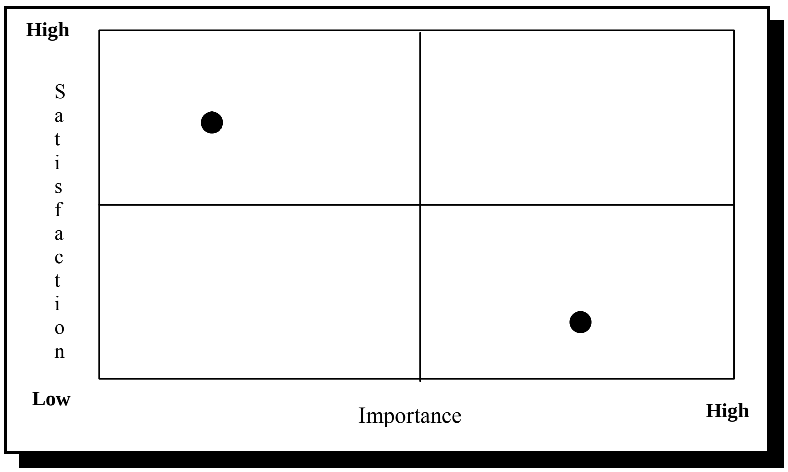
HYPOTHESIS DEVELOPMENT

A user's technological frame of reference may be molded by a number of personal and environmental factors. Because of the technical nature of their education and the early use of technology in their professional careers, accountants may be more familiar with information technology and more comfortable using a variety of software packages. In terms of functional responsibilities accountants utilize information technology to capture, record, and report financial information that is used by management and other stakeholders. Jiang et al. (2000) suggested that end users employed in various functional areas of organizations may have different perceptions of the importance of, and performance of, certain information technology support. We postulate that because of their education, training and functional responsibilities, accountants may have unique perceptions of the importance of certain IT services. Hypothesis H1 compares the importance accountant end users place on IT services with those of other end users. It is stated in the alternative form below:

H1: There is a difference in perceived importance of information technology services between accountant end users and other end users.

In their development of a technological frame of reference, Shaw et al. (2003) found that users who expected less from the computer were more easily satisfied, and users with higher expectations were more easily dissatisfied. It could be argued that a similar situation exists for users who place low (high) importance on IT support: those who place low importance on IT support would be easier to satisfy, while users who place high importance would be less satisfied with IT support. This is depicted graphically in Figure 1.

Figure 1. Proposed model



Following the results of Shaw et al. (2003), we expect that users who place high importance on IT support will be less satisfied than users who place low importance on IT support. Based on our previous argument that accountants will have a different perception of importance of IT support, we anticipate their satisfaction level will be different than the non-accountant group. Stated in the alternative form, Hypothesis 2 tests this proposal as follows:

H2: There is a difference in perceived satisfaction of information technology services between accountant end users and other end users.

Survey Instrument

A questionnaire was used to measure two dimensions of IT support. Users were requested to rate the importance of 18 items on a 5-point Likert-type scale, from not important (1) to very important (5). The second portion of the survey contained identical items, but asked users how satisfied they were with support they received. A similar 5-point scale was used, ranging from not satisfied to very satisfied.

Comparing the importance and satisfaction on identical measurement items can help assess satisfaction (Davis, Misra and Van Auken 2002, p. 219). For example:

1. It has the potential to provide more insight than a one-dimensional satisfaction survey that simply asks users whether they are satisfied with IT support. If they are satisfied with one aspect of IT support that is not very important to them, but not satisfied with another aspect that is important, one might infer that users would be less satisfied with IT support, in general.
2. It can be used for a baseline for continuous improvement for the IT function. By identifying initial gaps between importance and satisfaction, management can direct resources to issues that warrant improvement.
3. It allows for development of longitudinal trends in IT support. End users' requirements change with technological advances and organizational innovation. By administering the importance/satisfaction survey on a periodic (annual, bi-annual) basis, the organization can track the changes and alter IT support accordingly.
4. Measuring two dimensions using the same questions provides a quantitative basis for analysis, a scientific approach that can be validated.

Measurement Items

The survey consisted of two sections: the first section contained questions designed to measure the importance of quality, interpersonal skills, dependability, teamwork or leadership, and responsiveness. The second section asked users whether they were satisfied with IT support on those same items. Asking questions that measure different perceptions on identical issues allows analysis of a positive (negative) gap; if the difference is positive, the user's satisfaction rating is greater than his or her importance rating. Conversely, if the difference is negative, the user is suggesting that important IT issues are not being adequately addressed. For example, if users rated "follow through" as very important, but indicated they were only somewhat satisfied with IT's performance, a negative gap would result. A complete list of the measurement items is provided in the Results section.

RESEARCH METHODOLOGY

Two hundred twenty surveys were hand delivered to local business enterprises in the southern region of the U.S. The surveys were accompanied by a cover letter and a return envelope. The cover letter requested that management distribute the survey forms to accountant or non-accountant end users and assured the respondents of the confidentiality of their answers. No personal identifying information was requested on the questionnaire. The accountant end users were employed in a variety of accounting positions in the organizations. The non-accountant end users were employed in positions such as personnel, marketing and management. Approximately two weeks after initially distributing the surveys, phone calls were made to management to assure that the designated employees had completed the survey. One hundred ten accountant end users and 93 other end users completed and returned the survey.

A simple comparative ranking of the survey questions was performed by listing each group's mean score for all questions and rearranging one column (accountants) from 1 (highest mean) to 18 (lowest mean). This ranking allows visual comparison of the groups of the most important IT support features. Although this is not a statistical test, it provides important information regarding differences (and similarities) between the two groups.

Mean scores of Importance and of Satisfaction were created using these same 18 items. T-tests were used to compare the means between the groups to test Hypotheses 1 and 2. Item rankings and results of hypothesis testing are discussed in the following section.

RESULTS

Demographics of the respondents are presented in Table 1. As shown, more women than men are represented in the accounting profession (male=48 or 44%, female=57 or 51%, not reported=5 or 5%), and more men are employed in the other-user category (male=56 or 60%, female=37 or 40%). The average of participants' ages was 43 for accountants and 38 for the other end users. The industry breakdown also is presented, indicating that most respondents were employed in manufacturing, with service and the public sector following closely.

Table 1. Descriptive Statistics

Gender:	Accountant Users		Other Users		Industry:	
M	48	44%	56	60%	Manufacturing	60
F	57	51%	37	40%	Service	54
Not reported	5	5%	-	-	Public Sector	45
Totals	110	100%	93	100%	Retail & Whls	24
					Banking	16
Age:	Accountants	Others			Other	4
Max	63	61			Total	203
Min	22	20				
Average	43	38				
Not reported	7	2				

The survey was modified from one developed and validated by Jiang, et al. (2000) to compare satisfaction perceptions of end users and information systems personnel. To ensure data from the current study remain appropriate for the model, we conducted a confirmatory factor analysis and found that items from two of the constructs loaded on the same factor. It is understandable that “follow through” (dependability construct) is quite similar to “apply preventative/permanent solutions” or “stick with user’s problem until resolved” (responsiveness construct). The new factor was revised to include the measurement items from both constructs and was renamed Dependability and Responsiveness.

Tests for internal reliability and goodness-of-fit were also conducted. Internal reliability, which refers to the extent to which the survey instrument is free from measurement error, was verified using Cronbach’s alpha. As presented in Table 2, Cronbach’s alpha values range from .70 to .89, considered to be acceptable levels of internal reliability. Goodness-of-fit statistics include the Goodness of Fit Index (GFI), Root Mean Squared Residual (RMR), Bentler’s Comparative Fit Index, and Bollen’s Non-normed Index. They are presented in Table 2, along with normally accepted values.

Table 2. Construct Reliability and Goodness-of Fit Indices

Construct		Cronbach Alpha
Quality		0.70
Interpersonal Skills		0.81
Dependability and Responsiveness		0.89
Teamwork and Leadership		0.82
Goodness of Fit Indices	Current Study	Acceptable Values
Goodness of Fit Index (GFI)	0.92	>= 0.90
Root Mean Square Residual (RMR)	0.03	<= 0.05
Bentler's Comparative Fit Index	0.95	>= 0.90
Bollen's Non-normed Index	0.96	>= 0.90
n = 203		

Simple item rankings by each group are presented in Table 3. The left column depicts accountant users that have been ranked from 1 – 18. The right column shows the comparative rankings of the other end users. It is easy to see that, for the most part, the rankings were relatively consistent between the groups. For example, a timely response was ranked very important by both groups, #1 for accountants and #2 for other users. Only three questions were rated substantially different: “sticking with the problem” was ranked #1 by non-accountant users, although it only ranked #8 for the accountants. It is possible that other users felt somewhat abandoned prior to satisfactory resolution of their issues, while it was not so for the accountants. “Follow through” was ranked much higher for other users (#5) than accountants (#11). This seems related to “sticking with the problem,” which was ranked higher by other users, so this result is not unexpected. Interestingly, another difference is the importance for IT personnel to "understand and follow procedures and instructions." This was ranked #2 for accountants, but #8 for other users. Perhaps this is because the accounting function usually includes a series of steps or established procedures – accountants might expect IT personnel to work in a similar fashion.

Table 3. Simple Rankings of Measurement Items

Item	Accountant Users	Other Users
Respond in timely fashion	1	2
Understand and follow applicable procedures and instructions	2	8
Implement changes without errors or rework	3	3
Make ideas understood	4	4
Make an effort to listen to and understand the users	5	6
Apply preventative or permanent solutions to problems	6	7
Stick with the problem until it is resolved	7	1
Meet commitments	8	9
Show respect; build cooperative relationships; facilitate dialog	9	10
Recommend ways to be more effective and efficient	10	11
Follow through	11	5
Use tools and standards properly and consistently	12	12
Anticipate user's needs; giving high priority to user satisfaction	13	13
Willingness/ability to accept new assignments	14	14
Lead a team toward its stated objectives	15	15
Coach, instruct, and/or support other IT personnel	16	16
Contribute actively to project and non-project related efforts	17	18
Keep users informed about technologies related to user's job (hardware, software, books)	18	17

Gap Analysis

Gap analysis has been used in prior studies to compare the individual's perception of importance of an activity with his or her satisfaction with the completion of that activity (c.f. Davis, et al. 2002). As described earlier, a positive gap exists when the satisfaction score exceeds the score for importance on the same measurement item. In the current study, only one construct resulted in a positive gap: the other user group rated satisfaction of teamwork and leadership higher than importance. Teamwork and leadership also had the lowest mean of any of the constructs. For both groups, importance of all other constructs was ranked higher than satisfaction, resulting in negative gaps. Table 4 presents the importance and satisfaction scores, along with the gaps for each item.

Table 4. Gap Analysis

	Quality	Interpersonal Skills	Dependability/ Responsiveness	Teamwork/ Leadership
Accountants:				
Importance	4.57	4.59	4.45	4.23
Satisfaction	4.06	4.20	4.03	3.86
Gap	-0.51	-0.39	-0.42	-0.37
Other Users:				
Importance	4.32	4.39	4.27	3.87
Satisfaction	4.15	4.13	4.18	4.09
Gap	-0.17	-0.26	-0.09	0.22
n = 203				

Tests of hypotheses

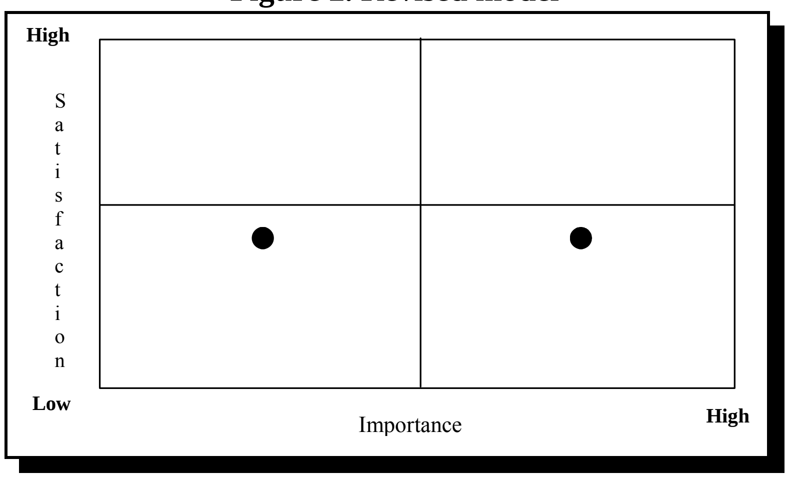
An independent-samples t-test was used to determine whether there were reliable differences of mean importance scores between the two groups. As presented in Table 5, the accountants placed greater importance on the IT support features (Mean of 4.46, S.D. of .42) than the other end users (Mean of 4.23, S.D. of .49). The data support Hypothesis 1 at $p < 0.001$.

Table 5. Results of Hypothesis Tests

		Accountant Users		Other Users		p
H1:		Means	S.D.	Means	S.D.	
	Importance	4.46	0.42	4.23	0.49	< 0.001
H2:						
	Satisfaction	4.06	0.65	4.14	0.75	n/s
n = 203						

To assess the possible impact of these differences, the standardized effect size was calculated by dividing the mean difference by the average standard deviations. In the current study, the standardized effect size is .50, considered to be a medium effect according to Cohen's (1988) guidelines (.2 for a small effect, .5 as medium, and .8 as large).[3] A medium effect can be relatively easy to visualize when describing tangible evidence, such as an algae bloom in an otherwise crystal clear mountain lake. It becomes more difficult when applied to differences in perceptions of importance of IT support. Nevertheless, that does not mean the effect is inconsequential or nonexistent. Such perceptual differences may have an overall impact on organizational resources. It was expected that users who placed higher importance on attributes of IT support would be less satisfied than those who seemed less concerned (by placing less importance on the measurement items). Hypothesis 2 was tested using an independent-samples t-test. The results indicate that although the accountant users were less satisfied, there was only a very small difference, which was not statistically significant, as shown in Table 5. This leads to the revised illustration shown in Figure 2, which suggests that regardless of the importance attributed to IT support, users were almost equally satisfied.

Figure 2. Revised model



DISCUSSION

As predicted, the accountants' perspective on the importance on information technology services was distinctly different from other end users. Our research included responses from a large cross section of business entities; therefore, organizational climate is not a factor in explaining these differences. It is more likely explained by the psychological and subunit (departmental) climate in which accountants work (Glick 1985). Accountants begin their formal education using technology to solve problems and assemble financial information. Upon graduation, they become professionals who operate in an environment where technology is utilized extensively and they are likely to be technologically proficient. As sophisticated end users, it is expected they would place greater importance on the delivery of information technology services.

Nonetheless, it is unclear why they are not less satisfied than the other user group that did not place as much importance on technology support. It is possible that accountants are more aware of the difficulties encountered in installing and supporting software. Increased experience makes one sensitive to the possibilities of software programming deficiencies, equipment incompatibilities, and other possible problems involved in getting an application to run properly. Because of their experience, accountants may have more realistic expectations as to the ability of IT personnel to solve problems.

In addition to the psychological climate that accountants bring to the work place, personality traits may also play a role in explaining the differences between accountants and non-accountants. Day and Silverman (1989) found significant correlations between some personality traits of accountants and certain job performance dimensions. Using a well-established personality test, the study found that work orientation, degree of ascendancy, and degree and quality of interpersonal orientation were significantly correlated with the job performance dimensions of 1) potential for success, 2) technical ability, 3) client relations, and 4) cooperation with other personnel.[4] Although cognitive ability explains much of the reasoning in how individuals select a career in accounting, personality traits appear to be a key factor as well.

It is important to examine how the differences between the two groups potentially impact the organization. There is much research indicating that user involvement in information systems design improves user satisfaction with the system (c.f., Hunton and Beeler 1997; Baroudi, Olson, Ives and Blake 1986, and others). This same principle should apply to information technology support. When users and systems personnel work together during installation and support of new software it would seem likely that they would have a greater understanding of the benefits of the software and the deficiencies that must be overcome. Satisfaction with performance should improve when perceptions of importance are more closely aligned between IT personnel and end users.

Technology skill levels among end users in most organizations are uneven, at best. To a large extent, the end user's technological frame of reference influences the perception of the value of IT support services and how they can best be utilized. End users who have minimal technological experience are likely to expect IT support to solve all problems and make the system work. Experienced end users will be more realistic as to the ability of IT personnel to solve problems and will be better prepared to maximize available support services.

This research supports the notion of equalizing users' technological frames of reference. Certain end users might benefit from a structured educational/support function as described in Huang (2002).[5] General technology training could be developed for those who possess minimal technical skills. Once they have achieved the minimum level of general application skills, additional education could be introduced for specific business applications. Over time, all end users could be brought to an optimum level of competency, whereby the IT support function would provide maximum benefit to the end users and the organization. Such an educational support system could redeploy IT support to deal with more complex issues and increase the efficiency of the entire organization.

LIMITATIONS AND FUTURE RESEARCH

The use of gap analysis in examining the differences between importance and satisfaction has been criticized, because there is not necessarily a linear relationship between the two constructs (c.f. Anderson and Fornell 1994; Babakus and Boller 1992; and others). Although this is a valid criticism, the argument relates more to those relationships that are positive or zero. In the current study, all of the relationships are negative with the exception of the teamwork/leadership construct.

To develop this line of research on end user satisfaction with information technology support, future studies might incorporate an assessment of personality traits of different groups of users. The Jackson Personality Research Form is a well-recognized personality trait assessment instrument that would be suitable for this purpose.

ENDNOTES

[1] IT support activities include, but are not limited to: diagnosing and solving problems; designing and developing software; installing, debugging, testing, modifying, correcting, and maintaining hardware or software; repairing hardware; training users; answering questions; and keeping users informed

[2] For a meta-analysis, see Mahmood, Burn, Leopoldo and Jacquez (2000).

[3] (4.46 - 4.23)/((.42 + .49)/2) = .50

[4] The Jackson Personality Research Form – Form E was used. Work orientation was significantly correlated with Technical and Client Relations; Ascendancy was correlated with Potential, Technical, and Cooperation; Interpersonal was correlated with Potential, Technical, Client Relations, and Cooperation. Other significant correlations, not of interest in the current study, are also reported (Day and Silverman 1989, p. 31).

[5] Huang (2002) describes a three-tier IT training strategy that includes initial formal training in general technology to help establish a general level of technology proficiency, followed by specific training on software applications, and "just-in-time" training to help employees build on their fluency.

REFERENCES

Anderson, E. & Fornell, C. (1994). A customer satisfaction research prospectus. In R. T. Rust & R. L. Oliver (eds.), *Service Quality: New directions in theory and practice.* 241-268. Thousand Oaks, CA. Sage Publishing.

Babakus, E. & Boller, G. W. (1992). An empirical assessment of the SERVQUAL scale. *Journal of Business Research*. 24, 253-268.

Baroudi, J., Olson, M., Ives, B. & Davis, G. (1986) An empirical study of the impact of user involvement on system usage and information satisfaction. *Communications of the ACM*, 29(3), 232-239.

Cohen, J. (1988), *Statistical Power Analysis for the Behavioral Sciences*, 2nd edition. Hillsdale, NJ: Erlbaum.

Davis, R., Misra, S. & Van Auken, S. (2002), A gap analysis to marketing curriculum assessment: A study of skills and knowledge. *Journal of Marketing Education,* 24(3), 218-224.

Day, D. V. & Silverman, S. B. (1989). Personality and job performance: Evidence of incremental validity. *Personnel Psychology.* 42, 25-36.

Glick, W. H. (1985). Conceptualizing and measuring organizational and psychological climate: Pitfalls in multilevel research. *Academy of Management Review.* 10(3), 601-616.

Huang, A. H. (2002). A three-tier technology training strategy in a dynamic business environment. *Journal of End User Computing*, 14(2), 30-39.

Hunton, J.& Beeler, J. (1997). Effects of user participation in systems development. *MIS Quarterly,* 21(4): 359-388.

Jiang, J., Sobol, M. & Klein, G. (2000). Performance ratings and importance of performance measures for IS staff: The different perceptions of IS users and IS staff. *IEEE Transactions on Engineering Management,* 47(4), 424-434.

Lee, S., Kim, Y. & Lee, J. (1995). An empirical study of the relationships among end-user information systems acceptance, training, and effectiveness. *Journal of Management Information Systems.* 12(2), 189-202.

Mahmood, M., Burn, J., Leopoldo, A. & Jacquez, C. (2000). Variables affecting information technology end-user satisfaction: A meta-analysis of the empirical literature. *International Journal of Human-Computer Studies,* 52, 751-771.

Shaw, N., Lee-Partidge, J. & Ang, J.S.K. (2003), Understanding the hidden dissatisfaction of users toward end-user computing. *Journal of End User Computing*, 15(2), 1-22.

VALUE CHAIN MANAGEMENT IN ONLINE REVERSE AUCTION: TOWARDS STRATEGIC AND OPERATIONAL EXCELLENCE

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ABSTRACT

This paper examines the impacts of e-business strategies on existing value chain management settings and the implications for change based on the strategic and operational excellence of those strategies. Reverse auctions as a mean of e-procurement is analyzed toward the concepts of value chain management. Further, the paper identifies the fundamental necessity and relationship of value chain management for the successful conduction and implementation of e-business strategies.

Keywords: Value Chain, Reverse Auctions, e-Business, e-Procurement

INTRODUCTION

The concepts of Supply Chain Management have been around for quite a while and have already shown their possible positive impact on the performance of a company. In recent years the stakes of this game have changed. It is no longer considered being a field of innovative competitive advantage over the competition, but a necessity to stay profitable and competitive. Most companies have realized that only close collaboration with all involved partners can produce the kind of speed and reaction time to customer demands that are needed in today's business world.

Another shift in the focus took place in the past; the first steps in Supply Chain Management were mainly concerned about the integration of suppliers to ease the operations for their own company. Some companies even only focused on new strategies for procurement to squeeze the profits from their suppliers. But the slow move to put the customer in the center of all operations brought many firms to the point where they realized that only cooperation could deliver the desired results. Supply Chain Management changed to Demand Chain Management by examining the downstream components of the whole chain; the part directed towards the customer, but this focus is too narrow, so the Value Chain Management finally evolved. Value Chains are concerned about the whole chain, from the raw material supplier to the end customer, and set the value or the satisfaction perceived by the end customer in the center of attention.

The relationship with e-business can be a very close one; both concepts can greatly gain from the application of the other concept. Only a working value chain management can offer a company the benefits from e-business, especially in e-commerce, to their fullest extend and e-business can boost the cooperation in the value chain to improve the performance of the whole chain.

SUPPLY AND VALUE CHAIN MANAGEMENT

The modification of the supply chain management concept is to expand the focus and include more partners, especially in downstream direction that further increased the benefits and importance of supply chain management. This was another step towards managing the whole chain from the raw material produced by the supplier to the end customer and building a network or chain of partners working jointly together to achieve better customer satisfaction. Demand chain management brought some new concepts and ideas into consideration that partly replaced the concepts of supply chain management in a narrow sense. If one takes this narrow definition of the supply chain that is concerned about the smooth operations with partners mainly upstream in the chain, the system can be defined as a push-system while demand chain management is a pull-system. (Vakharia, 2002)

This paper will not distinguish between demand and supply chain management and see them as different forms of the same idea. Every company should always consider the whole value chain from the beginning to the end and the demand chain for one company is the supply chain for a company's further downstream. Therefore the whole chain has to decide whether to use a 'push-systems', based on demand forecast and assumed consumption, or a 'pull-systems', based on the real consumption and demand of the end customer instead of forecast. The value chain also pushes the scope further by not only focusing on the smooth flow of goods and information and the small cooperation with the direct neighbors in the chain. It should also look at the operation of the whole chain and assessing the performance based on the ultimate measurement, customer satisfaction, and changing and improving the overall way of performing the related tasks. The, probably, easiest distinction between a supply chain and a value chain is the focus. Rash (2001) stated that supply chain management is mainly concerned about the manufacturing part of operations and thereby the flow of goods and information needed to process the goods, while value chain management also includes the general flow of information.

The 'pull-systems' should be implemented in highly responsive value chains that are able to quickly respond to customer demand and are faced with a highly volatile environment that would produce too many mistakes in forecasting customer demand. These chains need flexible operations and, more than anything else, the ability to share information about the real demand without noise or pollution and in a very brief period of time. Using e-business applications and the Internet to exchange data in real-time has helped companies using this approach to value chain management.

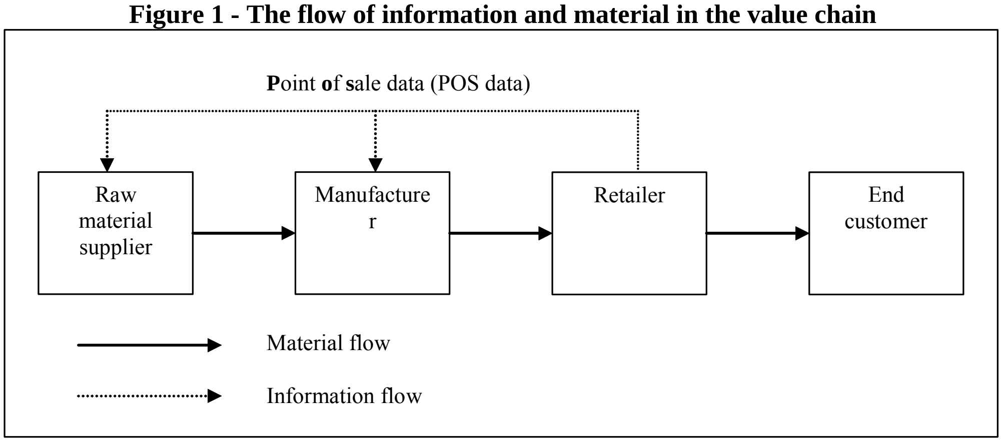
THE INFLUENCE OF E-BUSINESS TO VALUE CHAIN MANAGEMENT

To achieve excellence in the daily operations in the electronically connected world a company has to master both, e-business and value chain management. The advent of electronic data interchange and later of e-business processes introduced infinite possibility for companies to really manage the whole value chain. (Taninecz, 2000; Talurri et al, 2007) The use of e-business can generally be divided into three main parts; a) sharing of information, b) cooperation, and, c) conducting of transactions.

SHARING INFORMATION

One example for the power of shared information is the possibility to share and exchanging POS (point of sale) data with the entire value chain and thereby enabling the involved upstream operations to increase the accuracy of the production schedule and helping to level the signals given to the suppliers. (Bandyopadhyay, et al, 2005) This reduced noise in the demand signal towards the upstream end of the chain, thus reduces the negative consequences of the so called “Bull Whip Effect”, that refers to the increased volatility of demand when procurement decision are taken based on local information and the application of batch-and-queue systems. Every company sends a more distorted signal about the demand to the suppliers, when using batch-and-queue, the amount purchased will be infrequent and very volatile, and this effect usually increases with every step upstream. This leads to unnecessary overcapacity for the supplier, as the demand peaks have to be met while the utilization drops in between the infrequent orders. Sharing the actual demand of the end customer with every involved party as shown in Figure 1 allows to level the amount purchased and produced based on this more accurate number, even when the value chain does not implement the pull-systems as mentioned earlier. Sharing of information can also include informal information about evolving marketing opportunities or changes in the business environment.

Figure 1 - The flow of information and material in the value chain



Cooperation in the value chain

The implementation of e-business technology is not limited to information sharing. Due to the fast pace of a changing environment, the companies have to make adjustment to their operations faster than ever before. Since the first economic revolution with the advent of mass production (Essig and Arnold, 2001) companies are able to achieve economies of scale and consequently lower production cost by concentrating on their core competencies, (Franke, 2003) and creates an even stronger pressure to cooperate with the other companies in the value chain. A single company can no longer meet the customer demand and the benefits of value chain management increase the competition. Franke (2003) suggests forming virtual web organizations where a net-broker chooses the companies based on the customer needs from a pool of firms to form a value chain tailored to the demand. Because the corporations are limited to their field of core competencies, they need to be part of several value chains with different partners. The necessary framework is set when the companies enter the pool; this addresses the need to have a stable environment and especially trust to create a relationship between two or more firms and the needed easiness to conduct business with the changing partners.

Forming trust in the value chain

Trust is usually one of the biggest obstacles to overcome in the endeavor to form a partnership and ultimately to jointly manage the value chain. In the past, trust was created by a long term business relationship, and cooperation could be slowly increased, but time is luxury in today's business world. Therefore companies have to become more flexible and open to partnership, as the competitive advantages of the past are a necessity of the present time even without forming the virtual web organization according to Franke; but there is a pressure for corporations to create partnerships with their suppliers and customers to form a value chain. E-business technology can help to ease the cooperation within the chain and together with a good framework help to create trust and enhance productivity of all partners. This holds especially true in the fields of engineering and research & development (Taninecz, 2000).

Collaboration along the value chain

One important prerequisite of collaboration is the ability and willingness to see the whole value chain and understand the impact of any kind of change on the overall performance. Measuring the effectiveness of changes using the end customer satisfaction and the positive or negative impacts on operations of partners helps to achieve a superior implementation of the concepts of value chain management. This leads to higher end customer satisfaction and more success in the business. Also the use of e-business applications has to be seen as measuring the influence on the whole chain. Craighead and Shaw (2003) have develop a simple model to assess the impact based on a matrix with four fields, including the creation or destruction of value in the own company and the effected partners. According to their framework, every implementation of new information technology has to be tested on the overall creation of value and the roadmap for the future to get to the stage where value is created both in the implementing company and their partners. This might include changes in the application or the underlying business processes within the value chain to get the full benefits of e-business information technology.

The possible starting points for the initiative to cooperate can be manifold and the contribution of technology offers many solutions. The interconnection between suppliers and customers using e-business can affect every department. The engineering department and the efforts for research and development can achieve cost savings through collaboration. Especially the long-term savings are very appealing when joint product development makes the production for all involved parties more streamlined and cheaper.

A second field where collaboration leads to a significant smoothing of the operations is to jointly forecast customer demand and the available capacities for production and transportation. Most theoretical approaches to value chain management recognizes the value of leveling production, especially the theory of constraints urges companies to produce as much as the bottleneck is able to handle. Initially this theory was developed for the implementation in a single company but it can easily be expanded to a whole value chain. The biggest challenge is to precisely determine the bottleneck and predict its future capacity. (Rippenhagen, 2002)

All these approaches have to be taken by companies not only to lower the price of the product but also to shorten order cycle time and increase the level of customer service. Briant (2000b) concluded that expertise and service are more important than the factors like price or product line.

Transaction processing and e-procurement

E-business processes have the biggest impact on the ubiquitous of business transaction processing through EDI, Open EDI, and the extranets. Orders can be sent and accepted within minutes instead of probably days using postal mail or hours using a fax machine. But speed is not the only advantage of online transaction; the reduction of errors based on the human nature is also an important factor to shift order processing. (Briant, 2000a) In the past every order had to be written by a human on the customer side and it had to be entered by a human on the supplier side, naturally this was a possible source of data errors. Today partners can communicate automatically using the same electronic format helping both companies to integrate their production system into the procurement process.

The most outstanding and most important factor for every industry or business-to-business (B2B) exchanges remains the reduction of cost. This argument is twofold and touches the core of this paper. First, the necessary transaction cost to process the order and the time and money spend to search for the best offer can be significantly decreased by the use of online procurement or at least the use of electronic data interchange (EDI) with the existing supplier base. The easier access to information about the partner can also address the asymmetric allocation of information that usually leads to uncertainty for the buyer. These concerns about the incomplete information and strategies to hedge the risk using clauses in the contracts can be partly dissolved with more information. Particularly when using online marketplaces and standardized contracts and transaction formats the gain in time saved for negotiation and closing the deal, as well as, the time saved to collect the data about the supplier is even more increased. The supplier is also able to save on transaction costs when the order is processed using electronic connections integrated to the software of the firm. This advantage is generally undisputed and aligns with the firm's strategic commitment in cost reduction and towards operational excellence.

The second aspect of the possible cost savings is more ambiguous. From the short-term perspective, online exchanges and marketplaces offer infinite possibilities either to the suppliers or the customers, mainly based on the fact which side has greater power. On the first sight it seems to be heavenly to be able to buy or sell to the whole world, all of a sudden the supplier base is huge and the markets are promising, but people start to realize that this fairy tale has a drawback. Even though the cost savings of the purchases are tremendous, the volatility of the supplier basis is very costly for the company on the long run. As mentioned in the two prior sections, value chain management has to rely on the ability to share and exchange information and collaborate within the value chain. The realized cost savings of this strategy are not obvious for the purchasing activities, but the company as a whole can extremely benefit from the long-term relationship. Taking the holistic view by including financial and quality measures that offer the companies smooth production processes and increasing cost on product development and production.

ONLINE REVERSE AUCTIONS AS A FORM OF E-PROCUREMENT

The use of reverse auctions as a procurement tool has been discussed very controversially. While in normal auctions the buyers keep offering a higher price to buy the product. On the other hand, reverse auctions, is designed so that sellers keep offering a lower selling price to get the contract with the buyer. Obviously this is only applicable when the buyer has enough power and several suppliers are willing to compete for the business. Additionally the buyer has to find a way to qualify the supplier to the quality system and requirements of the buyer such as the RFQ (Teich, et al, 2006), to compare the bids. Only if all the sellers meet the minimum requirements, the process and bought product appears to be useful.

In reverse auctions, the savings on the cost per unit are usually impressive for the buyer. Many suppliers condemn the use of reverse auctions to squeeze their margins and destroy long-term relationships with their customers. According to Hannon (2003), some advantages are unchallenged; online reverse auctions make the bidding process much faster in comparison to the old days when this type of bidding process was conducted via mail. Now the use of real-time auction software enables the participants to complete the process within hours including the award of the resulting contract. Secondly, the business is open to more companies, thus offering suppliers the chance to win new contracts and new customers. This argument is similar to the general argument of e-commerce that it opens new markets and businesses for the company. And that is true in the case of online reverse auctions when the auction is announced clearly enough by the buyer to attract companies that usually did not take part in the normal bidding process. Other advantages for the supplier can include lower marketing and sales costs, faster reaction time and improved feedback on the offer. Emiliani (2000) stated that another advantage is greater information for the buyer, even if the company is not willing to bid aggressively, the information about the market price and the bidding behavior of competitors has value for the company. This can be used as an indicator about the competitiveness of the operations and the offered price.

The use of online reverse auctions is spreading due to the advent of cheaper and easier software packages that enable even small firms to start reverse auctions. Hannon (2003) studied has shown that 35% of the companies with more than $100 millions to spend use online reverse auctions tools. Gartner Group has reported that the use of software has reached $13 billion in 2007 and will reach $20 billion by 2012.

Useful formats of reverse auctions

Types of auction that can be used include the English auction, single and multiple round sealed bids, aka the Vickery auction. (Talluri and Ragatz, 2004) One could also consider a reverse Dutch auction that has a possibility for an online reverse auction.

The English auction is what is commonly referred to as an auction where the bidders make their bids in real-time apparent to all participants of the auction until either a defined period of time is running out or only the highest bidder is left; in the case of reverse auctions until the lowest bidder is left. This procedure generally leads to aggressive bidding and thereby more favorable outcomes for the auctioneer. A possible drawback can be the possibility of collusion or suppliers' concerns about revealing the price.

Single and multi round sealed bids are characterized by the fact that the participants do not know the bids of the other companies. The single round version ends with this one bid while the companies are given the chance to lower the price after each round because the lowest price is announced when the multi round method is used. This procedure is widely used for the bidding process of construction projects or in some form for the procurement of goods in the industry when offers are collected. The two main differences to an online English auction are that the bids cannot be seen by the competitors and that there is no real time bidding process but all bids must be submitted prior to a certain deadline. Therefore, this process is not as competitive as the English auction.

A modification of the sealed bid auction was developed by Vickrey, who observed that the outcome of an English auction be obtained in a sealed bid auction when the winner is awarded the underlying for the price of the second highest/lowest bid. Milgrom (1989) stated that this procedure is supposed to motivate the bidder to name the price they are truly willing to accept, as the winner will be awarded the underlying for a price up to his bid, if he is the highest bidder. The achieved price is therefore closer to the market price as at least two participants would be willing to accept the price.

The normal Dutch auction is to some extend the opposite of the English auction. In a Dutch auction the auctioneer starts with a very high price and keeps lowering the price until one participant agrees, then the auction immediately ends. The behavior of the bidders is influenced by their predictions about the behavior of the competitors. Therefore every participant will probably end the auction at the highest price he is willing to accept, leading to the same price as in a single round sealed bid auction. (Milgrom, 1989) A reverse Dutch auction would obviously start at a low price and the auctioneer would keep increasing the price.

The bidders are price-takers in the English auction and the Vickrey auction as the price is also dependent on the behavior and the bidding of the other participants. This is obvious for the Vickrey procedure but also as the winning price in the English auction will probably be different from the maximum/minimum that the bidder was willing to offer. The difference will be smaller when more bidders participate and the closer the maximum/minimum prices are.

Theoretical literature has proven that the outcome and price is equal using all forms, when the bidders are risk-neutral, have independent valuations about the price they are willing to accept and only one unit is sold. (Talluri and Ragatz, 2004)

Milgrom (1989) stated that if the demand is more than one unit and the actual demand is a function of the price, auctions where the price is determined by the winner's price instead of the second bid will lead to lower prices and the quantity sold is higher. Interestingly the profit for the seller and the buyer will also be higher using these first-bid auctions. Another interesting fact is that the price in an open auction is independent from the fact whether the demand is fixed or variable while the price will be lower for variable demand in a sealed bid auction. (Hansen, 1988) This can explain the fact that first-bid auctions are more common in industrial procurement decision, especially the sealed bid auctions rather than the Dutch auction.

On the other hand it can be shown that if the amount of units is defined in advance, the value or cost associated by all bidders is no longer independent as the market value can be estimated. In this setting the resulting prices for second bids are likely to favor the buyer/customer as the bidder behavior and the price is also dependent on the behavior of the other participants. This will decrease the price in a reverse auction and thereby shift the profits to the customer. (Milgrom, 1989) This gives a possible explanation why English auctions are widely used for auctions where the auctioneer is the seller of clearly specified goods.

Effective set-up for the auction

The actual setup of the auction can also influence the outcome. Especially the applied rules and the number of participants are important questions to answer before setting up the actual online auction. The number of invited suppliers should be limited to qualified suppliers that are able to guarantee a certain set of standards for quality, delivery, lead time and other operational requirements. The actual recommended number differs in the literature; Emiliani (2000) suggest that in order to have 10 to 20 suppliers bidding, the number of invited companies can be as high as 50 to 60 firms, while Talluri and Ragatz (2004) only set a lower limit of four or five suppliers to ensure a competitive bidding process.

From the point of view of value chain management the number of possible suppliers should be lower. This is the result of the strategic product positioning for the firm and the perceived value of branding to the customer. Furthermore, the integration and cooperation of the value chain require commitment and familiarity between the involved companies. Commodities or products that do not have a high value for the operations of the value chain can of course include a bigger number of possible suppliers as the switching costs and the interconnection between the buyer and the seller is less complicated.

The question of applied rules is a delicate topic. As the customer usually has more power in the industries where reverse online auctions are used, the rules usually favors the buyer, therefore a code of business rules has to be developed to ensure the fairness of the auction. (Herbert, 2003) The principles for business developed by the Caux round table (Caux, 2001) are a starting point for online reverse auctions as well, but are typically not yet introduced. (Emiliani and Stec, 2002b) Providers of online auction tools normally offer a set of rules ensured by the software. Part of the rules includes the process of how to factor in aspects of quality and performance into the bidding process if these are not on the same level for all participants. On the other hand, in the study of reverse auctions with non-competitive contracts, Engelbrecht-Wiggans and Katok (2006) indicated that "one of the goals of procurement is to establish a competitive price while affording the buyer some flexibility in selecting the suppliers to deal with. Reverse auctions do not have this flexibility, because it is the auction rules and not the buyer that determines the winner. In practice, however, hybrid mechanisms that remove some suppliers and a corresponding amount of demand from the auction market are quite common." (p.581)

Talluri and Ragatz (2004) have shown an example of how to determine the winner of the bidding by including several attributes like price, quality and delivery. These auctions offer the possibility to assess the biddings based on more information than solely on the one-dimensional focus on the price that is often criticized by the invited suppliers. This approach needs more preparation for the customer as the value of each factor or attribute has to be determined and the weights should be made public to ensure a fair bidding process. When using a real time auction like the English auction, there needs to be tool to calculate the score in regard to the weights and to instantly show the lowest/highest bid. The winner of a sealed auction is determined afterwards without the need of calculating the score in real time. A DSS tool was proposed by Talluri, et al (2007) to handle the multitude of information to select the winning bid.

Limitations of online reverse auctions

But besides the impact on relationships and value chain management that will be discussed later there are drawbacks that limit the effective use of online reverse auctions to very specific products. The process is mainly only applicable to products that can be bought from the shelf or commodities. These groups of products guarantee the possibility to compare the bids and the fit into the product of the buyer. Products that need complicated technical requirements and that cannot be clearly described on the announcement of the bidding process will not end up in a successful online reverse auction. This situation will lead to confusion and inconsistent bids on the product that will probably not fit the customer's needs and demand.

According to Talluri and Ragatz (2004) the underlying products are limited by certain constraints. First the product or service as to be easily specified for the above mentioned reasons. Further on price should be at least a major factor in the decision to take advantage of the reverse auction without forgetting about the additional factors. Also there should be sufficient number of suppliers in the market to have competition and choices without having an already established commodity market but the switching cost between those suppliers and their products should be rather low. Finally, products that are considered "strategic" for the company should not be purchased through online reverse auctions to ensure a smooth production flow for the customer. Talluri and Ragatz (2004) thereby follow the definition of a strategic item introduced by Kraljic (1983). According to this definition strategic items are characterized by the need for long-term availability and the scarcity and/or the high-value of the goods.

Also the anonymity of the bidders sometimes leads to problems when the buyer is not able to make sure that the supplier is actually able to meet the requirements. (Anonymous, 2000) This has to be addressed by a qualification program before the bidding process is entered. Nevertheless these auctions can still be used as a tool to negotiate the price at a later stage of the procurement process when the product specifications and details are clarified with some reliable suppliers. (Schwartz, 2004) In this case the reverse auction only serves the purpose to achieve the lowest price after a qualification process that is also included in the normal procurement process.

This approach can overcome some of the drawbacks of a pure online reverse auction. The biggest disadvantage is the fact that usually non-financial figures are not part of the bidding process. The flexibility or integration into the processes of the customer is usually not included in those negations that mainly focus on the price. But focusing on solely the procurement price is the wrong approach as those total cost can actually increase when the wrong supplier is chosen. (Tam Harbert, 2003) This can be addressed if the auction rules enable the buyer to choose any bid and not necessarily the lowest bid. In such a situation, factors like quality and reliability can be taken into account. (Emiliani and Stec, 2002a)

As usually the buyer is very powerful when a reverse auction is implemented, the applied rules favor the buyer over the seller. (Harbert, 2003) Therefore a framework and code of business has to be used that protects sellers from misuse of this tool. As a result, the use of pricing information to influence other suppliers or the behavior in the negotiations and decision-making process after the auction should follow ethical rules (Emiliani and Stec, 2002b)

Online reverse auctions and the impact on value chain management

In the case of sophisticated and specialized products, the reverse auctions stand in contradiction to what value chain management is asking for. Powerful buyers have already asked for a lot when including their suppliers in the value chain; the company has to be extremely flexible, deliver flawless quality in a just-in-time operation, provide engineering support for free, reduce cost and respond to the fluctuation of the demand. (Altman, 2003) Most suppliers changed their processes accordingly in order to keep the business and now the customer is introducing the online reverse auction as a tool for procurement with the goal to lower the price. This behavior clearly destroys the trust and the relationship between the two companies leading to negative results for the value chain. As trust and partnership is the most valuable intangible asset in value chain management, the effects of online reverse auctions might be well beyond the financial consequences discussed later. If implemented for other products than off-shelf-products or commodities these behaviors clearly do not aim at mutual benefits but at solely reducing the price for the purchased good. (Emiliani and Stec, 2002b) Generally speaking reverse auctions are a tool to increase the competition between the suppliers instead of fostering the cooperation along the value chain. (Jap, 2003)

Modern value chains operations have to be synchronized to a high level based on long-term commitment and cooperation. Squeezing the margins is not considered an acceptable action in such an environment and pressuring the supplier to produce at lower cost has to result in a mutual benefit. This is not part of value chain management that is only managing the own procurement efforts but as already mentioned above, the resulting overall cost can be significantly higher because of quality issues or the lacking integration of operational processes. The reintroduction of higher inventory levels due to the lost integration can affect the bottom line severely and eat up all savings on the negotiated price.

The approach to conduct multi attribute auctions clearly is more compatible with the concept of value chain management. Factors like cooperation and interconnection to the customer can be used to assess the bid and the winner of the process. In regards to value chain management, the used of weights for factors other than the price should be high, especially for quality and reliability, to ensure smooth flow of material and an easy integration into the existing system.

In general the buyer has to be careful that the sellers do not bid too low, otherwise the long-term survival of the supplier is not guaranteed. Aggressive bidding in reverse auctions is generally not rewarded on the long run as, under the assumption that all competitors are generally able to provide the service for the same price, the winning bidder underestimates it costs. (Milgrom, 1989) Therefore the winner probably does not get the desired profit margin.

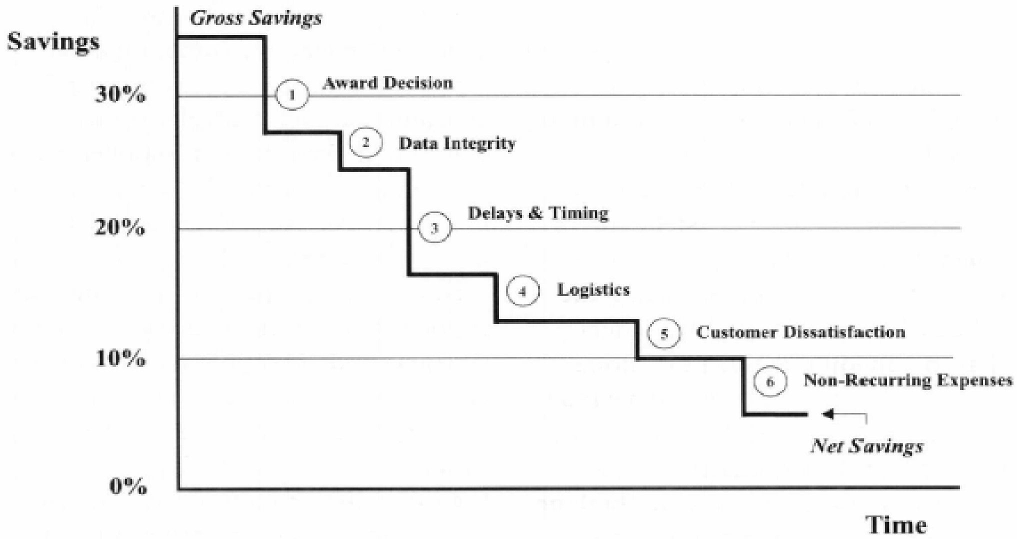
Value chain management should aim at long-term supplier development and mutual efforts to improve the operations and cooperation. This includes efforts to secure the survival and financial well being of all involved partners. Inflating the aggressive bidding of the suppliers will not lead to the financial well-being of the company and thereby also harm the customer when the switching cost for the underlying product are significantly greater than zero, as should be the case for any product that is not a commodity or a off-the-shelf product. Shared efforts for process improvement will probably lead to more substantial savings than squeezing the supplier's margin for short-term improvements. Online reverse auctions have appeal for the managers of the customer because they show a big impact on cost in a rather short period of time; they are a "quick-hit" solution, but they do not help to unveil the root causes for the lack of operational excellence. (Emiliani and Stec, 2002a)

Savings from online reverse auctions

Customers have to determine the real savings based on the total cost instead of being bedazzled by the numbers published by the auction service companies. Therefore one has to distinguish between gross savings and net savings. (Emiliani and Stec, 2002a) Gross savings is the difference between the last price paid for that part and the lowest bid, while net savings also take the occurring losses related to the process into account. The most obvious loss is the switching cost to a new supplier. This can include expenses for qualification, restructuring of the processes for both firms, training for employees or the electronic connection between the customer and the seller. A rough estimation of the switching cost is usually shown in the reserve price. (Emiliani and Stec, 2002a) The buyer will most probably not change the supplier if the reserve price is not met because the obvious switching cost would be higher than the savings on the purchase price. It can be difficult to accurately determine the switching cost as long term effects have to be considered as well, therefore the reserve price is not a guarantee that the company is really saving money when using an online reverse auction.

The buyer has to assess every possible source of additional cost that is related to changing the supplier including the smoothening effect of personal relationships with the management of the seller. These factors have helped to build trust between the companies and benefited both firms, but the supplier probably feels left alone when the customer is switching to reverse auctions and other suppliers or trying to squeeze the margins. (Altman, 2003) According to Emiliani and Stec (2002a) the most common contributors to losses need to be divided into direct losses that are part of the negotiation process. These include losses related to the award decision, data integrity and timing, while indirect losses include logistics, recurring or non-recurring expenses and customer satisfaction. See Figure 2 for an example how these losses can change the actual savings of a customer.

Figure 2 - Schematic diagram of direct and indirect losses that buyers may experience when implementing online reverse auction results. Source: Emiliani and Stec, 2002a



Note: Savings are not realized until the buyer begins to receive parts from the supplier

According to Kumar and Chang (2007), reverse auctions is tactical and can provide short term gain due to price as a single criterion for purchase. However, there is virtually no value added advantage beyond the quoted price and the buyer faces further indirect cost, especially with new suppliers.

The net savings are sometimes hard to assess, as the understanding of the impact of decision made in one department on other departments' operations is not highly developed. However, this holistic view has to be taken to achieve the improvements. Value chain management usually introduced this approach to a certain extend and enabled companies to see the impact of their suppliers' behavior on their performance and especially on the end towards customer satisfaction.

CONCLUSION

E-business can obviously boost the performance of a value chain as the transactions and internal processes of the value chain are simplified by the use of modern information technology. The savings regarding cost and time offered by e-business procedures should easily be translated into cost reduction and increased competitive advantage. Therefore, companies have to adjust their way of conducting business to meet global business environment by the implementation of an e-business infrastructure.

On the other hand value chain management is a prerequisite for e-commerce as a part of e-business. Only companies that have mastered their production in cooperation with their supply network will be able to offer the flexibility and speed necessary for e-business. Companies and value chains that are not responsive enough or lack the efficiency will loose the battle for e-business. As much as the speed and the connectivity of e-business have enhanced the value chain managements and as much as it has increased the pressure to perform and optimize value chain management.

Online reverse auctions as a mode of e-business or e-procurement have become popular in the last years as the development of the used technology became more advanced. Many companies see the chance to increase their profitability by utilizing these tools but overlook the limitations of the concept. The results can be clearly positive if the company pays attention to those limitations regarding the underlying products and services and carrying out of the actual online auction. This includes applying the concept only for suitable products that can easily be specified and the supplier can easily be switched.

Nevertheless, there are significant concerns about the compatibility of value chain management and some forms of online reverse auctions. As long as long term commitment and stability of the chain in some form is not considered in the process, the overall impacts for a company that has successfully implemented value chain management will be negative, even though the financial performance of the purchasing department will increase on the short run. A company without an efficient value chain management processes will take the wrong approach to future competitiveness and financial and operational soundness. In Jap (2007) concluding remark of online reverse auctions, preserving the inter-organizational relationships is a delicate balancing act.

When all these concerns are addressed and the procedure is used in accordance to the partnership with the pool of qualified supplier, the use of an online reverse auction can save time in regard to negotiation of the price and other operational measures. In this case the auction tool will be a part of the e-business strategy in saving time and money for all involved parties as any other e-business tool. It is therefore important to approach this topic as mutually beneficial and proceed jointly in order not to disrupt the value chain management.

REFERENCES

Altman, B. (2003). Reverse Auctions Destroy Relationships. *Manufacturing Engineering,* 130(6), 112

Anonymous (2000). Revisiting reverse auctions. *Agency Sales,* 30 (9) 31-33

Bandyopadhyay, S., Barron, J. & Charturvedi, A.R. (2005). Competition among sellers in online exchanges. *Information Systems Research,* 16 (1), 47-60

Briant, John (2000a). Making sense of the e-supply chain. *Machine design,* 72 (19) 62-70

Briant, John (2000b). B-Webs changing rules of commerce. *Electronic Buyers' News,* 1215 84-85

Caux (2001). Caux Round Table: principles for business. [On-line] Available: http://www.cauxroundtable.org/englisch.htm

Craighead, C.W. & Shaw, N. G. (2003). E-Commerce Value Creation and Destruction: A Resource-Based, Supply Chain Perspective. *Database for Advances in Information Systems,* 34 (2) 39-49

Emiliani, M.L. (2000). Business-to-business online auctions: key issues for purchasing process improvement. *Supply Chain Management,* 5 (4) 176-186

Emiliani, M.L. & Stec, D.J. (2002a). Realizing savings from online reverse auctions. *Supply Chain Management,* 7 (1) 12-23

Emiliani, M.L. & Stec, D.J. (2002b). Squaring online reverse auctions with the Caux Round Table Principles for Business. *Supply Chain Management,* 7 (2) 92-100

Engelbrecht-Wiggans, R. & Katok, E. (2006). E-sourcing in Procurement: Theory and Behavior in Reverse Auctions with Noncompetitive Contracts. *Management Science*, 52 (4), 581-596

Essig, M. & Arnold, U. (2001). Electronic procurement in Supply Chain Management: An information economics-based analysis of electronic markets. *Journal of Supply Chain Management,* 37 (4) 43-50

Franke, U.(2003). Virtual Web organizations revolutionize business. *Information Technology Newsletter,* 14 (1) 21-27

Hannon, D. (2003). CAPS Research study defines staying power of e-auctions. *Purchasing,* 132 (12) 48-49

Harbert, T. (2003). Can OEMs turn back from reverse auctions? *Electronic Business,* 29 (13) 39-40

Hansen, R. G. (1988). Auctions with Endogenous Quantity. *The Rand Journal of Economics,* 19 (1) 44-58

Jap, S. D. (2007). The impact of online reverse auction designed for buyer-supplier relationships. *Journal of Marketing*, 7, 146-159

Jap, S. D. (2003). An Exploratory study of the Introduction of Online Reverse Auctions. *Journal of Marketing*, 67, 96-107

Kraljic, P. (1983). Purchasing must become supply management. *Harvard Business Review,* 61 (5) 109-117

Kumar, S. & Chang, C.W. (2007). Reverse Auctions: How much total supply chain cost savings are there? – A business simulation model. *Journal of Revenue and Pricing Management,* 6 (3), 229-240

Milgrom, P. (1989). Auctions and Bidding: A Primer. *Journal of Economic Perspectives,* 3 (3) 3-22

Rash, W. (2001). Supply Chain Transcend The Physical World. *Internet Week*, 857 20

Rippenhagen, .C. (2002). Integrating Manufacturing Into the Supply Chain Model. *Semiconductor International,* 25 (1) 68-70

Schwartz, K. D. (2004). Reversal of Fortune. *Government Executive,* 36 (1) 58-60

Talluri, S., Narasimhan, R. & Viswanathan, S. (2007). Information Technologies for procurement decisions,: a decision support system for multi-attribute for e-reverse auctions. *International Journal of Production Research*, 45 (11), 2615-2628.

Talluri, S. & Ragatz, G.L. (2004). Multi-Attribute Reverse Auctions in B2B Exchanges: A Framework for Design and Implementation. *Journal of Supply Chain Management,* 40 (1) 52-60

Taninecz, G. (2000). Value chain IT infrastructure. *Industry Week*, 249 (8) 33-38

Teich, J. E., Wallenius, H. , Wallenius, J. & Zaitsev, A. (2006). A multi-attribute e-auction mechanism for procurement: Theoretical foundations. *European Journal of Operational Research*, 175 (1), 90-100.

Vakharia, A. J. (2002). E-Business and Supply Chain Management. *Decision Sciences*, 33 (4) 495-504

THE REVOLUTION OF SIX-SIGMA: AN ANALYSIS OF ITS THEORY AND APPLICATION

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ABSTRACT

Six-sigma is a discipline that has revolutionized many corporations. It has literally transformed them from a state of loss to one of profitability. It can be used to improve any process, and is particularly useful for improving any production system, whether one used for tangible products or services. Although the Japanese are ordinarily credited with having originated and advanced the quality movement, the roots of the quality movement, and consequently the roots of the six-sigma discipline actually originated in the United States. If the history of six-sigma is not well understood, neither is the rather subtle theory behind it. In this paper we develop the historical roots of the quality revolution, show how it developed into six-sigma, develop the theory behind six-sigma, and analyze the uses of some six-sigma tools used in an effective, coherent six-sigma program.

INTRODUCTION

Data is good but good data is better. However, in order to get this good data it is important to have measures in place such as quality control systems to ensure information accuracy. Quality has evolved over the past two centuries when it first became an important business measure of comparison. The ways in which it has been used to define and assess quality have also evolved as new business practices and degrees of acceptance are enforced. One of the first definitions of quality was conformance to valid customer requirements or the Goalpost View, Gitlow & Levine and Levine (2005). As long as the company's process met the customer's requirements, then both the customer and the company were satisfied. Frederic Taylor in his theories of scientific management subscribed to this viewpoint. He believed segmenting jobs into specific works tasks was the best way to control outputs because then efficiency would increase, Basu (2001). Employees were told what to do and how to do it with little or no input. They also rarely worked in teams or cross-functional efforts because each person had his or her own tasks to complete. Moreover, post-production inspection was the primary means of quality control, which showed the lack of concern for waste and error at intermediary steps in the process, Evans and Lindsay (2005). Under this traditional approach, companies did little to understand customer requirements, neither external nor internal, and rarely focused efforts on finding a way to improve quality if it did not come from a technological breakthrough.

As companies began to realize this approach did not take into consideration the cost of waste and variation, many began looking for new ways to measure and define quality. This led to a more modern definition of quality being accepted as the predictable degree of uniformity and dependability, Gitlow & Levine (2005). This Continuous Improvement View supported the notion that every process contains an element that can be improved. Inherently, continuous quality improvement focused on fine tuning parts of the whole through incremental changes. When a problem was discovered, it was addressed until the next problem was discovered and so on. Industrial scientists such as William Edwards Deming, Joseph Juran, Walter Shewhart, Harold Dodge and others were at the forefront of this era. They began by applying statistical methods of control to quality. These methods showed the shift from inspection of the final product and putting a band-aid on the problem to actually implementing quality control into the manufacturing process. This also illustrated the increasing importance of management decision-making in the quality control efforts instead of simply finding a quick fix to the problem so it fell within the specification limits of product or service satisfaction and acceptance.

Deming and Juran believed in a new concept called Total Quality Management. Research by Evans and Lindsay (2005) indicate this viewpoint was based on three fundamental principles:

1. Focus on customers and stakeholders
2. Participation and teamwork by everyone in the organization
3. A process focus supported by continuous improvement and learning

Through Total Quality Management (TQM), workers were empowered to provide input throughout the entire process to ensure and instill confidence that products met customer specifications. In meeting the customer requirements, the term *quality assurance* became widely used as any planned and systematic activity directed toward providing consumers with products of appropriate quality along with the confidence that products meet consumers' requirements Evans and Lindsay (2004). This extension of the Continuous Improvement viewpoint coined the terms Big Q and Little Q, which referred to the quality of management and the management of quality, respectively Evans and Lindsay (2004). Driven by upper management, TQM focused on not just identifying and eliminating problems that caused defects but educating the workforce to improve overall quality. Upper management realized it needed to focus more on identifying and eliminating problems that were causing the defects throughout the process rather than just waiting until the end for post-production inspections. In order to do this, continuous education programs were implemented at all levels. As time passed, these total quality management efforts soon began to fall short of expectations of businesses in the United States. Companies vowed they could promise a certain level of quality by getting it right the first time, but in the end the processes were still not meeting all needs and requirements of the consumer. TQM was joined by many other acronyms like

JIT, MRP and TPM that all guaranteed an unreachable quality standard Basu (2001). Because these methods focused so greatly on the parts of the whole rather than the whole, they fell short in implementing rapid changes. This led to the introduction of certain holistic quality control programs, one of the most recent being Six- sigma.

Six-sigma is a discipline based on the Greek letter sigma which is the conventional symbol for standard deviation. Six-sigma is a very structured process that focuses on quantitative data to drive decisions and reduce defects Benedetto (2003). Many companies have tried to implement this program without truly understanding the theory and concept behind it. Because of such misguided efforts, Six-sigma has received a somewhat jaded reputation, but it is not the discipline that is flawed but rather the application of it. As Evans and Lindsay note, a cookbook approach in which management reads the latest self-help book advocated by business consultants and blindly follows the author's recommendations, will destine Six-sigma or any other management practice to failure because experience only describes what happened and is no help to the emulating management team Evans and Lindsay (2004). Understanding the subtle theory, on the other hand, will enable one to better understand the cause and effect relationships that are applied in Six-sigma and other management practices. In this paper, we will further develop the historical roots of the quality revolution already illustrated, show how quality revolution developed into Six-sigma, delve further into the underlying theory of Six-sigma and then analyze the uses of some Six-sigma tools used in an effective, coherent Six-sigma program.

LITERATURE REVIEW

Multiple scientists have contributed to the evolution of quality management. The main three who added to the development of six-sigma and will be discussed here are William Edwards Deming, Joseph Juran and Philip Crosby. Deming had a Ph. D. in physics and was trained as a statistician at Yale University. He and Juran both worked for Western Electric during the 1920s and 1930s Evans and Lindsay (2004). From there he started working with the U.S. Census Bureau where he perfected his skills in statistical quality control methods. He opened his own practice in 1941 and thus began teaching SQC methods to engineers and inspectors in multiple industries. Deming, better known as the Father of Quality, was widely ignored in the United States for his works. As a result, he went to Japan right after World War II to begin teaching them SQC. His work there is what truly bolstered the "Made in Japan" label to its well-respected level of quality today W. Edwards Deming (2007). Dr. Deming's most famous work is the 14 points in his System of Profound Knowledge. There are four interrelated parts in the program: Appreciation for a System, Understanding of Variation, Theory of Knowledge and Psychology, Evans and Lindsay (2004). In the first point, Deming believed it was poor management to purchase materials at the lowest price or minimize the cost of manufacturing if it were at the expense of the product. The second and third points emphasized the importance of management understanding the project first and foremost before taking any steps to reduce variation. The methods to reduce variation include technology, process design and training. Under the fourth point, Deming stressed understanding the dynamics of interpersonal relationships because everyone learns in different ways and speeds and thus the system should be managed accordingly. Other points in the Deming school of thought were on-the-job training, creating trust, building quality into a product or service from the beginning and inclusion of everyone in the company to accomplish project improvement. The common methodology used by Deming for improving processes is PDCA which stands for Plan – Do – Check – Act.

Joseph Juran is well known for his book, the *Quality Control Handbook* published in 1951. He too went to Japan in the 1950s after working at Western Electric to teach the principles of quality management as they worked to improve their economy. His school of thought was different from Deming's in that he believed to improve quality companies should use systems with which managers are already familiar. When consulting firms, he would design programs that fit the company's existing strategic efforts to ensure minimal rejection by staff. The main points he taught were known as the Quality Trilogy: Quality Planning, Quality Control and Quality Improvement. Quality planning was the process of preparing companies to meet quality goals by identifying the customers and their needs. Quality control was the process of meeting quality goals during operations with minimal inspection. Quality improvement was the process of breaking through to unprecedented levels of performance to produce the product (Evans and Lindsay, 2004). His philosophy required a commitment from top management to implement the quality control techniques and emphasized training initiatives for all.

The third philosopher who contributed greatly to six-sigma was Philip Crosby. Crosby worked as the Corporate VP for Quality at International Telephone and Telegraph for 14 years. His most well-known work is the book *Quality is Free* where he emphasized management should "do it right the first time" and popularized the idea of the "cost of poor quality." Crosby emphasized that management must first set requirements and those are on which the degree of quality will be judged. He also believed doing things right the first time to prevent defects would always be cheaper than fixing problems which developed into the cost of poor quality idea. Similar to six-sigma, Crosby focused on zero defects and created four Absolutes of Quality Management to ensure that goal was accomplished Skymark Corporation (2007):

1. Quality is defined as conformance to requirements, not as "goodness" or "elegance"
2. The system for causing quality is prevention, not appraisal
3. The measurement standard must be zero defects, not that's close enough
4. The measurement of quality is the Price of Nonconformance, not indices.

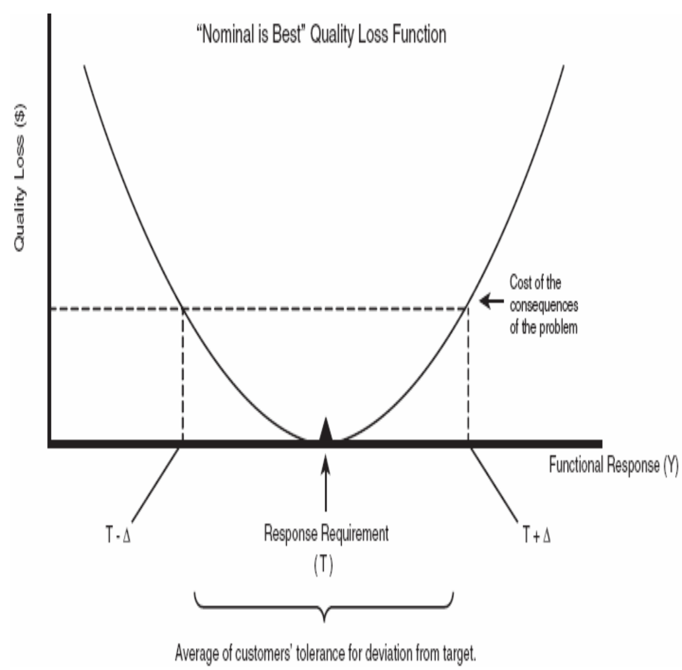
These philosophies have been categorized as more evolutionary because the changes resulting from their implementation were more gradual. As time continued, managers became increasingly disappointed with TQM and searched for philosophies that would create more drastic changes in the existing processes and systems. These revolutionary processes recognized that processes are key to quality, that most processes are poorly designed and implemented, that overall success is sensitive to individual sub-processes success rates and that rapid, dramatic change requires looking at the entire process. One of the first of these revolutionary philosophies was Reengineering. Reengineering is defined as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance Benedetto (2003). It places heavy reliance on statistics and quantitative analysis.

Six-sigma emerged during this revolutionary time period after reengineering. The two approaches are very similar but also have many differences. Whereas reengineering focuses on the statistical aspect, Six-sigma places more emphasis on data to drive decisions. When comparing six-sigma to Total Quality Management it is very apparent that great changes have come about in the evolution of quality. Six-sigma has a more structured and rigorous training development program for those professionals using it. Six-sigma is a program owned by the business leaders, also known as *champions*, while TQM programs are based on worker empowerment. Six-sigma is cross functional and requires a verifiable return on investment in contrast to TQM's function or process based methodology that has little financial accountability Evans and Lindsay (2004).

Six-sigma started as a problem solving approach to reduce variation in a product and manufacturing environment. It has since grown to be used in a multitude of other industries and business areas such as service, healthcare and research and development. It represents a structured thought process that begins with first thoroughly understanding the requirements before proceeding or taking any action. Those requirements define the deliverables to be produced and the tasks to produce those deliverables which in turn illustrate the tools to be used to complete the tasks and produce the deliverables Hambleton (2007). Six-sigma was initiated in the 1980s by Motorola. The company was looking to focus its quality efforts on reducing manufacturing defects by tenfold within a five-year period. This goal was then revised to a tenfold improvement every two years, 100-fold every four years and 3.4 defects per million in five years Gitlow & Levine (2005). A defect in six-sigma terms is any factor that interferes with profitability, cash flow or meeting the customers' needs and expectations. This led to the next important concept of six-sigma: critical to quality. Critical-to-Quality (CTQ) items are points of importance to the customer be it internally or externally, Adomitis and Samuels (2003). Six-sigma projects aim to improve CTQs because research has proven that a high number of CTQs correlates with lost customers and reduced profitability. Ultimately, the company will have reduced the number of defects and focused on the CTQs such that it will cost more to correct the defects any further than to prevent their occurrence in the first place.

This thought was advanced in the 1980s by Dr. Genichi Taguchi with his Quality Loss function. Prior to that time, it was thought that the customer would accept anything within the tolerance range and that product costs do not depend on the actual amount of variation as long as it was still within the tolerance range, Evans and Lindsay (2004). Taguchi introduced a model that discredited that school of thought by showing the approximate financial loss for any deviation from a specified target value – an idea that coincides with six-sigma's inclusion of financial data in the assessment of a process or function. His work contradicted the original concept and showed that variation is actually a measure of poor quality such that the smaller the variation is about the nominal level, the better the quality is. As the graph below depicts, this loss function also applied an economic value to variation and defects from the standard. As the process or project deviates from its target value, costs become increasingly higher and the customer becomes increasingly dissatisfied. Quality loss can be minimized by reducing the number of deviations in performance or by increasing the product's reliability. In six-sigma, the goal is to minimize the number of defects and keep the process as close to the nominal value as possible to avoid high degrees of variability. The concepts of Taguchi are part of Six-sigma's key philosophy of reducing defects and variation from the norm.

Figure 1: Nominal is Best Quality Loss Function



As previously mentioned six-sigma is a product of the statistical methods era of controlling quality. It stressed the common measure of quality, the defect. In measuring output quality, the key metrics used are defects per million opportunities (DPMO), Cost of Poor Quality (COPQ) and sigma level, Druley and Rudisill (2004). Defects per million opportunities takes into consideration the number of defects produced out of the entire batch and the number of opportunities for error. It is important to assess quality performance using the defects per million opportunities because two different processes may have significantly different numbers of opportunities for error, thus making comparison unbalanced. Furthermore, large samples provide for a higher probability of detection of changes in process characteristics than a smaller sample. When Motorola created this ultimate goal of six-sigma, it was set to be equivalent to a defect level of 3.4 defects per million opportunities. According to Evans and Lindsay, this figure was chosen because field failure data suggested that Motorola's processes drifted by this amount on average, Evans and Lindsay (2004). The cost of poor quality metric was introduced by Crosby. It includes the costs of lost opportunities, lost resources and all the rework, labor and materials expended up to the point of rejection. This metric is used to justify the beginning of a six-sigma project. When a company is choosing which project to undertake, the project with the highest COPQ will most likely be selected. Lastly, the sigma level indicates the degree of quality for the project. *Sigma* is a statistical term that measures how much a process varies from the nominal or perfect target value based on the number of DPMO. As mentioned, Motorola's goal was to have 3.4 defects per million opportunities which would happen at the six-sigma level. The DPMOs for various sigma levels are compared in Table 1 below (iSixSigma, 2002).

Table 1: Defects per Million Opportunities at Various Sigma Levels

Sigma Level	Defects per Million Opportunities
One Sigma	690,000
Two Sigma	308,000
Three Sigma	66,800
Four Sigma	6,210
Five Sigma	230
Six-sigma	3.4

One phenomenon that has been widely discussed in relation to six-sigma is the 1.5 sigma shift. Because six-sigma focuses on variation, a chart to understand deviation from the mean should be used to further understand this concept. A Z-table shows the standard deviation from the mean. A process' normal variation, defined as process width, is +/- 3-sigma about the mean. In looking at Table 2, it is clear that a quality level of 3-sigma actually corresponds with 2,700 defects per million opportunities. This number may sound small but it is similar to 22,000 checks deducted from the wrong bank account each hour or 500 incorrect surgical operations each week. This level of operating efficiency was deemed unacceptable by Motorola hence the search for a design that would ensure greater quality levels. A six-sigma design would have no more than 3.4 DPMO even if shifted +/-1.5 sigma from the mean. In looking once again at Table 2, it is evident a quality level of six-sigma actually corresponds with two defects per billion opportunities while the more commonly known value of 3.4 defects per million opportunities is found at the six-sigma level with a +/-1.5-

sigma shift off the center value or +/-4.5-sigma. This shift is a result of what is called the Long Term Dynamic Mean Variation, Swinney (2007). In simpler terms, no process is maintained perfectly at center at all times, thus allowing drifting over time. The allowance of a shift in the distribution is important because it takes into consideration both short and long-term factors that could affect a project such as unexpected errors or movement. Also worth noting is that the goal of 3.4 DPMO can be attained at 5-sigma with a +/-0.5-sigma shift or at 5.5-sigma with a +/-1-sigma shift. However as Taguchi pointed out, it is important to minimize the noise factors that could shift the process dramatically from the nominal value. Table 2 below shows the DPMO quality levels achieved for various combinations of off-centering and multiples of sigma, Evans and Lindsay (2004).

Table 2: Defectives per Million Opportunities for Various Process Off-Centering and Quality Levels

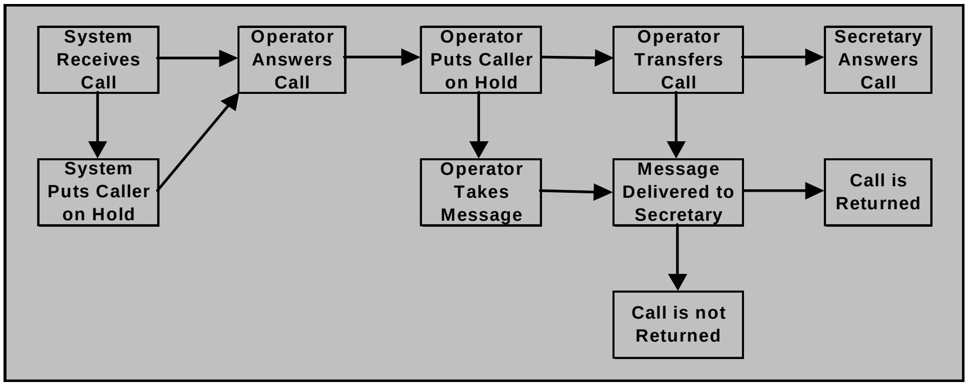
	Quality Level						
Off-Centering	3-sigma	3.5-sigma	4-sigma	4.5-sigma	5-sigma	5.5-sigma	6-sigma
0	2,700	465	63	6.8	0.57	0.034	0.002
0.25-sigma	3,577	666	99	12.8	1.02	0.1056	0.0063
0.5-sigma	6,440	1,382	236	.32	**3.4**.	0.71	0.019
0.75-sigma	12,288	3,011	665	88.5	11.0	1.02	0.1
1-sigma	22,832	6,433	1,350	233	32	**3.4**	0.39
1.25-sigma	40,111	12,201	3,000	577	88.5	10.7	1
1.5-sigma	66,803	22,800	6,200	1,350	233	32	**3.4**
1.75-sigma	105,601	40,100	12,200	3,000	577	88.4	11
2-sigma	158,700	66,800	22,800	6,200	1,300	233	32

METHODOLOGY

Within six-sigma there are different project based methods that can be followed. Among them are Lean Sigma, Design for Six-sigma, Six-sigma for Marketing and the most common DMAIC – Define, Measure, Analyze, Improve and Control, Hambleton (2007). Lean Sigma is a more refined version of the standard Six-sigma program that streamlines processes to its essential value-adding activities. In doing this, the company aims to do things right the first time with minimum to no waste. Wait time, transportation, excess inventory and overproduction are among the wasteful activities that can be eliminated. One test used to identify the value-add activities that will reduce waste is the 3C Litmus Test: Change, Customer, Correct, Hambleton (2007). If the activity changes the product or service, if the customer cares about the outcome of the activity and/or if the activity is executed and produced correctly the first time then it is a value-add activity and should be kept. Lean Sigma was popularized in Japan after World War II by Toyota. The Toyota Production System challenged Ford's standard for a large lot production system by using systematically and continuously reducing waste through small lot productions only. Design for Six-sigma (DFSS) expands Six-sigma by taking a preventative approach by designing quality into the product or process. DFSS focuses on growth through product development, obtaining new customers and expanding sales into the current customer base, Hambleton (2007). It focuses on not just customer satisfaction but customer success because from the inception of the product or service the company will focus on optimizing CTQs. In order to do this, companies use multivariable optimization models, design of experiments, probabalistic simulation techniques, failure mode and effects analysis and other statistical analysis techniques. This method is usually begun only after the Six-sigma program has been implemented effectively. The Six-sigma for Marketing methodology simply means applying six-sigma ideas and principles to improving other functions of the business such as marketing, finance and advertising. The most common methodology is DMAIC. One goal of using the DMAIC methodology is to identify the root cause of the problem and select the optimal level of the CTQs to best drive the desired output. Another goal is to improve PFQT: Productivity, Financial, Quality and Time spent, Hambleton (2007). It is used as an iterative method to combat variation. With the built in ability to contrast variation, DMAIC intrinsically allows for flexibility because as knowledge is learned thorough implementation, assumptions of the root cause may be disproved, requiring the team to modify or revisit alternative possibilities. Kaoru Ishikawa promoted seven basic tools that can be used in assessing quality control. The list has since been expanded upon to include many other tools but the original seven were Cause-and Effect diagrams, Check sheets, Control charts, Histograms, Pareto charts, Scatter diagrams and Stratification, Hambleton (2007). Some of these tools will be further explained below.

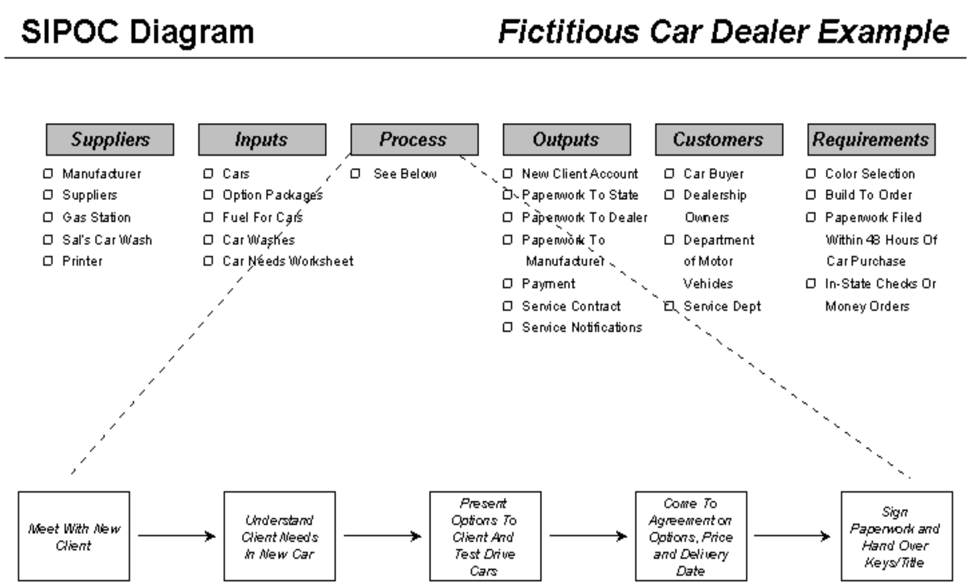
In the first step Define, the company clearly defines the problem. It begins the trust and dedication from all stakeholders and all persons included in the project team. The project team consists of the Champion, Master Black Belt, Black Belt, Green Belt and Team Members. Key activities occurring in this phase include selecting the team members and their roles, developing the problem statement, goals and benefits and developing the milestones and high level process map iSixSigma (2007). One tool used in this step is the process flowchart. Four main types of flow charts are considered: top-down, detailed, work flow diagram and deployment, Kelly and Sutterfield (2006). This tool shows how various steps in a process work together to achieve the ultimate goal. Because it is a pictorial view, a flow chart can be applied to fit practically any need. The process map allows the user to gain an understanding of the process and where potential waste or bottlenecks could occur. It also could be used to design the future or desired process. An example process map for a call answering operation is shown below in Figure 2.

Figure 2: Process Flow Chart



In the second step Measure, the company quantifies the problem by understanding the current performance and collecting necessary data to improve all CTQs. Key activities occurring in this phase include defining the defect, opportunity, unit and cost metrics, collecting the data, determining the process capability. One tool used in this step is the SIPOC Diagram. SIPOC stands for Suppliers, Inputs, Processes, Outputs and Customers. This tool is applied to identify all related aspects of the project – who are the true customers, what are their requirements, who supplies inputs to the process – at a high level before the project even begins (iSixSigma, 2007). These diagrams are very similar to process maps which are also a tool applied at this phase of the DMAIC cycle. A SIPOC diagram is shown below in Figure 3, Simon (2007).

Figure 3: SIPOC Diagram

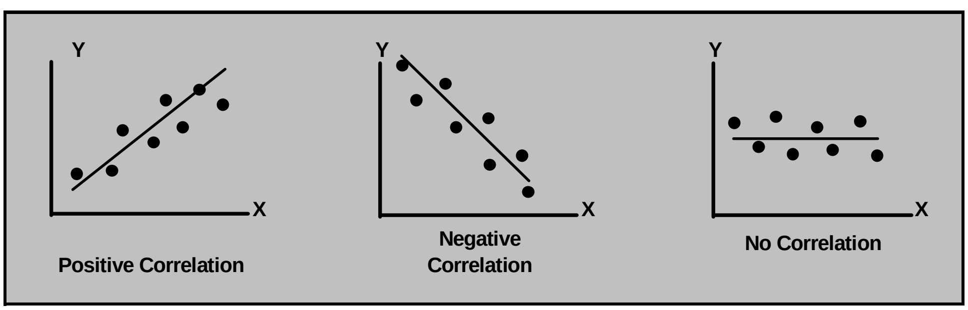


In the third step Analyze, the root cause of the project's problem is investigated to find out why the defects and variation are occurring. Through this detailed research, the project team can begin to find the areas for improvement. Key activities in this phase are identifying value and non-value added activities and determining the vital few or critical-to-quality elements. The care applied to this phase of the Six-sigma project is very important to the project's success because a lack of understanding and thorough analysis is what causes most defects and variation. Evans and Lindsay (2005) described that it could also be caused by:

- ❏ Lack of control over the materials and equipment used
- ❏ Lack of training
- ❏ Poor instrument calibration
- ❏ Inadequate environmental characteristics;
- ❏ Hasty design of parts and assemblies.

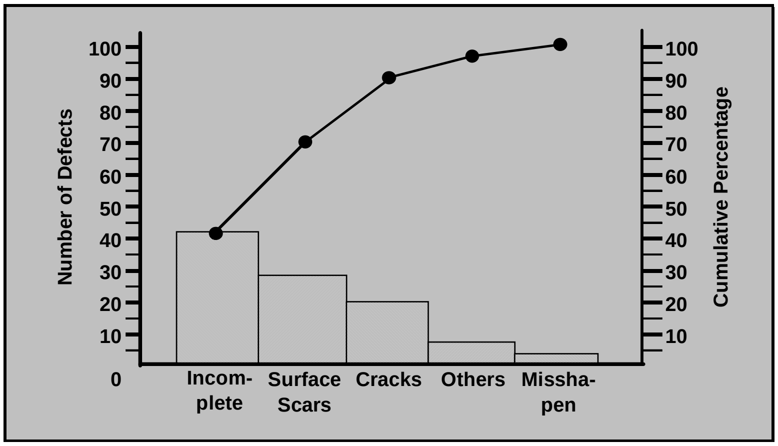
Multiple tools exist to guide the efforts of this process. They include but are not limited to scatter diagrams, Pareto charts, histograms, regression analyses and fishbone diagrams. A scatter diagram shows the relationship between two variables. The correlation is indicated by the slope of the diagram which could be linear or non-linear. If linear the correlation could be direct or indirect and positive, negative or null. If non-linear, a regression analysis can be used afterwards to measure the strength of the relationship between the variables. The various types of scatter plots are shown in Figure 4.

Figure 4: Scatter plot diagram



The Pareto chart is used to separate the "vital few" from the "trivial many" when analyzing a project. It communicates the *80/20 rule* which states that 80 percent of an activity comes from 20 percent of the causes which thus provides rationale for focusing on those vital few activities, Hambleton (2007). The problem frequencies are plotted in the order of greatest to least and show the problems having the most cumulative effect on the system, Kelly and Sutterfield (2006). As mentioned earlier, six-sigma focuses on eliminating as many noise factors as possible and this Pareto analysis helps to do just that. So, the company does not expend resources on wasteful activities that do not add value, but instead cost. to the end project. Figure 5 shows a typical cumulative Pareto chart.

Figure 5: Pareto chart

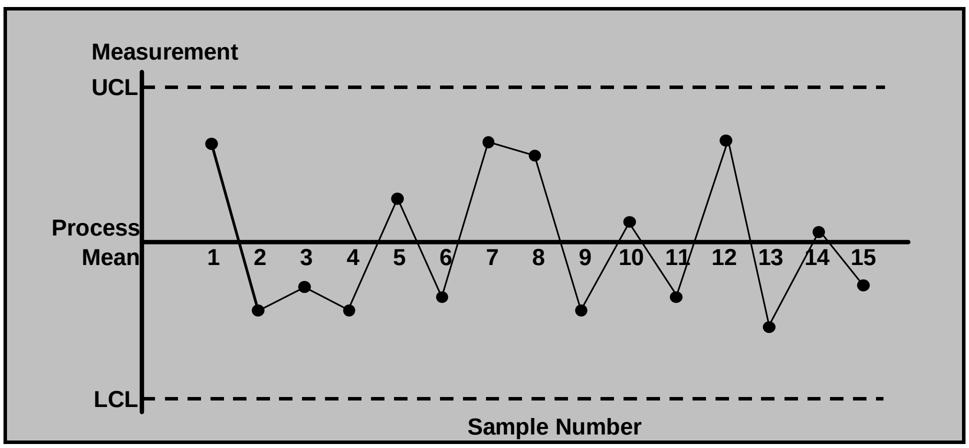


In the fourth step Improve, the research of the problem's root cause is actually put into work by eliminating all the defects and reducing the degree of variation. Key activities in this phase are performing design of experiments, developing potential solutions, assessing failure modes of potential solutions, validating hypotheses, and correcting/re-evaluating potential solutions. Failure Mode and Effects Analysis is a tool used in this step of the DMAIC process to identify a failure, its mode and effect through analysis. The analysis prioritizes the failures based on severity, occurrence and detection. Through this analysis a company can create an action plan if a failure occurs. Results of an FMEA include a list of effects, causes, potential failure modes, potential critical characteristics, documentation of current controls, requirements for new controls and documentation of the history of improvements. Items listed low on the priority list do not necessitate an action plan to correct them unless they have a high probability of occurrence or are special cause circumstances, Hambleton (2007).

In the fifth and final step Control, the project improvements are monitored to ensure sustainability. Key activities include developing standards and procedures, implementing statistical process control, determining process capability, verifying benefits, costs, and profit growth, and taking corrective action when necessary to bring the project back to its nominal value, iSixSigma (2007). The most important tool used in this phase is the Control chart. It is a statistical method based on continuous monitoring of process variation. The chart is drawn using upper and lower control limits along with a center or average value line. As long as the points plot within the control limits, the process is assumed to be in control. The upper and lower control limits are usually placed three sigma away from the center line because for a normal distribution data points fall within 3-

sigma limits 99.7 percent of the time. These control limits are different than the specification limits. Control limits help identify special cause variation and confirm stability while specification limits describe conformance to customer expectations (Skymark Corporation, 2007). However, if there are many outliers, points gravitating toward one of the control limits, or there seems to be a trend in the points, the process may need to be adjusted to reduce the variation and/or restore the process to its center. The control chart can help to assess quantitative gains made through the improvements because each point will be compared to the target value. An example of a control chart for a process in control is shown in Figure 6 below.

Figure 6: Control Chart



APPLICATION OF METHODOLOGY

Multiple success stories have come from implementing the aforementioned tools into a six-sigma project. The most well known success story is that of General Electric under the direction of Jack Welch. Welch began a six-sigma project to work on the rail car repairs and aircraft engine imports for Canadian customers. Through his guided efforts, the company reduced repair time, redesigned its leasing process, reduced border delays and defects and improved overall customer satisfaction. Quantitatively, General Electric saved over $1 billion in its first year of six-sigma application and then $2 billion in the second year. The company's operating margin rose to 16.7 percent while revenues and earnings increased by 11 and 13 percent respectively, Black, Hug and Revere (2004).

Six-sigma has grown in application from just in the manufacturing environment to also banking, healthcare and automotive. In 2001 Bank of America's CEO Ken Lewis began focusing on increasing the customer base while improving company efficiency. The company handled nearly 200 customer interactions per second and thus set the ultimate goal of its six-sigma efforts to be *customer delight*. Bank of America established a customer satisfaction goal and created a measurement process to evaluate current performance in order to work toward improving the state. In the first year, the bank's defects across electronic channels fell 88 percent, errors in all customer delivery channels and segments dropped 24 percent, problems taking more than one day to resolve went down 56 percent and new checking accounts had a 174 percent year over year net gain. Within four years of beginning the project, the bank's customer delight rose 25 percent. Through the application of six-sigma, Bank of America was able to focus on the voice of the customer in determining what was most important to them to make their experience a pleasant one, Bossert and Cox (2004).

The Scottsdale Healthcare facility in Arizona began a six-sigma project to work on its overcrowded emergency department because it took 38 percent of the patient's total time within the department to find a bed and transfer the patient out of the waiting room. Before implementing quality efforts, multiple intermediary steps existed in the process which inevitably slowed down the time from start to finish and reduced the potential yield. As a result of the DMAIC and Lean Sigma efforts, the facility identified the root cause of the problem was not that of finding a bed, as originally thought, but rather reducing the number of steps involved in the transfer process. This solution produced incremental profits of $600,000 and reduced the cycle time for bed control by 10 percent. Moreover, the patient throughput in the emergency room increased by 0.1 patients/hour (Lazarus and Stamps, 2002). This project proved one of six-sigma's key arguments that inspection is unproductive and instead quality control should be implemented from the beginning of a product or service to reduce non-value add activities.

It is important to note that not all applications of six-sigma have led to success. A common explanation for the failures is that companies and managers read the latest self-help book and blindly followed the author's recommendations. In doing this, they failed to fully grasp the theory behind the approach. Experience only describes programs like six-sigma, but understanding the theory will help to understand the cause-and-effect relationships which can then be used for rational prediction and management decisions. Also it is important to note that many of the failures are not due to a flaw in six-sigma's conceptual basis, but rather failures in the mechanics of team operation. According to Evans and Lindsay, 60 percent of six-sigma failures are due to the following factors:

- ❑ Lack of application of meeting skills
- ❑ Improper use of agendas
- ❑ Failure to determine meeting roles and responsibilities
- ❑ Lack of setting and keeping ground rules
- ❑ Lack of appropriate facilitative behaviors
- ❑ Ambivalence of senior management
- ❑ Lack of broad participation
- ❑ Dependence on consensus;
- ❑ Too broad/narrow initiatives.

To ensure the success of a six-sigma implementation, it is vitally important that the project champion and other top management officials are very intimately involved in the process. Also implementing constant training for all employees on related topics will minimize the misunderstanding and maximize resources, both financial and human.

CONCLUSION

The objective of this paper was not to examine the tools of Six-sigma in great detail, but rather to explain their history and evolution, because it is more important to understand the origin and development of a discipline, and the reason(s) that it is better than its predecessors. As explained, Six-sigma is used to resolve problems resulting in deviation between what should be happening and what is actually happening. The methodology and tools of Six-sigma can handle any problem type from conformance to efficiency to product/service design. However, in order for the program to effectively mitigate all project risks and be implemented successfully, there must be commitment from the top-down. Through this paper the history of quality has been presented. As its definition and application have evolved from Frederic Taylor's scientific management theories to the present program of six-sigma, and even looking forward to more refined programs such as Fit Sigma, quality continues to be a concept of vital importance for all businesses and industries. In this paper, the underlying theory and concepts contributed by each quality philosopher, and each revolutionary model were explained to show how they are similar but more importantly to show how they are different. For each company and each industry the same quality control methodology may not be appropriate because each operates under different circumstances. The benefits that accrue from applying the different techniques of six-sigma to various production situations are invaluable to a company truly intent upon quality improvement, longevity in its market, and global competitiveness.

REFERENCES

Basu, R. (2001). Six-sigma to Fit Sigma. *IIE Solutions*, *33*(7), 28-34.

Benedetto, A. R. (2003). Adapting manufacturing-based Six-sigma methodology to the service environment of a radiology film library. *Journal of Healthcare Management, 48*(4), 263.

Black, K., Revere, L., & Hug, A. (2004). Integrating six-sigma and CQI for improving patient care. *The TQM Magazine, 16*(2), 105.

Bossert, J., & Cox, D. (2005). Driving organic growth at Bank of America. *Quality Progress, 38*(2), 23-28.

Druley, S. & Rudisill, F. (2004). Which six-sigma metric should I use? *Quality Progress, 37*(3), 104.

Evans, J.R. & Lindsay, W. M. (2004). *An introduction to six-sigma*, United States: Thompson Southwestern.

Evans, J.R. & Lindsay, W. M. (2005). *The management and control of quality*. United States: Thompson Southwestern.

Gitlow, H. S. & Levine, D. M. (2005). *Six-sigma for green belts and champions*. United States: Pearson Education.

Hambleton, L., (2007). *Treasure chest of six-sigma growth methods, tools and best practices*. United States: Pearson Education.

iSixSigma (2007). *Six sigma DMAIC roadmap*. Retrieved January 15, 2008 from http://www.isixsigma.com/library/content/c020617a.asp.

iSixSigma (2002). *Sigma level.* Retrieved January 15, 2008 from http://www.isixsigma.com/dictionary/Sigma_Level-84.htm.

Lazarus, I. R. & Stamps, B. (2002). The promise of six-sigma. *Managed Healthcare Executive, 12*(1), 27-30.

Samuels, D. I. and Adomitis, F. L. (2003). Six-sigma can meet your revenue-cycle needs. *Healthcare Financial Management*, *57*(11), 70.

Simon, K. (2007). *SIPOC diagram*. Retrieved January 15, 2008 from http://www.isixsigma.com/library/content/c010429a.asp.

Skymark Corporation (2007). *Control Charts*. Retrieved January 12, 2008 from http://www.skymark.com/resources/tools/control_charts.htm.

Skymark Corporation (2007). *Dr. W. Edwards Deming*. Retrieved January 12, 2008 from http://www.skymark.com/resources/leaders/deming.asp.

Skymark Corporation (2007). *Philip Crosby: The Fun Uncle of the Quality Revolution*. Retrieved January 12, 2008 from http://www.skymark.com/resources/leaders/crosby.asp.

Sutterfield, J.S., and Kelly, C. S. J. (2006). The six-sigma quality evolution and the tools of six-sigma. *2006 IEMS Proceedings, Cocoa Beach, FL,* pp. 370-378.

Swinney, Jack (2007). *1.5 sigma process shift explanation.* Retrieved January 15, 2008 from http://www.isixsigma.com/library/content/c010701a.asp.

COMPARISONS OF PERFORMANCES BETWEEN ONLINE LEARNERS AND OFFLINE LEARNERS ACROSS DIFFERENT TYPES OF TESTS

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ABSTRACT

Student performances in multiple choice and non-multiple choice questions are examined to see if there is any difference in the performance between on-line learners and off line learners in this study. Academic and demographic data of 119 students who took undergraduate accounting courses offered through online as well as offline at California State University-San Bernardino during a three-year period extending from fall 2003 to spring 2005 are examined using sample mean comparisons, regression models, and Mann-Whitney Test. Overall, empirical results from the analyses suggest that there are no significant differences in testing performances such as total scores, multiple scores, and non-multiple choice scores between online learners and offline learners, which is robust across different performance measures and testing methodologies.

INTRODUCTION

A considerable body of research on distance learning suggests that there is no significant difference in achievement levels between online learners and offline learners (E.G., The Institute for Higher Education Policy (1999), Chamberlin (2001) and Yin et. al. (2002)). However, most of these previous studies examined the course grade but not the components of the course grade such as multiple choice questions, assignments, problems, etc. Besides that, online learners may perform differently than offline learners due to differences in student perception, available learning tools, use of the learning tools, and other technical issues. (See Barker (2002), Beard et. al. (2002), Dunbar (2004), Kendall (2001), Lightner et. al. (2001), Perreault et. al. (2002), Schulman et. al. (1999), Schwartzman et. al. (2002), and Woods (2002)) Thus, the purpose of this study is to examine student performances in those course grade components (multiple choice and non-multiple choice questions, in particular) to see if there are any differences in their performances between on-line learners and off line learners.

The remainder of the paper is organized as follows: first, sample data descriptions are discussed the next section, which is followed by discussions on data analyses and their results. Concluding remarks are made in the final section.

SAMPLE DESCRIPTIONS

Sample data are collected from students who took undergraduate accounting courses offered through online as well as offline at California State University-San Bernardino during the three years from fall 2003 to spring 2005. Both online and offline classes were taught by the same instructor who used Blackboard as a web-based learning assistance tool. The same textbook was used and the same lecture notes for each chapter developed by the instructor were provided to students in both classes. Exams for on line and off line classes are developed by the instructor in such a way that exams for on line classes are equivalent to those for off line classes. All exams were proctored and graded by the same instructor.

Student performance data such as test scores and GPA are collected from the course instructor or the university database, while student demographic data such as gender, age, and working hours are from survey questionnaires to the student sample. After deleting students with insufficient data, the final data of 119 students are analyzed in this study.

The sample descriptions are presented in Table 1. There are no significant difference in gender compositions, marital status, GPA, the number of courses taking, and class standing between on line learners and their matching off line learners. On the other hand, significant differences exist in age, commuting distance, and working hours between on line learners and off line learners. Thus, it is necessary to control for the effect of these differential factors between the two learner groups on student performances to examine the net difference in student performances between on line learners and off line learners in this study.

Table 1: Description of Sample

Item	Online	Offline	Difference
Gender	F:44 M:15 N:59	F:25 M:15 N:40	Mean diff:0.1208 t-val: 1.281 (p-val: 0.20337)
Age	Mean: 30.3333 SD: 8.397 N:57	Mean: 26.5500 SD: 6.6984 N:40	Mean:3.783 t-val:2.018 (p-val:0.0477)
Married (No:0, Yes:1)	Mean: .3793 SD: .4895 N:59	Mean: .3590 SD: .4859 N: 39	Mean:0.02 t-val:0.1843 (p-val: 0.8542)

Table 1: Description of Sample			
Item	Online	Offline	Difference
Distance(mile)	Mean: 44.7797 SD: 29.6090 N:59	Mean: 18.450 SD: 13.2702 N:40	Mean:26.33 t-val:5.270 (p-val:8.23e-7)
Working Hour (hour)	Mean: 31.0702 SD: 13.0628 N:57	Mean: 22.3077 SD: 14.6381 N:39	Mean:8.763 t-val:3.073 (p-val:0.00277)
No. of taking courses	Mean: 3.3898 SD: .8308 N:59	Mean: 3.650 SD: .9212 N:40	Mean:-0.26 t-val:-1.6292 (p-val: 0.1467)
No. of course for graduate	Mean: 7.5789 SD: 3.0469 N:57	Mean: 7.4500 SD: 3.063 N:40	Mean:0.129 t-val:0.2047 (p-val:0.838)
GPA	Mean: 3.1458 SD:0.4651 N:50	Mean: 3.1421 SD:0.49574 N:40	Mean:0.04 t-val:0.0364 (p-val:0.9710)

ANALYSIS AND RESULTS

Preliminary comparisons between online learners and offline learners in their performances in multiple-choice questions and non-multiple choice questions are made and their results are presented in Table 2. There are significant differences in total scores and multiple choice scores but not in non-multiple choice scores between online learners and offline learners. Since multiple choice scores and non-multiple choice scores are two major determinants of total scores, the significant difference in total scores may be due to the significant difference in multiple choice scores. [1]

Table 2: Simple Mean Comparisons Between Online and Offline Learners			
Item	Online	Offline	Difference
Total Score	Mean: 68.55385 SD:15.0973 N:65	Mean: 73.06849 SD:13.2578 N:73	Mean diff:-4.51464 t-val:-1.87045 (p-val: 0.06357)
Multiple Choice	Mean: 43.50769 SD:7.7341 N:65	Mean:46.41781 SD:6.5187 N:73	Mean diff:-2.91011 t-val: -2.39784 (p-val: 0.01785)
Non-Multiple Choice	Mean: 26.05385 SD:7.3108 N:65	Mean: 26.66438 SD:7.6981 N:73	Mean diff:-0.6105 t-val: -0.4807 (p-val: 0.6315)

As suggested in many previous studies, student performances can be affected by student characteristics such as gender, age, educational experience, and motivation. (E.G., Sullivan (2001), Younger (1999)) Thus, effect of these characteristics on student performances should be controlled for to see the online versus offline difference in the performance. For this, the following comparative static analyses are conducted and their results are presented in Tables 3 through 6.

Table 3: Mean Comparisons after controlling for GPA			
Panel A: total Scores			
Item	Online	Offline	Difference
Low GPA	Mean: 59.083	Mean: 68.544	Mean diff: 9.461
	SD: 15.3066	SD: 13.3822	t-val: 2.83
	N:30	N:45	(p-val: 0.00599)
High GPA	Mean: 76.671	Mean: 80.339	Mean diff: 3.667
	SD: 9.0681	SD: 9.3779	t-val: 1.571
	N:35	N:28	(p-val: 0.12129)
Panel B: Multiple Choice Scores			
Item	Online	Offline	Difference
Low GPA	Mean: 38.716	Mean: 44.300	Mean diff: 5.583
	SD: 7.7589	SD: 6.5064	t-val: 3.36
	N:30	N:45	(p-val: 0.00121)
High GPA	Mean: 47.614	Mean: 49.821	Mean diff: 2.207
	SD: 4.8614	SD: 4.9837	t-val: 1.771
	N:35	N:28	(p-val: 0.08159)
Panel C: Non-Multiple Choice Scores			
Item	Online	Offline	Difference
Low GPA	Mean: 24.266	Mean: 24.266	Mean diff: 1.716
	SD: 7.6291	SD: 7.4445	t-val: .969
	N:30	N:45	(p-val: 0.33589)
High GPA	Mean: 29.057	Mean: 30.517	Mean diff: 1.4728
	SD: 5.5539	SD: 6.1153	t-val: .992
	N:35	N:28	(p-val: 0.32524)

In order to control for the effect of GPA on student performances, all sample students are divided into two subgroups: i.e., LOW GPA and HIGH GPA. Students with higher GPA than the sample mean GPA of 3.144 belong to HIGH GPA, while students with lower GPA than the sample mean GPA to LOW GPA. As shown in Panel A of Table 3, there are significant differences in total scores between online learners and offline learners in LOW GPA group, while no significant differences between online learners and offline learners in HIGH GPA group. Offline learners with low GPA do significantly better than online learners with low GPA by on average of 9.461 points, which is statistically significant at 1%.

Table 4: Mean Comparisons after Controlling of Gender			
Panel A: Total Scores			
Item	Online	Offline	Difference
Male	Mean: 69.41176	Mean: 74.58333	Mean diff: -5.17
	SD: 18.129	SD: 14.1616	t-val: 0.89031
	N:17	N:15	(p-val: 0.38039)
Female	Mean: 70.28629	Mean: 72.65	Mean diff: -2.3637
	SD: 13.619	SD: 11.932	t = 0.75784
	N:62	N:25	p = 0.45064
Panel B: Multiple Choice Scores			
Item	Online	Offline	Difference
Male	Mean: 45.79412	Mean: 46.76667	Mean diff: 0.97252
	SD: 6.339	SD: 7.088	t-val: 0.4098
	N:17	N:15	(p-val: 0.68487)
Female	Mean: 44.39516	Mean: 46.16	Mean diff: -1.7649
	SD: 7.710	SD: 5.796	t = 1.03151
	N:62	N:25	p = 0.30523
Panel C: Non-Multiple Choice Scores			
Item	Online	Offline	Difference
Male	Mean: 24.79412	Mean: 27.85	Mean diff:
	SD: 9.8924	SD: 7.611	t-val: 0.96917
	N:17	N:15	(p-val:0.34021)
Female	Mean: 25.89113	Mean: 26.51	Mean diff: -0.6189
	SD: 6.8289	SD: 7.2033	t = 0.37658
	N:62	N:25	p = 0.70743

The similar results are found for multiple choice scores shown in Panel B of Table 3. Offline learners in both LOW GPA and HIGH GPA groups earn higher points in multiple choices than online learners by on average 5.583 points in LOW GPA and 2.207 points in HIGH GPA, which are statistically significant at 1% and 10 %, respectively. This different performance between on line learners and off line learners may not be due to the difference in question type, because both on line class and its matching off line class were taught by the same instructor using the same textbook and supplementary learning materials. Besides that, the instructor used and graded the same student learning assessment rubrics including questions in both on line class and its matching off line class.

Table 5: Mean Comparisons after Controlling for Age

Panel A: Total Scores			
Item	Online	Offline	Difference
Young	Mean: 72.1087	Mean: 72.96774	Mean diff:-0.8590
	SD: 13.579	SD: 12.769	t = 0.27877
	N:46	N:31	p = 0.78119
Old	Mean: 66.375	Mean: 76.97222	Mean diff: -10.5972
	SD: 14.972	SD: 12.483	t = 1.96319
	N:38	N:9	p = 0.05582
Panel B: Multiple Choice Scores			
Item	Online	Offline	Difference
Young	Mean: 45.51087	Mean: 46.35484	Mean diff:
	SD: 7.535	SD: 6.022	t = 0.5211
	N:46	N:31	p = 0.60383
Old	Mean: 42.88158	Mean: 47.5	Mean diff: -4.618
	SD: 7.080	SD: 6.727	t = 1.77504
	N:38	N:9	p = 0.08265
Panel C: Non-Multiple Choice Scores			
Item	Online	Offline	Difference
Young	Mean: 26.59783	Mean: 26.64516	Mean diff: -0.0474
	SD: 6.936	SD: 7.5987	t = 0.02826
	N:46	N:31	p = 0.97753
Old	Mean: 24.01974	Mean: 29.47222	Mean diff: -5.4525
	SD: 8.0222	SD: 6.5555	t = 1.89009
	N:38	N:9	p = 0.0652

If students with low GPA have poorer studying habits than those with high GPA, it is intuitively appealing that students with low GPA perform better in a more controlled learning environment (Off line course) then in a self driving learning environment (On line course).

However, there are no significant differences in non-multiple choice scores between online and offline learners.

To control for the effect of gender on performances, sample students are divided into female group and male group. As shown in Table 4, there are no significant differences in total scores, multiple choice scores, and non-multiple choice scores between female online learners and male offline learners. Similar results are observed from male learners.

Table 6: Mean Comparisons after Controlling for Working Hours			
Panel A: Total Scores			
Item	Online	Offline	Difference
Short working hours	Mean: 70.98611	Mean: 72.65385	Mean diff:-1.66774
	SD: 14.2171	SD: 14.395	t = 0.37974
	N:18	N:26	p = 0.70605
Long working hours	Mean: 70.21795	Mean: 76.25	Mean diff:
	SD: 13.959	SD: 8.9320	t = 1.45639
	N:39	N:13	p = 0.15154
Panel B: Multiple Choice Scores			
Item	Online	Offline	Difference
Short working hours	Mean: 44.66667	Mean: 45.80769	Mean diff:-.4109
	SD: 7.3083	SD: 6.9743	t = 0.52328
	N:18	N:26	p = 0.60353
Long working hours	Mean: 43.42308	Mean: 48.11538	Mean diff:-4.6923
	SD: 7.9128	SD: 4.032	t = 2.04193
	N:39	N:13	p = 0.04645
Panel C: Non-Multiple Choice Scores			
Item	Online	Offline	Difference
Short working hours	Mean: 26.31944	Mean: 26.88462	Mean diff:-0.56518
	SD: 7.8603	SD: 7.7773	t = 0.23598
	N:18	N:26	p = 0.8146
Long working hours	Mean: 26.79487	Mean: 28.13462	Mean diff: -1.3397
	SD: 6.9497	SD: 7.1031	t = 0.59875
	N:39	N:13	p = 0.55205

Results from comparisons between online learners and offline learners after controlling for the age effect are presented in Table 5. Sample students are classified as young if their ages are lower than the sample mean age, or classified as old. Old offline learners earn higher total scores, multiple choice scores, and non-multiple choice scores than old online learners by on average of 10.5972 points, 4.618 points, and 5.4525 points, respectively, all of which are statistically significant at 10%. However, there are no significant differences in any scores between young online learners and young offline learners.

Results from comparisons between online learners and offline learners after controlling for the effect of working hours are presented in Table 6. Sample students are classified as short working if they work less than the sample mean working hours, or classified as long working. There are no significant differences in any scores between online learners and offline learners in both short working and long working groups.

Regression Analyses

Coefficients of correlations between influencing factors on student performances are computed to control for the interaction effect of those related factors. As shown in Table 7, there is a significant positive correlation between working hours and commuting distance. Age, commuting distance, and working hours have significant positive correlations with online-offline identifier, indicating that online learners are older, live further away from the campus, and work longer hours than off line learners. Thus, product terms of these interrelated factors are included in the following regression model to control for their interaction effects on student performances.[2]

$$\begin{aligned}\text{Scores} = \alpha_0 &+ \alpha_1 \text{ Gender} + \alpha_2 \text{ Age} + \alpha_3 \text{ Distance} + \alpha_4 \text{ Hour} + \alpha_5 \text{ On-Off} \\ &+ \alpha_6 \text{ Distance*Hour} + \alpha_7 \text{ On-Off *Age} + \alpha_8 \text{ On-Off *Distance} \\ &+ \alpha_9 \text{ On-Off *Hour} + \varepsilon \qquad (1)\end{aligned}$$

Where Scores = total score, multiple choice scores, or non-multiple choice scores,
Distance = the distance from a student's residence to the campus,
Hour = the number of working hours,
On-Off = 0 if offline or 1,
α_i = the partial regression coefficients of variable 'i',
ε = the error term.

Results from the multiple regression model (1) are presented in Table 8. The regression coefficients of On-Off are -0.616, -0.508, and -0.639 for total scores, multiple-choice scores, and non-multiple choice scores, respectively, all of which are not statistically significant. These results indicate that there are no significant differences in total scores, multiple scores, and non-multiple scores between online learners and offline learners.

Table 7: Correlation Coefficients						
	Gender	Age	Distance	Working Hour	GPA	On-Off
Gender	1					
Age	-0.067	1				
Distance	0.026	0.112	1			
Working Hour	0.075	0.026	0.358**	1		
GPA	-0.141	0.064	-0.079	-0.075	1	
On-Off	0.129	0.236*	0.472**	0.302**	0.004	1

*: Correction is significant at the 0.05
**: Correction is significant at the 0.01

Table 8: Single-Step Regression Analyses					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Panel 1. Total Scores					
Constant	77.831	14.354		5.422	.000
Age	.016	.358	.010	.044	.965
Distance	.175	.233	.344	.750	.456
Working Hour	.001	.202	.001	.005	.996
Distance * Working Hours	.001	.006	.083	.171	.865
On-Off	16.655	16.234	-.616	1.026	.308
Gender	-.939	3.588	-.033	-.262	.794
GPA	-3.022	3.225	-.118	-.937	.352
On-Off*Age	-.220	.433	-.272	-.507	.613
On-Off *Distance	-.224	.224	-.508	-.999	.321
On-Off * Working Hour	-.235	.277	-.310	-.848	.399
Panel 2. Multiple Choice Scores					
Constant	49.091	7.713		6.365	.000
Age	.052	.192	.058	.273	.786
Distance	.127	.125	.458	1.014	.314
Working Hour	.038	.108	.073	.351	.727
Distance * Working Hours	-.002	.003	-.270	-.565	.574
On-Off	-7.496	8.724	-.508	.859	.393

Table 8: Single-Step Regression Analyses					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Gender	-.684	1.928	-.044	-.355	.724
GPA	-2.164	1.733	-.155	-1.248	.216
On-Off*Age	-.147	.233	-.333	-.630	.531
On-Off *Distance	-.090	.120	-.374	-.746	.458
On-Off * Working Hour	-.090	.149	-.217	-.603	.548
Panel 3. Non-Multiple Choice Scores					
Constant	28.704	7.624		3.765	.000
Age	-.036	.190	-.042	-.192	.849
Distance	.047	.124	.177	.382	.703
Working Hour	-.037	.107	-.074	-.348	.729
Distance * Working Hours	.003	.003	.436	.895	.374
On-Off	-9.124	8.623	-.639	1.058	.294
Gender	-.240	1.906	-.016	-.126	.900
GPA	-.839	1.713	-.062	-.490	.626
On-Off*Age	-.073	.230	-.172	-.319	.751
On-Off *Distance	-.134	.119	-.575	-1.124	.265
On-Off * Working Hour	-.145	.147	-.362	-.985	.328

Another way to measure a net effect of On-Off on Scores after controlling for the effects of all the other influencing variables is to run a two- step regression in which the following regression model is estimated in the first step,

$$\text{Scores} = \alpha_0 + \alpha_1 \text{ Gender} + \alpha_2 \text{ Age} + \alpha_3 \text{ Distance} + \alpha_4 \text{ Hour} + \alpha_6 \text{ Distance*Hour} + \alpha_7 \text{ On-Off *Age} + \alpha_8 \text{ On-Off *Distance} + \varepsilon \qquad (2)$$

In the second step, the error term from the first step (ε) is regressed over On-Off variable using the following model,

$$\varepsilon = \beta_0 + \beta_1 \text{ On-Off } + 3 \qquad (3)$$

Results from this two-step regression analyses are presented in Table 9. The regression coefficients of On-Off from the model (3) are -1.002, -0.779, and –0.714 for total scores, multiple choice scores, and non-multiple choice scores, respectively, all of which are not statistically significant. These results are consistent with those from a multiple regression (1) reported in Table 9.

Table 9: Two-Step Regression Analyses					
Panel 1. Total Scores					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	.664	2.510		.265	.792
On-Off	-1.002	3.083	-0.036	-.325	.746
Panel 2. Multiple Choice Scores					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	0.441	1.184		0.373	0.710
On-Off	-.779	1.574	-0.055	-0.495	0.622
Panel 3. Non-Multiple Choice Scores					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	0.404	2.214		0.183	0.856
On-Off	-0.714	2.942	-0.027	-.243	0.809

Mann-Whitney Test

To mitigate the problem of skewness and outliers in Scores, a non-parametric method called Mann-Whitney test is conducted for the performance difference between online learners and offline learners. As presented in Table 10, Z-values are -0.881, -1.343, and –0.332 for total scores, multiple scores, and non-multiple scores, respectively, all of which are not statistically significant at 10%. This confirms that there are no significant differences in total scores, multiple scores, and non-multiple scores between online learners and offline learners, again.

In sum, from comparative static analyses we found that students with low GPA perform better in off line courses than in on line courses. Old students also do better in off line course that in on line courses. From regression analyses and Mann-Whitney test we could not find any significant difference in student performance between on line learners and off line learners, which is robust across different performance measures and testing methodologies.

Table 10: Mann-Whitney Test				
Panel 1. Total Scores				
GRADE	ON_OFF	N	Mean Rank	Sum of Ranks
	Offline	40	53.09	2123.50
	Online	59	47.91	2826.50
	Total	99		
	Z value = -0.881 p-value = 0.378			
Panel 2. Multiple Choice Scores				
GRADE	ON_OFF	N	Mean Rank	Sum of Ranks
	Offline	40	54.70	2188.00
	Online	59	46.81	2762.00
	Total	99		
	Z value = -1.343 p-value = 0.179			
Panel 3. Non- Multiple Choice Scores				
GRADE	ON_OFF	N	Mean Rank	Sum of Ranks
	Offline	40	51.16	2046.50
	Online	59	49.21	2903.50
	Total	99		
	Z value = -0.332 p-value = 0.740			

CONCLUSIONS

Student performances in multiple choice and non-multiple choice questions are examined to see if there is any difference in the performance between on line learners and off line learners in this study. Academic and demographic data of 119 students who took undergraduate accounting courses offered through online as well as offline at California State University-San Bernardino during a three-year period extending from fall 2003 to spring 2005 are examined.

A couple of interesting findings are that students with low GPA perform better in off line courses than in on line courses. Old students also do better in off line course that in on line courses. These findings may have an important implication for student admission decisions to on line classes. In general, results other than the above mentioned two suggest that there are no significantly different student performances between on line learners and off line learners, which is robust across different performance measures and testing methodologies.

ENDNOTES

1 A sample exam consisting of multiple choice and non-multiple choice questions is presented in the appendix.

2 GPA is not included as an independent variable in the regression model because there is no significant difference in GPA between online learners and offline learners as shown in Table 1.

REFERENCES

Barker, Phillip (2002). On being online tutor. Innovations in Education and Teaching International, Vol 39 (1), 3-13.

Beard, L. A. & C. Harper (2002). Student perception of online versus campus instruction. *Education, Vol. 122 (4),* 658-664.

Chamberlin, W. S. (2001). Face to face vs. cyberspace: finding the middle ground. *Syllabus, Vol. 15*, 11.

Cuellar, N. (2002). The Transition from Classroom to Online Teaching. *Nursing Forum*. July/Sep. pp. 5-13.

Dunbar, Amy E. (2004). Genesis of an Online Course. *Issues in Accounting Education. Vol 19, No.3,* pp 321-343.

The Institute for Higher Education Policy. (1999). What's the difference?: A review of contemporary research on the effectiveness of distance learning in higher education

Kendall, Margaret (2001). Teaching online to campus-based students: The experience of using WebCT for the community information module at Manchester Metropolitan University. *Education for Information, Vol 19,* 325-346.

Lightner, S. & C. O. Houston (2001). Offering a globally-linked international accounting course in real time: a sharing of experiences and lessons learned. *Journal of Accounting Education, Vol 19 (4),* 247-263.

Orde, Barbara J., J. Andrews, A. Awad, S. Fitzpatrick, C. Klay, C. Liu, D. Maloney, M. Meny, A. Patrick, S. Welsh & J. Whitney (2001). Online course development: Summative reflections. *International Journal of Instructional Media, Vol. 2 (4),* 397-403.

Perreault, H., Waldman L. & Zhao, M. (2002) . Overcoming Barriers to Successful Delivery of Distance-Learning Courses. *Journal of Education for Business*. July/August. 313-318.

Schulman, A. & Sims, R. (1999). Learning in an Online Format versus an In-class Format: An Experimental Study. *Journal Online*

Schwartzman, R. & H. Tuttle (2002). What can online course components teach about improving instruction and learning?. *Journal of Instructional Psychology, Vol. 29, No.* ,29-38.

Sullivan, Patrick. (2001). Gender differences and the online classroom: male and /female college students evaluate their experiences. *Community College Journal of Research and Practice. Vol. 25*, 805-818.

Woods Jr., Robert H (2002). How much communication is enough in online courses? – exploring the relationship between frequency of instructor-initiated personal email and learner's perceptions of and participation in online learning. *International Journal of Instructional Media, Vol. 29(4),* pp.377-394.

Yin, L. Roger, L. E. Urven, R. M. Schramm & S. J. Friedman (2002). Assessing the consequences of on-line learning: issues, problems, and opportunities at the University of Wisconsin-Whitewater. *Assessment Update, Vol 14, No. 2,* pp. 4-13.

Younger, Michael, M. Warrington & J. Williams (1999). The Gender Gap and Classroom Interactions: reality and rhetoric?. *British Journal of Sociology of Education; Vol. 20.* 325-341.

Appendix: A Sample Exam.
Exam II (ACCT 347)

Name: __________________________ Date: _____________

Multiple Choice (20 x 3 = 60 points)

1. Hartley, Inc. has one product with a selling price per unit of $200, the unit variable cost is $75, and the total monthly fixed costs are $300,000. How much is Hartley's contribution margin ratio?
   A) 62.5%.
   B) 37.5%.
   C) 150%.
   D) 266.6%.

2. Which statement describes a fixed cost?
   A) It varies in total at every level of activity.
   B) The amount per unit varies depending on the activity level.
   C) Its total varies proportionally to the level of activity.
   D) It remains the same per unit regardless of activity level.

3. Which statement below describes a variable cost?
   A) It varies in total with changes in the level of activity.
   B) It remains constant in total over different levels of activity.
   C) It varies inversely in total with changes in the level of activity.
   D) It varies proportionately per unit with changes in the level of activity.

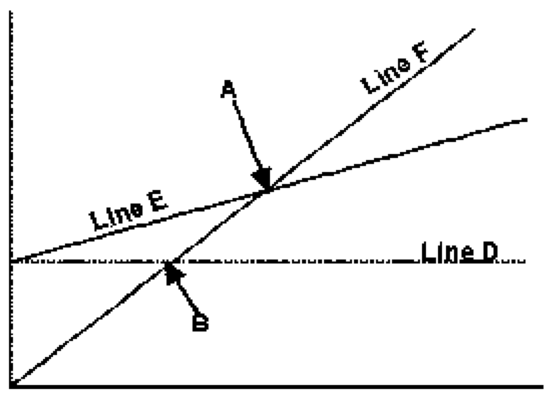
4. Which one of the following is most likely a variable cost?
   A) Direct materials
   B) Depreciation
   C) Rent expense
   D) Property taxes

5. If a company identifies it has a mixed cost, which one of the following is a reasonable option?
   A) It should break it into a variable cost element and a fixed cost element.
   B) It should consider the cost to be a fixed cost.
   C) It should consider the cost to be a variable cost.
   D) It should omit the cost from the analysis.

6. Which one of the following computes the margin of safety ratio?
   A) actual sales – break-even sales
   B) (actual sales – break-even sales) ÷ actual sales
   C) (actual sales – break-even sales) ÷ break-even sales
   D) (actual sales – expected sales) ÷ break-even sales

7. Wasp, Inc. produced 200 items and had the following costs: Hourly labor, $5,000, depreciation, $2,000; materials, $2,000; and rent, $3,000. How much is the variable cost per unit?
   A) $60
   B) $50
   C) $25
   D) $35

8. Select the correct statement concerning the cost volume-profit graph that follows



   A) The point identified by 'B' is the breakeven point.
   B) Line F is the break even line.
   C) Line F is the variable cost line.
   D) Line E is the total cost line.

9. Which cost is not charged to the product under absorption costing?
   A) direct materials.
   B) direct labor.
   C) variable manufacturing overhead.
   D) fixed administrative expenses.

10. Variable costing
    - A) is used for external reporting purposes.
    - B) is required under GAAP.
    - C) treats fixed manufacturing overhead as a period cost.
    - D) is also known as full costing.

11. In income statements prepared under absorption costing and variable costing, where would you find the terms contribution margin and gross profit?

	Contribution margin	Gross profit
A)	In absorption costing income statement	In variable costing income statement
B)	In absorption costing income statement	In both income statements
C)	In variable costing income statement	In absorption costing income statement
D)	In both income statements	In variable costing income statement

12. When units produced exceeds units sold,
    - A) net income under absorption costing is higher than net income under variable costing.
    - B) net income under absorption costing is lower than net income under variable costing.
    - C) net income under absorption costing equals net income under variable costing.
    - D) the relationship between net income under absorption costing and net income under variable costing cannot be predicted.

13. If a division manager's compensation is based upon the division's net income, the manager may decide to meet the net income targets by increasing production
    - A) when using variable costing, in order to increase net income.
    - B) when using variable costing, in order to decrease net income.
    - C) when using absorption costing, in order to increase net income.
    - D) when using absorption costing, in order to decrease net income.

14. Manuel Company's degree of operating leverage is 2.0. Techno Corporation's degree of operating leverage is 6.0. Techno's earnings would go up (or down) by ________ as much as Manual's with an equal increase (or decrease) in sales.
    - A) 1/3
    - B) 2 times
    - C) 3 times
    - D) 6 times

15. In cost-plus pricing, the target selling price is computed as
    - A) variable cost per unit + desired ROI per unit.
    - B) fixed cost per unit + desired ROI per unit.
    - C) total unit cost + desired ROI per unit.
    - D) variable cost per unit + fixed manufacturing cost per unit + desired ROI per unit.

16. In cost-plus pricing, the markup percentage is computed by dividing the desired ROI per unit by the
    - A) fixed cost per unit.
    - B) total cost per unit.
    - C) total manufacturing cost per unit.

D) variable cost per unit.

17. The cost-plus pricing approach's major advantage is
A) it considers customer demand.
B) that sales volume has no effect on per unit costs.
C) it is simple to compute.
D) it can be used to determine a product's target cost.

18. The following per unit information is available for a new product of Blue Ribbon Company:

Desired ROI	$ 48
Fixed cost	80
Variable cost	120
Total cost	200
Selling price	248

Blue Ribbon Company's markup percentage would be
A) 19%.
B) 24%.
C) 40%.
D) 60%.

19. Bryson Company has just developed a new product. The following data is available for this product:

Desired ROI per unit	$36
Fixed cost per unit	60
Variable cost per unit	90
Total cost per unit	150

The target selling price for this product is
A) $186.
B) $150.
C) $126.
D) $96.

20. In time and material pricing, the charge for a particular job is the sum of the labor charge and the
A) materials charge.
B) material loading charge.
C) materials charge + desired profit.
D) materials charge + the material loading charge.

21. Ripple Company bottles and distributes Ripple Fizz, a flavored wine beverage. The beverage is sold for $1 per 8-ounce bottle to retailers. Management estimates the following revenues and costs at 100% of capacity.(10 points)

Net sales	$2,100,000	Selling expenses-variable	$90,000
Direct materials	500,000	Selling expenses-fixed	70,000
Direct labor	300,000	Administrative expenses-variable	20,000

Manufacturing overhead-variable	350,000	Administrative expenses-fixed	50,000
Manufacturing overhead-fixed	275,000		

Instructions

A. How much is net income for the year using the CVP approach?

B. Compute the break-even point units and dollars.

C. How much is the contribution margin ratio?

22. Determine whether each of the following would be a product cost or a period cost under an absorption or a variable system for Carson Company (10 points).

	Absorption		Variable	
	Product	Period	Product	Period
a. Direct Materials	_______	_______	_______	_______
b. Direct Labor	_______	_______	_______	_______
c. Factory Utilities (variable)	_______	_______	_______	______
d. Factory Rent	_______	_______	_______	_______
e. Indirect Labor	_______	_______	_______	_______
f. Factory Supervisory Salaries	_______	_______	_______	______
g. Factory Maintenance (variable)	_______	_______	_______	______
h. Factory Depreciation	_______	_______	_______	_______
i. Sales salaries	_______	_______	_______	_______
j. Sales commissions	_______	_______	_______	_______

23. Momentum Bikes manufactures a basic road bicycle. Production and sales data for the most recent year are as follows (no beginning inventory): (10 points)

Variable production costs	\$90 per bike
Fixed production costs	\$450,000
Variable selling & administrative costs	\$22 per bike
Fixed selling & administrative costs	\$500,000
Selling price	\$200 per bike

Production	20,000 bikes
Sales	17,000 bikes

Instructions
(a) Prepare a brief income statement using variable costing.
(b) Compute the amount to be reported for inventory in the year end variable costing balance sheet.

24. Trout Company is considering introducing a new line of pagers targeting the preteen population. Trout believes that if the pagers can be priced competitively at $45, approximately 500,000 units can be sold. The controller has determined that an investment in new equipment totaling $4,000,000 will be required. Trout requires a return of 14% on all investments. (10 points)

Instructions
Compute the target cost per unit of the pager.

IS PROCESS INNOVATION EVOLUTION IN ORGANISATIONS

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ABSTRACT

This study identifies how Information System process innovations' (ISPIs) were evolved in three organisations using a sample of 124 internally developed ISPIs over a period that spanned four decades.

The four distinct time generations analysed are early computing (1954-1965); main frame era (1965-1983); office computing era (1983-1991), and distributed applications era (1991-1997). These follow roughly Friedman's and Cornford's categorisation of IS development eras. Four categories of ISPI's are distinguished: base line technologies (T), development tools (TO), description methods (D), and managerial process innovations (M).

ISPI evolution in the three organisations is characterised with two types of modifications based on Tolvanen's (1998) local method development framework: the degree and frequency of modifications. The degree of ISPI modification defines how large the changes are that are made to the local ISPI to improve its applicability. The frequency of ISPI modification explains how often an ISPI is changed.

For each era the variation between the modifications in the four ISPI categories is analysed. The analysis shows that within the organisations, the degree of ISPI modifications and the frequency of ISPI modifications varied significantly in the ISPI categories. The variation can be partly explained by differences in the development environments, differences in ISPI categories, and the differences in the organisations.

Keywords: Empirical research, Longitudinal Study, IS Process Innovations, degree of ISPI modification, frequency of ISPI modification

INTRODUCTION

One type of innovation, called here Information System (IS) Process Innovation has become important for organisational effectiveness. IS process innovation (ISPI) is defined here as any new way of developing, implementing, and maintaining information systems in an organisational context (Swanson, 1994).

IS development (ISD) can be described as a change process, which aims at improving and changing a present information system (IS) or implementing a new information system. IS process innovations (ISPIs) on the other hand play a major role in changing the information system development (ISD) process in organisations, and they can improve the process and outcomes of information systems. In the context of our paper we consider that a specific ISPI is chosen for use at a specific ISD project.

Our ISPI definition is relatively broad and covers a wide range of innovative activity within IS development. First, an ISPI can embrace changes in the technologies that offer new computing functionality or novel non-functional features (like portability, security) for the delivered IS. Typical technological innovations include adoptions of programming languages or operating systems. ISPIs can also include administrative innovations, such as the deployment of project management methods, the introduction of participative approaches to guiding development interactions, or the contracting of development work outside. In Swanson's terminology, ISPIs thus cover thus both technological (Type Ia) as well as administrative innovations (Type Ib) (Swanson, 1994).

Both administrative and technological innovations can be further classified into two sub-categories. In the administrative ISPI category we distinguish between management innovations (M) and description innovations (D). Within the technological innovations, we separate between tool innovations (TO) and core technology innovations (T). The motivation for such classification is that most of the IS development literature clearly distinguishes between organisational innovations (like project management principles, programming teams, extreme programming) and notational innovations (like the development of UML, method engineering and so forth). Some ISPIs specifically address the need for software engineering task improvement or advance core technologies including programming languages or data base management systems.

Management innovations (M) embrace changes in rules and administrative processes that improve, control, manage and co-ordinate development activities. Examples of managerial innovations are project management guidelines or organisational arrangements, such as chief programmer teams (Swanson, 1994). Description innovations (D) include changes in notational systems and standards, which are used to describe and communicate development products or processes between different stakeholders. Such innovations include the adoption of standardised modelling techniques like Data Flow Diagrams or Unified Modelling Language (UML). Some ISPIs- especially within description and managerial innovations- have long life spans. Cases in point are the more abstract concepts of decomposition and structured design or the idea object orientation (Fichman and Kemerer, 1993). Such ISPIs create cumulative paths within organisations that over time solicit incremental flows of complementary innovations, which center on a focal "starting" ISPI. Some ISPIs can thereby induce disruptive innovations into ISD processes as they fundamentally change the nature of the problems and design spaces they impose (Lyytinen and Rose, 2003).

Tool innovations (TO) include capital-intensive software assets such as application generators, CASE tools, documentation tools, data dictionaries, etc. They may also include mundane technologies that range from desktop publishing software, GroupWare applications to indexing software. Core technologies (T) consist of improvements in technical platforms that are critical to delivering the IS products and include, among others programming languages, database management systems, telecommunication software, middleware frameworks, etc. These ISPIs often have a short life expectancy and thus suggest a continued pursuit of innovation.

One aspect in ISPI evolution is the dynamics in the development practices, i.e. how the set of ISPIs used changes over time in locales (Friedman and Cornford, 1989). Based on Friedman and Cornford (1989) ISPIs are classified into several eras. Friedman and Cornford (1989) point out- based on an extensive empirical analysis of the historical evolution of IS development- that the four categories of innovations discussed above are often closely "horizontally" related, and they can be accordingly classified into a set of evolutionary generations. Shifts between generations in Friedman's and Cornford's analysis are caused by: 1) changes in hardware and software (T/TO innovations), 2) changes in types of systems being developed i.e. harnessing computing capability into untried organisational domains and tasks (what Swanson (1994) calls type II and type III IS innovations, respectively); and resulting in 3) changes in types of users. The latter two form external pull factors that drive the content and scope of ISPIs within each generation.

In this study four ISPI generations are recognised over a 43 year time period starting from the year 1954. The first generation (from the late 1940s until the mid 1960s) is largely hampered by "hardware constraints", i.e. hardware costs and limitations in its capacity and reliability (lack of T innovations). The second generation (from the mid 1960s until the early 1980s), in turn, is characterised by "software constraints", i.e. poor productivity of system developers and difficulties in delivering reliable systems on time and within budget (lack of D, M, and TO innovations). The third generation (early 1980s to the beginning of 1990s), is instead driven by the challenge to overcome "user relationships constraints", i.e. system quality problems arising from inadequate perception of user demand and resulting in inadequate service (lack of M, D, and TO innovations). Finally, the fourth generation (from the beginning of 1990s) was affected by "organisational constraints" (lack of M and D innovations). In the latter case the constraints arose from complex interactions between computing systems and specific organisational agents including customers and clients, suppliers, competitors, co-operators, representatives and public bodies (Friedman and Cornford, 1989).

In addition to above concepts an important concept defined is development units. Development units are generally: "regions involved as part of the setting of interaction, having definite boundaries, which help to concentrate the interaction in one way or another" (Giddens, 1984, p. 375). Our definition is purposefully loose in that a development unit may comprise of a single formal organisational unit, or several units; or a half of a unit, if such a unit is the target of the development behaviour. A focal point in distinguishing a development unit is the assumed scope within which the people are expected to develop an ISPI, or know about it. We denote development units as locales.

After Tolvanen (1998) ISPI evolution is defined as how the general ISPI modifications affect ISPI development relevant to the ISD situation in hand. Tolvanen (1998), Harmsen et al. (1994a, 1994b), and Hardy et al. (1995) defined two dimensions of ISPI modifications as follows. The first dimension, the degree of ISPI modifications is defined as how large a change is required to the local method to improve its applicability (Tolvanen, 1998; Harmsen, et al., 1994a, 1994b). The second dimension, the frequency of ISPI modifications explains how often a method needs to be changed (Hardy et al., 1995). More specifically, it measures how often changes in the ISD situations are reflected in the methods (Tolvanen, 1998).

Wynekoop and Russo (1993) argue even though the organisations' local methods are relatively common it is not known why and how organisations develop their methods, or how frequently methods are refined or updated. An effort has been made to identify evolution paths between different types of methods or even to construct a family tree of methods (Smolander et al. 1989). A survey of method's historical evolution can be found from Tolvanen (1998). Tolvanen (1998) argues that the methods must be viewed from an evolutionary perspective by analysing how organisations develop their methods. Tolvanen (1998, p. 59) characterises the local method development with the degree of and the frequency of modifications (Figure 1). Examples of local method development efforts can be found from Tolvanen's (1998) study (see Table 1).

Figure 1. Two dimensions of the local method evolution: the degree and frequency of modifications (in Tolvanen, 1998, p. 59)

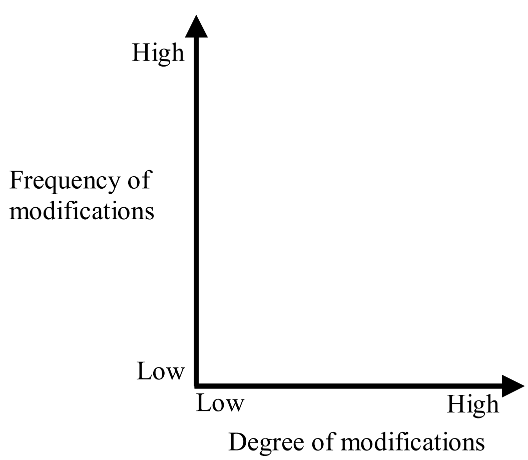


Table 1. Examples of local method development efforts (in Tolvanen, 1998).

Frequency of Modifications	within a method	combine methods	own methods
continuous			Aalto 1993, Jaaksi 1997, Nissen et. al. 1996
project-by-project basis		Bennetts and Wood-Harper 1996	Tollow 1996
organisation contingency based		Kronlöf 1993, Kurki 1996, Cronholm and Goldkuhl 1994	
external method based	FIPS 1993a, CCTA 1995		
	Degree of Modifications		

ISPI EVOLUTION MODEL

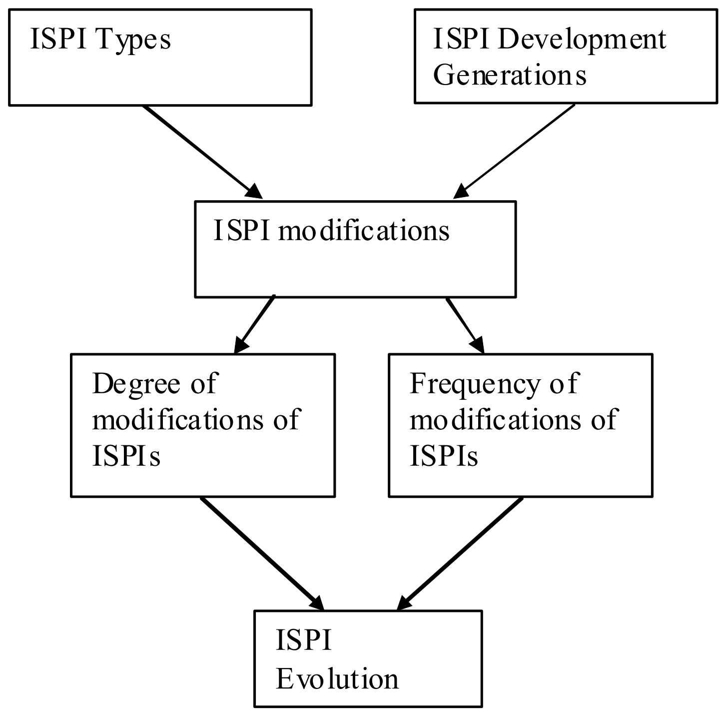
In this study the evolution of local ISPIs is studied by carrying out an analysis where the focus is on two dimensions of ISPI evolution, the degree of ISPI modifications and the frequency of ISPI modifications (see Figure 1, and Table 1). In our study three Finnish organisations were used as case examples over a 43-year time period (1954-1997). This investigation is crucial for ascertaining how the degree of ISPI modifications and frequency of ISPI modifications are varied.

While past research does not help to analyse the variation between the ISPI modifications over time, Tolvanen's (1998) local method development framework (Figure 1) was adopted to draw attention to the ISPI modifications. Tolvanen (1998) classifies the degree of ISPI modifications into three categories, and the frequency of ISPI modifications into four categories (see Table 2). In the context of ISPIs based on past studies, and Tolvanen's (1998) local method development framework (see Figure 1) we derived our main research question as follows: "Why and how do ISPI modifications change over time across different ISPI categories and time generations in locales?"

Table 2. Degree of modifications and frequency of modifications in ISPI evolution	
ISPI modification categories (Tolvanen, 1998)	Definition (Tolvanen, 1998)
Degree of ISPI modifications (Tolvanen, 1998): categories D1 to D3	The degree of modifications defines how large the changes are that are made to the local ISPI to improve its applicability (Harmsen et al., 1994a, 1994b)
D1: Tied to the selection paths provided by the ISPI (Harmsen et al., 1994a, 1994b)	Selection paths within a method. Here the only possible modification alternatives are those provided by the method (i.e. built-in flexibility), and thus are limited to a few contingency factors: development of small versus large systems, the use of prototyping, and the use of application packages.
D2: Based on combining ISPIs (Harmsen et al., 1994a, 1994b)	A combination of methods for internal use occurs when a chosen method, and its possible selection paths, does not meet the situational contingencies. The adaptation can be carried out either by combining available methods or method parts, or by modifying a single method for internal use.
D3: Based on the development of an organisation's own ISPI (Harmsen et al., 1994, 1994b)	An organisation or a project which develops its own methods faces situations which are outside the set of situations to which known methods are suited. Minor modifications into known methods are no longer sufficient.
Frequency of ISPI modifications (Tolvanen, 1998): categories F1 to F4.	How often an ISPI is changed (Hardy et al., 1995). More specifically, it measures how often changes in ISD situations are reflected in ISPIs.
F1: Advances and changes in external ISPIs (Tolvanen, 1998)	Method modifications based on advances in external method knowledge are typical in organisations where methods follow a national or industry standard. Thus, new versions are the result of externally decided modifications. Similarly, if the method is supported by a method-dependent CASE tool, the vendor can dictate the frequency of new versions.
F2: Changes in an organisation's ISD situations (Tolvanen, 1998)	Method modifications based on changes in an organisation's ISD situations deal with local method development in which contingencies related to the whole organisation change and are reflected in methods: outsourcing ISD, introducing new technologies, or starting to develop a new type of IS.
F3: A project-by-project basis (once an IS project starts) (Tolvanen, 1998)	Method modifications on a project-by-project basis are considered in method engineering (ME) research to be the most typical. Each project is characterised by individual features which need to be mapped to methods. Modifications are not made during the method use but only at the beginning of every project.
F4: Continuous refinement within a project (Tolvanen, 1998)	Continuous method refinement happens when ISD contingencies are uncertain or change rapidly, e.g. when a new method or methods are used in a new area. These modifications do not occur only at the individual level, but also in ISD projects, and in the longer run in the whole organisation.

In the context of ISPIs based on past studies, and Tolvanen's (1998) local method development framework (Figure 1), an ISPI evolution research model was developed (see Figure 2).

Figure. 2 An ISPI evolution research model.



FIELD STUDY ON ISPI EVOLUTION

A qualitative case study was chosen (Laudon, 1989; Johnson, 1975; Curtis et al., 1988) with a multi-site study approach, where three organisational environments were investigated, known here as companies A, B, and C, respectively. Company A is a big global paper-producer. Company B designs, implements, and maintains information systems mostly for company A but also for other companies in paper industry. The origin of company B is that in 1984 company A transferred its information systems (IS) department into a newly-formed company, company B that was owned partly by company A and partly by the employees of company B. In 1995 company B was further divided into five separate companies. One of them is company C which was located close to the headquarters of company B and continued to serve mainly company A. These three companies' development units have been situated in three separate Finnish cities. Company A was located in city in Eastern part of Finland and housed several IS activities between 1954-1969 in its separate functional departments (accounting, engineering etc.). In 1969 a separate IS department was established, and it was continued until 1984 when the department was transformed into a separate profit center. Company A had also in-house IS activities in Helsinki between the years 1961-1969. During 1969-1984 these belonged to the IS department of company A. Despite having separate locations, we chose to treat both sites as a development unit, named company A, due to the fact the two were working intimately together and belonged to the same IS department and also followed the same formal development guidelines. After the 1984 company B's site in the eastern part of Finland is treated as a separate development unit. Between the years 1995-1997, this site continued to operate separately. The third company -company C- was established in 1989 as a separate division which was located in a different city in Eastern Finland within company B. It continued its existence until 1995 under the formal management of company B. We treat it as a separate development unit because it had totally independent IS development functions. Operated on a different technological platform and it was treated as a separate profit center in company B. The IS and business knowledge within company A's IS department was inherited through outsourcing to company B. Not surprisingly, company B continued the same organisation structure as before the outsourcing, and company A recognised company B easily as its main IS vendor. Considerable organisational development and internal changes, as a result of ISPIs and market changes however, have taken place in fast pace since 1984.

Our study forms a descriptive case study (Yin, 1993): it embodies time, history and context, and it can be accordingly described as a longitudinal case study, which involves multiple time points (Pettigrew, 1985, 1989, 1990). The research approach followed was Friedman's and Cornford's (1989) study, which involved several generations and time points. This was because the bulk of the gathered data was qualitative, consisting of interviews and archival material, of which largely historical research methods were adopted (Copeland and McKenney, 1988; Mason et al., 1997a, 1997b).

Our definitions of ISPI modifications for development formed the basis for interviews and collection of archival material. Empirical data contained tape-recorded semi-structured interviews dealing with the experiences from developing and using ISPIs. The archival files and collected system handbooks, system documentation and minutes of the meetings were explored. The archival data encompassed a period between 1960 and 1997 serving as primary and secondary source of data (Järvenpää, 1991). Thus triangulation was used to verify the veracity of the data by using multiple data sources.

The first round of data was gathered between February 1995 and May 1997. The obtained data set was arranged in a manuscript, which included ISPI events etc. This manuscript was corrected for multiple mistakes and omissions. However since the analysis had several important omissions more data was gathered until November 1997, and a second version of the manuscript was written in December 1997. The new manuscript was again corrected for omissions and mistakes.

The data set was first arranged in the form of a Baseline Story Data manuscript that covered ISPI "events" etc. which were respectively arranged in chronological order. Using the validated data sets the events were arranged into a table were each development decision formed one row. Each row included a description of the company; the year when the development decision was made; its locale; the IS project; an incidence of the degree of ISPI modification; an incidence of the frequency of ISPI modification in each development decisions; and an incidence if the ISPI was internally developed. While "reconstructing" the historical evidence, we assumed that the modification was "influential" when it had supportive data. Thus, we found 124 development decisions where they were present. At the data categorisation stage, the degree of ISPI modifications and frequency of ISPI modifications were divided into four time generations, four ISPI categories, and three locales, which were company A, company B, or company C. Then the data set was converted into a data matrix based on the presence of a specific feature. For a single development decision, called a sample the maximum number of degree of ISPI modifications was three, and the maximum number of frequency of ISPI modifications was four. The data consisted of 16 binary variables; 3 variables for degree of modifications ("tied to the selection paths provided by a method" to "based on development of an organisation's own method"), 4 variables for frequency of ISPI modifications ("advances and changes in external methods" to "continuous refinement within a project"), 3 variables for the four time generations, 3 variables for the three locales, and 3 variables for the four ISPI categories. The presence of a feature was denoted by 1 and absence by 0 (like c.f. Ein-Dor and Segev, 1993). (ISPI category D and time generation one was left out from the analysis due to the lack of data).

From these 16 variables 7 were selected as independent variables which were used to explain the rest of the 9 dependent variables. The independent variables were (1) tied to the selection paths provided by the ISPI, (2) based on combining ISPIs, (3) based on development of an organisation's own ISPI, (4) advances and changes in external ISPIs, (5) changes in an organisation's ISD situation, (6) a project-by-project basis, and (7) continuous refinement within a project. The reason for this selection of the independent and dependent variables was based on our research question.

The variation in the ISPI modifications was modelled with the component plane and the U-matrix (unified distance matrix) representations of the Self-Organizing Map (SOM) (Kohonen, 1989; Ultsch and Siemon, 1990; Kohonen, 1995). The SOM is a vector quantisation method to map patterns from an input space VI onto typically lower dimensional space VM of the map such that the topological relationships between the inputs are preserved. This means that the inputs, which are close to each other in input space, tend to be represented by units (codebooks) close to each other on the map space which typically is a one or two dimensional discrete lattice of the codebooks. The codebooks consist of the weight vectors with the same dimensionality as the input vectors. The training of the SOM is based on unsupervised learning, meaning that the learning set does not contain any information about the desired output for the given input, instead the learning scheme try to capture emergent collective properties and regularities in the learning set. This makes the SOM especially suitable for our type of data where the main characteristics emerging from the data are of interest, and the topology-preserving tendency of the map allows easy visualisation and analysis of the data.

Training of the SOM can be either iterative or batch based. In the iterative approach a sample, input vector *x(n)* at step *n*, from the input space V_I, is picked and compared against the weight vector w_i of codebook with index *i* in the map V_M. The best matching unit *b* (bmu) for the input pattern *x(n)* is selected using some metric based criterion, such as ïï$x(n)$-$w_b$ïï = min_iïï $x(n)$-w_i ïï, where the parallel vertical bars denote the Euclidean vector norm. The weights of the best matching and the units in its topologic neighborhood are then updated towards *x(n)* with rule w_i *(n+1)* = w_i *(n)* + *a(n)* $h_{i,b}(n)$ *(x(n) – $w_i(n)$)*, where *i Î* V_M and *0£a(n) £1* is a scalar valued adaptation gain. The neighborhood function $h_{i,b}(n)$ gives the excitation of unit *i* when the best matching unit is *b*. A typical choice for $h_{i,b}(n)$ is a Gaussian function. In batch training the gradient is computed for the entire input set and the map is updated toward the estimated optimum for the set. Unlike with the iterative training scheme the map can reach an equilibrium state where all units are exactly at the centroids of their regions of activity (Kohonen, 1995). In practice batch training can be realised with a two step iteration process. First, each input sample is assigned best matching unit. Second, the weights are updated with w_i = å$_x$ $h_{i,b(x)}$ *x* / å$_x$ $h_{i,b(x)}$. When using batch training usually few iterations over the training set are sufficient for convergence. In our experiences we used batch learning scheme.

According to the experiences it is desirable to divide the training into two phases: 1) initial formation of a coarsely correct map, and 2) final convergence of the map. During the first phase the width of the function $h_{i,b(x)}$ should be large as well as the value of *a* should be high. The purpose of the first stage is to ensure that a map with no ``topological defects'' is formed. During learning these two parameters should gradually decrease allowing finer details to be expressed in the map. However, in most cases these choices are not so crucial, because the method tends to perform well for a wide range of parameter settings.

The mathematical properties of the SOM algorithm have been considered by several authors (e.g. Kohonen, 1989, 1995; Luttrell, 1989; Cottrel, 1998). Briefly, it has been shown that after learning the weight vectors in the map with no ``topological defects'' specify the centers of the clusters covering the input space and the point density function of these centers tends to approximate closely the probability density function of the input space. Such mapping, of course, is not necessarily unique.

The basic SOM based data analysis procedure typically involves training a 2-D SOM with the given data, and after training, various graphs are plotted and qualitatively or even quantitatively analysed by experts. The results naturally depend on the data, but in the cases, where there are clear similarities and regularities in the data, these can be observed by the formed pronounced clusters on the map. These observable clusters can provide clues to the experts on the dependencies and characteristics of the data, and some data clusters of particular interest can be picked for further more detailed analysis. To help this type of exploratory analysis, a typical visualisation step is so called component plane plotting (Kohonen, 1995), where the components of codebook vectors are drawn in the shape of the map lattice. By looking component planes of two or more codebook variables it is possible to observe the dependencies between the variables. The above type of component plane analysis was performed on the data analysed here.

The U-matrix (unified distance matrix) representation of the SOM (Ultsch and Siemon, 1990) visualises the distances between the neurons, i.e. codebooks. The distance between the adjacent neurons is calculated and presented with different colors. If a black to white colouring schema is used typically a white colour between the neurons corresponds to a large distance and thus a gap between the codebooks in the input space. A black colouring between the neurons signifies that the codebook vectors are close to each other in the input space. Dark areas can be thought of as clusters and light areas as cluster separators. In our case black and white coloured distances between codebooks are shown by colour bar in each U-matrix figure. This U-matrix representation can be a helpful when one tries to find clusters in the input data without having any prior information about the clusters. Of course, U-matrix does not provide definite answers about the clusters, but it gives clues what similarities (clusters) there may be in the data. Teaching SOM and representing it with the U-matrix offers a fast way to get insight on the data distribution. A simple algorithm for a U-matrix computation is as follows. For each node in the map, compute the average of the distances between its weight vector and those of its immediate neighbours. The average distance is a measure of a node's similarity between it and its neighbours.

The SOM map was trained with the data consisting of 124 samples, where each sample consisted of 7 independent variables (i.e., input space dimensionality is 7). After training, the dark units (the low values of the U-matrix) of the SOM represent the clusters, and light units (the high values of the U-matrix) represent the cluster borders.

RESEARCH FINDINGS AND ANALYSIS: ISPI MODIFICATIONS AND THEIR VARIATION OVER TIME ACROSS DIFFERENT ISPI CATEGORIES AND TIME GENERATIONS IN LOCALES

When searching for evidence on how organisations ISPI modifications vary it was discovered that the most important degree of ISPI modification observed was "based on the development of an organisation's own method (D3)" (68 %), and the second important degree of ISPI modification was "tied to the selection paths provided by a method (D1)" (21 %). The total number of occurrences of degree of ISPI modifications' was 171. The most important frequency of ISPI modification observed was "Changes in an organisations' ISD situations (F2)" (38 %), and "A project-by-project basis (once an ISD project starts) (F3)" (34 %). The total number of occurrences of frequency of ISPI modifications was 293 (see Table 3).

Table 3. ISPI modifications.					
Modification categories D1-D3, and F1-F4	Total number of occurrences in category D	Total number of occurrences in category T	Total number of occurrences in category TO	Total number of occurrences in category M	Relative amount in percentages
Degree of ISPI modifications categories					
Tied to the selection paths provided by a method (D1)	0	3	31	2	21 %
Based on combining methods (D2)	0	13	2	5	11 %
Based on the development of an organisation's own method (D3)	4	23	44	44	68 %
Total number of occurrences	4	39	77	51	100 %
Frequency of ISPI modifications categories					
Advances and changes in external methods (F1)	3	8	45	2	19 %
Changes in an organisations' ISD situations (F2)	3	18	45	44	38 %
A project-by-project basis (once an ISD project starts) (F3)	1	28	43	44	34 %
Continuous refinement within a project (F4)	0	22	0	3	8 %
Total number of occurrences	7	76	133	93	100 %
Total number of samples	11	115	210	144	100 %

Then next investigation of how the 124 samples in the data matrix were distributed according to three locales, four ISPI categories, and four time generations was carried out (see Table 4, Table 5, and Table 6).

Table 4. Sample distribution in the three locales.

Locale	Number of samples in category D	Number of samples in category T	Number of samples in category TO	Number of samples in category M	Relative amount %
Locale one (company A)	2	14	15	44	66
Locale two (company B)	0	4	30	2	29
Locale three (company C)	2	9	0	0	5

Table 5. Sample distribution in the four ISPI categories.

ISPI Category	Number of samples	Relative amount %
M (Project management and control procedures)	144	30
T (Technology)	115	21
TO (Development tools)	210	47
D (Description techniques)	11	2

Table 6. Sample distribution in the four time generations.

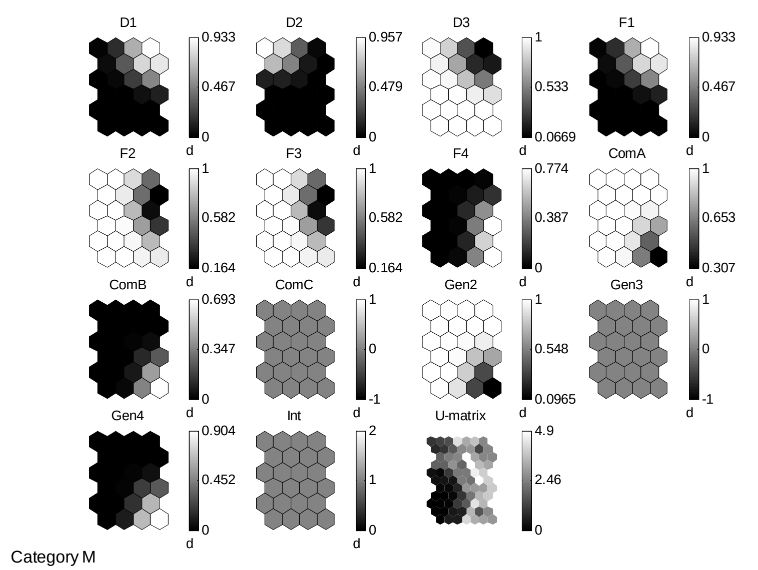
Time generation	Number of samples in category D	Number of samples in category T	Number of samples in category TO	Number of samples in category M	Time frame	Relative amount %
One	0	0	0	0	1954-1965	no samples
Two	2	14	16	43	1965-1984	61
Three	0	2	5	0	1984-1990	7
Four	2	11	24	3	1990-1997	32
Total number of samples	4	27	45	46		100 %

Locale three (company C) has the minority of the samples, and its time generation is the shortest. Locale one (company A) and locale two (company B) are different having a different number of samples and also their time generations are different. Time generation one has no samples, and therefore it is left out from the analysis. ISPI category D (description techniques) has only 2 % of the samples and therefore it is left out from the analysis. While locale one (company A) exists both in time generations one and two, time generation two becomes the most import lasting for 20 years.

The U-matrix visualises the distances between neighbouring map units, and helps to see the cluster structure of the map. The high values of the U-matrix (light units) indicate a cluster border. The elements of the same clusters are indicated by uniform areas of low values (dark units) and thus similar data is grouped together. The colour bar indicates the colour and its meaning. Figure 3 below presents the component planes and the U-matrix in a SOM of 4x6 units of variables in ISPI category M (project management and control procedures) and employing the seven independent variables: D1 (tied to the selection paths provided by the ISPI), D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), F1 (advances and changes in external ISPIs), F2 (changes in an organisation's own ISPI), F3 (a project-by-project basis), and F4 (continuous refinement within a project); and the six dependent variables: ComA (Company A), ComB (Company B), ComC (Company C), time generation two (Gen2), time generation three (Gen3), and time generation four (Gen4).

Figure 4 presents the component planes and the U-matrix in 4x6 units of variables in ISPI category T (base line technology innovations). Figure 5 presents the component planes and the U-matrix in 4x6 units of variables in ISPI category TO (development tools). Notice, that the middle grey colour in a component plane variable, such as in "Int", is a constant being 1 or 0, as its value is in the learning set.

Figure 3. The component planes and the U-matrix in a SOM of 4x6 units of variables D1, D2,D3, F1, F2, F3, F4, ComA, ComB, ComC, Gen2, Gen3, and Gen4 in ISPI category M.

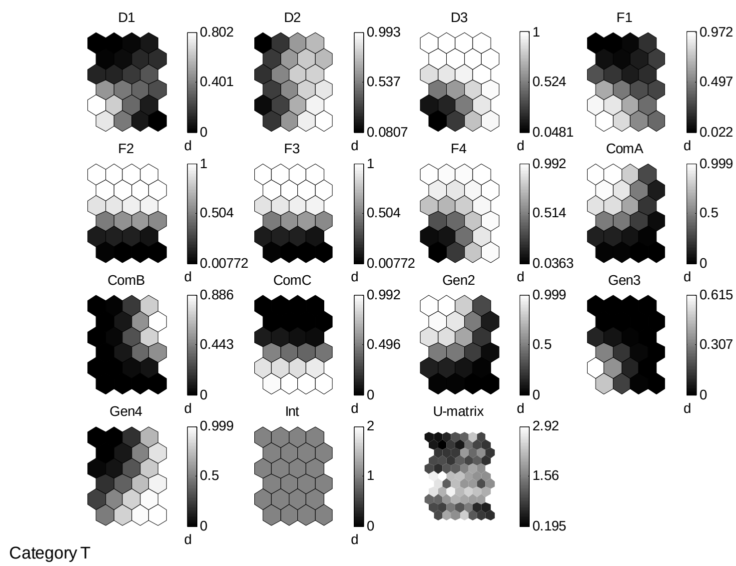


The component planes (the variables D1 to Int), and the U-matrix were investigated, and the following was discovered (Figure 3): Two clearly seen clusters are present in this dataset. The first cluster is situated in the upper left corner of the U-matrix and the second cluster is situated in the lower left corner of the U-matrix for ISPI category M.

In the first cluster (the upper left corner cluster), high values existed in the variables D2, D3, F2, F3, ComA, and Gen2, and the second cluster (the lower left corner cluster), high values existed in the variables D3, F2, F3, ComA, and Gen2.

Only company A in the second time generation (Gen2) used ISPI modifications D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), F2 (changes in an organisation's ISD situations), F3 (a project-by-project basis once an IS project starts). The other companies B and C did not use any modifications in the ISPI category M.

Figure 4. Component planes and U-matrix in a SOM of 4x6 units of variables D1, D2, D3, F1, F2, F3, F4, ComA, ComB, ComC, Gen2, Gen3, and Gen4 in ISPI category T.



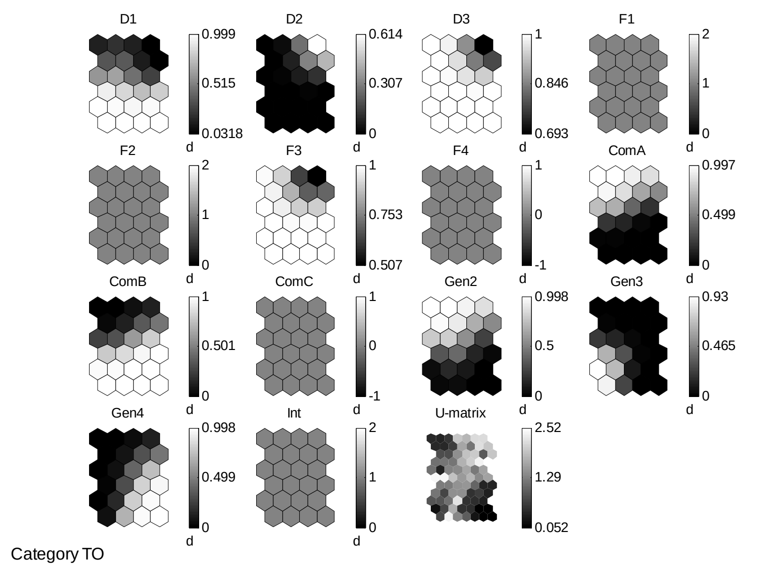
The component planes (the variables D1 to Int), and the U-matrix were investigated, and the following was discovered (Figure 4) in ISPI category T: Two clusters are clearly present in this dataset. The first cluster is in the upper part of the U-matrix, and the second cluster is the lower part of the U-matrix. Between these two clusters there is the cluster border (lighter units).

In the first cluster (the upper part of the U-matrix), high values existed in the variables D2, D3, F2, F3, F4, ComA, and Gen2. In the second cluster (the lower part of the U-matrix), high values existed in the variables D1, D2, D3, F1, F4, ComC and Gen4.

Company A in the second time generation (Gen2) used ISPI modifications D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), F2 (changes in an organisation's ISD situations), F3 (a project-by-project basis once an IS project starts), and F4 (continuous refinement within a project).

Company C in the time generation four (Gen4) used D1 (tied to the selection paths provided by the ISPI), D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), F1 (advances and changes in external ISPIs), and F4 (continuous refinement within a project).

Figure 5. Component planes and U-matrix in a SOM of 4x6 units of variables D1, D2, D3, F1, F2, F3, F4, ComA, ComB, ComC, Gen2, Gen3, and Gen4 in ISPI category TO.



The component planes (the variables D1 to Int), and the U-matrix were investigated, and the following was discovered (Figure 5) in ISPI category TO: Two clusters are clearly present in this dataset. The first cluster is in the upper left part of the U-matrix, and the second cluster is in the lower part of the U-matrix. Between these two clusters there is the cluster border.

In the first cluster (the upper part of the U-matrix), high values existed in the variables D2, D3, F3, ComA, and Gen2, and the second cluster (the down part of the U-matrix), high values existed in the variables D1, D3, F3, ComB, Gen3, and Gen4.

Company A in the second time generation (Gen2) used ISPI modifications D2 (based on combining ISPIs), D3 (based on the development of an organisation's own ISPI), and F3 (a project-by-project basis once an IS project starts).

Company B in the third time generation (Gen3) and four (Gen4) used D1 (tied to the selection paths provided by the ISPI), D3 (based on the development of an organisation's own ISPI), and F3 (a project-by-project basis once an IS project starts).

DISCUSSION AND CONCLUSIONS

Based on found clusters in the Figures 3, 4, and 5 it was found the following issues. Companies B and C in the project management and control procedures category ISPIs did not make any modifications. On the other hand company A in time generation two made modifications to project management and control procedures category ISPIs. Time generation two can be characterised as a poor productivity of the system developers and difficulties of delivering reliable systems on time and within the budget. The modifications were based on combining ISPIs, based on the development of an organisation's own ISPI, changes in an organisation's ISD situations, and on a project-by-project basis.

The reasons for these modifications are as follows. The rules and administrative procedures that help control, manage and co-ordinate ISD activities were always project based. The project management and control procedures category ISPIs were adapted for each project's use. The situations and the environment in which the projects took place were different from each other. The IS project groups developed their own IS project management and control procedures to meet the changing situations in technology, in resources, the project timetables, and the environment. Company A's (locale one) ISD situations changed because the organisation structures were changed and the IS organisation was changed. Outsourcing occurred in 1984 and the IS department was sold out, but the lack of resources (money, time, people) began already in the end of the 1970's, and finally it ended in the outsourcing decision. New technologies came on the market and new types of information systems were developed already in the 1970's, such as the order handling IS for the whole of company A. The project management and control procedures category ISPIs were taken in to use of the beginning of the IS projects and used until the end of the project.

Company A in time generation two made modifications to technology innovations category, which consisted of externally developed technical platforms, like programming languages, database management systems, and middleware components. Time generation two can be described as time of software constraints. The modifications were based on combining ISPIs, based on the development of an organisation's own ISPI, changes in an organisation's ISD situations, a project-by-project basis, and continuous refinement within a project.

Company C in time generation four made modifications to technology innovations category. Time generation four can be described as complex interactions between the systems and the actors, in other words as organisational constraints. The modifications were based on tied to the selection paths provided by the ISPI, based on combining ISPIs, based on the development of an organisation's own ISPI, advances and changes in external ISPIs, and continuous refinement within a project.

Both companies A in time generation two and company C in time generation four used the following modifications: based on combining ISPIs, based on the development of an organisation's own ISPI, and continuous refinement in a project. On the other hand the companies A and C had two differences in modifications: tied to the selection paths provided by the ISPI, and advances and changes in external ISPIs (only time generation two was included). The modification tied to the selection paths provided by the ISPI can be explained with the prototyping and application generators which came on market and were used in information system development. Advances and changes in external ISPIs can be explained by the fact that case tools were taken in to use, external technology platforms were changing: UNIX, windows, object orientation, C language, C++ language etc. were taken in to use.

The development tools category includes productivity tools for system development covering application generators, case tools, documentation tools, data dictionaries, or tools to configure, or manage software components. Time generation two can be described as software constraints, time generation three as user relationships constraints, and time generation four as organisational constraints. Information system development was uncertain and changes occurred rapidly. The whole organisation was changing, and the modifications occurred in the whole organisation. ISD situations changed and even internal ISPIs were modified for internal use. The IS project group developed its own technology category ISPIs. Technology was changing and it affected on the ISD.

Company A in time generation two, and company B in time generation three and four made the similar modifications: tied to the selection paths provided by the ISPI, based on the development of an organisation's own ISPI, and on project-by-project basis modification. Modifications tied to the selection paths provided by the ISPI can be explained by the fact that the development of small versus large systems, the use of prototyping, or use of application packages, such as internally developed Carelia tools. Based on the development of an organisation's own ISPI modification can be explained by the fact that the situations in ISD are changing and ISPIs must be changed. Large modifications are needed. Project-by-project basis modification can be explained by the fact that every IS project makes modifications.

The difference between the companies A and B was that company A in time generation two also used combining ISPIs, because the situational contingencies were not met, and adaptation was needed. Combining a single method, or method parts, or modifying a single method for internal use was important. This combining of ISPIs was the only difference between company A and company

B. Company C in time generation four had no data in development tools category. Table 7 summarises the modifications in the three organisations over time.

Table 7. The modifications in the ISPI categories in three locales over time

Locale	Time generation	Project management and control procedures category	Technology innovations category	Development tools category
Company A (locale one)	Gen 2	Combining of ISPIs, based on the development of an organisation's own ISPI, changes in an organisation's ISD situations, project-by-project basis modification	Combining of ISPIs, based on the development of an organisation's own ISPI, changes in an organisation's ISD situations, project-by-project basis modification, continuous refinement in a project	Modifications tied to the selection paths provided by the ISPI, combining of ISPIs, based on the development of an organisation's own ISPI, project-by-project basis modification
Company B (locale two)	Gen 3	-	-	Modifications tied to the selection paths provided by the ISPI, based on the development of an organisation's own ISPI, project-by-project basis modification
Company B (locale two)	Gen 4	-	-	Modifications tied to the selection paths provided by the ISPI, based on the development of an organisation's own ISPI, project-by-project basis modification
Company C (locale three)	Gen 4	-	Modifications tied to the selection paths provided by the ISPI, combining of ISPIs, based on the development of an organisation's own ISPI, advances and changes in external ISPIs, continuous refinement in a project	-

The analysis reported here shows that in the organisations the ISPI modifications varied significantly according to the ISPI category, and the time generation. The variation in modifications can partly be explained by differences in the development environments, differences in ISPI categories, and difference in the organisations.

Major findings from our field study over time indicated that before the internal IS department outsourcing in 1984 modifications were carried out in technology innovations, development tools, and project management and control procedures category ISPIs. After outsourcing no modifications were made in project management and control procedures ISPIs, and companies B and C began to concentrate on development tools, and technology innovations respectively. Therefore when comparing the modifications in company A and B in development tools category ISPIs the findings indicated that they made almost the same kind of modifications. On the other hand, in technology innovations ISPI category company A and company B used both similar and different modifications.

Our findings indicate clearly that ISPI modifications occur in a deterministic fashion in the organisations. The three organisations spent and great effort, time, and resources to modify the ISPIs to be suitable to ISD. These modifications were necessary to meet the changing IS development environments. In the organisations the decision making to change the ISPIs was rational, and the goal was to develop the IS projects. It was also an economical decision to achieve the customers' needs in the IS projects in certain time and money. ISPI modifications or customisations were made in order to meet the needs of the IS projects. Also the organisations, the locales had their own needs in IS projects to be full filled.

IMPLICATIONS FOR RESEARCH AND METHODOLOGY

Empirical research on how and why ISPIs are modified is lacking. ISPI evolution literature is very rare. This longitudinal data is important, because a horizontal survey research would not have given answers to our research question how and why ISPI modifications were changed over time. One of the most important requirements to study ISPI evolution phenomena in other organisations is that their ISPI evolution, use of ISPIs is based on the Friedman and Cornford's (1989) categorisation of the four time generations.

Swanson (1994) presented three types of innovations in his model whereas in this study his first type innovations (administrative and technological, Ia and Ib) are used for IS task. We further expanded both the Ia and Ib type innovations into two subcategories. In the administrative ISPI category we distinguished between management innovations and description innovation. Within technology innovations, we separated between tool innovations, and core technology innovations. Introducing these innovations into ISPI evolution research is important if we want to integrate empirical ISPI research with design and development of IS research.

We discovered a relationship between degree of modifications of ISPIs and frequency of modifications of ISPIs. The relationship can be seen visually from the Figures 3, 4, and 5 even if we did not measure a correlation or a linear relationship between the modifications. An important implication to methodology is the use of multi method research approach. In this study triangulation (Yin, 1993) was used to increase the reliability of the data. Even if our case study has weaknesses, we produced a logical chain of evidence with multiple data points. Using U-matrix representation as the analysing tools was proved to be suitable to the data analysis, even if there is no study were such a method is previously applied.

IMPLICATIONS FOR PRACTITIONERS

In our study the organisations faced situations were the ISD project groups modified and integrated the ISPIs together in order to manage and control the ISD. The users of the ISPIs become innovators. By the ISPI modifications the organisations enhanced the productivity of an ISPI by increasing its efficiency and effectiveness. ISD practices changed in these organisations, and the ISPIs induced disruptive innovations into ISD processes as they changed the nature of the problems and design spaces they imposed. The studied organisations were forced to invent and modify their own ISPIs suitable for technological platforms for the IS client. The organisations were aggressive and innovative towards modification of the new technologies and they have regarded themselves as the first class technological users, and this innovative tendency continued after the outsourcing. Thus, our findings indicated that IT leaders need to plan IS projects, of course, but that they also need to be flexible. This longitudinal study found that IT leaders work with plans that need to be modified as the plans unfold. If the leaders that we discovered had been unwilling to modify their plans then we believe that the several IS projects would have failed. The IT leaders, however, modified their plans in the companies A, B, and C with the following benefits, such as ISD work succeeded and information systems were delivered on time. It can be said that the plans are important but they must be flexible.

LIMITATIONS AND FUTURE RESEARCH

There are some limitations in our study. First the classification of ISPI data into innovation categories had to be accomplished sometimes by using the limited knowledge of the context and content of the innovation because access to secondary sources was allowed alone. The second limitation was concerned with the limited number of studied companies. The third limitation was concerned with the findings, which can be generalised across a set of organisations with care. At the same time, they showed that generalising explanations for variations in ISPI activities was difficult, and should be made with considerable caution. The fourth limitation was concerned with the results which may not be readily applicable to other organisations since the phenomena in this study was atypical. Thus, generalisation of the results was difficult, but not necessary impossible. If it were possible to collect the same kind of data from other organisations, the analysing methods used in this thesis would be applicable. The fifth limitation was concerned with the research model (Figure 2) suggesting a large number of modifications, which are not easy to observe with the recall method followed, the historical research method is limited, and our division into ISPI categories had to be made roughly, and interpretations are heuristic.

In the future a further subject of study could be the task of describing the ISPI modification process. Furthermore, the modifications' control groups, such as IS project groups, the customers, the users etc. could be also an interesting subject of study. One particular interesting subject of study would be to study the antecedents, and consequences of the ISPI modifications.

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REFERENCES

Aalto, J.-M. (1993). Experiences on Applying OMT to large scale systems. *Proceedings of the seminar on conceptual modelling and object-oriented programming*, 39-47.

Bennets, P. & T. Wood-Harper (1996). A traditional methodology: its context and future. *Proceedings of the 4th Conference on Information System methodologies*, 97-106.

CCTA (Central computer and telecommunication agency) (1995). SSADM4+, R*eference manual.*

Copeland, D.G. & J.L. McKenney (1988). Airline Reservations Systems: Lessons from History. *MISQ,* 353-370.

Cottrell, M. (1998). Theoretical Aspects of the SOM Algorithm. *Neurocomputing*, 21, 119–138.

Curtis, B., H. Krasner, & N. Iscoe (1988). A Field Study of the software design process for large systems. *Communications of the ACM*, 31 (11), 1268-1287.

Ein-Dor, P. & E. Segev (1993). A Classification of Information Systems: Analysis and Interpretation. *Information Systems Research*, 4 (2), 166-204.

Fichman R. & C. Kemerer (1993). Adoption of software engineering process innovations: the case of object orientation. *Sloan Management Review*, 34 (2), 7-22.

FIPS, (1993a). Integration definition for function modelling (IDEFIX). *Federal Information processing Standards publication 183 (FIPS 183).*

Friedman, A.& D. Cornford (1989). *Computer Systems Development: History, Organization and Implementation*. New York: John Wiley & sons.

Giddens, A. (1984). *The Constitution of Society*. Cambridge: Polity Press.

Hardy, C., J. Thomson & J. Edwards (1995). The use, limitations and customization of structured systems development methods in the United Kingdom. I*nformation and Software Technology*, 37 (9), 467-477.

Harmsen, F., S. Brinkkemper & H. Oei (1994a). A language and tool for the engineering of situational methods for information systems development, *Proceedings of the 4th International conference information systems development (ISD'94*), 206-214.

Harmsen, F., S. Brinkkemper& H. Oei (1994b). Situational methods engineering for information system project approaches. *Proceedings of the IFIP WG.1 Working Conference on Methods and Associated Tools for the Information Systems Life Cycle*, 169-194.

Jaaksi, A. (1997). *Object-oriented development of interactive systems*. Doctoral dissertation, Tampere University of Technology.

Johnson, J. M. (1975). *Doing field research*. New York: The Free Press.

Järvenpää, S. (1991). Panning for Gold in Information Systems Research: 'Second-hand' data. *Proceedings of the IFIP TC/WG 8.2,* 63-80.

Kohonen, T. (1989). *Self-Organization and Associative Memory.* Berlin, Heidelberg: Springer-Verlag.

Kohonen, T. (1995). *Self-Organized Maps*. Berlin: Springer-Verlag.

Kronlöf, K. (Ed.) (1993). *Method Intergration: concepts and case studies*. Chichester: John Wiley & Sons.

Kurki, T. (1996). Object-TT: an object-oriented system development model of TT-group Inc. *Systeemityö,* 1, 22-24.

Laudon, K. C. (1989). Design Guidelines for Choices Involving Time in Qualitative Research. *Harvard Business School Research Colloquium, The Information Systems Research Challenger: Qualitative Research Methods*, 1, 1-12.

Luttrell, S. P. (1989). Self-Organization: A derivation from first principles of a class of learning algorithms. *Proceedings of the IJCNN'89 International Joint Conference On Neural Networks*, 495–498.

Lyytinen K. & G.M. Rose (2003). Disruptive Information system innovation: the Case of internet computing. *Information Systems Journal*, 13 (4), 301-330.

Mason, R.O., J.L. McKinney & D.C. Copeland (1997a). Developing an Historical Tradition in MIS Research. *MISQ*, 21 (3), 257-278.

Mason, R.O., J.L. McKenney & D.C. Copeland (1997b). A Historical Method for MIS Research: Steps and Assumptions. *MISQ*, 21 (3), 307-320.

Nissen, H., M. Jeusfeld, M. Jarke, G. Zemanek & H. Huber (1996). Managing multiple requirements perspectives with metamodels. *IEEE Software*, March, 37-48.

Pettigrew, A. (1985). *The Wakening Giant, Continuity and Change in ICI*. Oxford and New York: Basil Blackwell.

Pettigrew, A.M. (1989). Issues of Time and Site Selection in Longitudinal Research on Change. In J.I. Cash Jr. & P.R. Lawrence (Eds.), *The Information Systems Research Challenge: Qualitative Research Methods*, 1, (3-19). Boston, Massachusetts: Harvard Business School Press.

Pettigrew, A.M. (1990). Longitudinal field research on change: theory and practice. *Organization Science*, 1 (3), 267-292.

Russo, N., J. Wynekoop & D. Waltz (1995). The use and adaptation of system development methodologies. *Proceedings of the International conference of IRMA (International Resources Management Association).*

Russo, N., R. Hightower & J. Pearson, J. (1996). The failure of methodologies to meet the needs of current development environments. In N. Jayaratna, B. Fitzgerald (Eds.), Lessons learned from the use of methodologies. *Proceedings of the 4th Conference on Information System Methodologies* (387-394). British Computer Society.

Smolander, K., K. Lyytinen & V-P. Tahvanainen (1989). *Family tree of methods* (in Finnish). Syti project, (internal paper), University of Jyväskylä, Finland.

Swanson, E. B. (1994). Information Systems Innovation Among Organizations. *Management Science*, 40 (9), 1069-1088.

Tollow, D. (1996). Experiences of the pragmatic use of structured methods in public sector projects. In N. Jayaratna, B. Fitzgerald (Eds): lessons learned from the use of methodologies, *Proceedings of the 4th conference on Information System Methodologies* (177-186). British Computer Society.

Tolvanen, J-P. (1998). *Incremental Method Engineering with Modelling Tools: Theoretical Principles and Empirical Evidence*. Doctoral dissertation, University of Jyväskylä.

Ultsch, A. & H.P. Siemon (1990). Kohonen's self organizing feature maps for exploratory data analysis. *Proceeding of the INNC'90, Internal Neural Network Conference*, 305-308. Dordrecht, Netherlands: Kluwer.

Yin, R.Y. (1993). Applications of Case Study Research. *Applied Social Research Methods series*, 34. Beverley Hills, Ca: SAGE publications.

Wynekoop, J. & N. Russo (1993). System Development Methodologies: Unanswered questions and the research-practice gap. *Proceedings of the 14th International Conference on Information Systems*, 181-190.

LONG TERM SURVIVAL AND QUALITY INFORMATION SYSTEMS: A LONGITUDINAL CASE STUDY

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ABSTRACT

Harris, in 1988, studied four high-tech entrepreneurial companies to determine whether their cost accounting systems had an impact on the success of the organizations. Nearly twenty years later, this longitudinal study was launched to determine whether the quality of the information systems and its uses had an impact on management decision making and long term survival of the firms. Only one of the original companies studied has remained in business and thrived. This study not only provided evidence of the necessity for an effective information system that provides data for managerial decision making, but it also highlighted the importance of internal systems that enable the effective usage of that information. Both the external and the internal environment seemed to impact the way in which information was obtained, shared and used and this appeared to impact the long term survival of these firms. Factors such as the stability of management, employee turnover, communication patterns, and organizational structures were noted to be significant factors.

INTRODUCTION

Recently, several leading managerial accounting researchers have critiqued the status of research in their discipline. The following quotes demonstrate their deep concern regarding the breadth and depth of current research:

> *Within the enterprise, accounting has become a less isolated phenomenon as it has become embedded in massive, more generic enterprise wide management systems. It is quite explicitly a part of the wider whole. At the same time, there also has been a significant diffusion of economic calculation throughout the whole enterprise. Accounting is now practiced by many others than just accountants. The forms of economic calculation that it creates are now a part of the functioning of operations, marketing, and a multitude of other departments in the firm (Hopwood, 2007, p. 1370).*
>
> *It has to be recognized that accounting research has experienced difficulty keeping up with these profound changes. Indeed, this is one of the main reasons why more and more questions are being asked about the state of the research art. We know very little about the processes and consequences of standardization and the accountings for new phenomena, let alone new issues that are emerging in the areas of different organizational forms, sustainability and so on (Hopwood, 2007, p.1370).*

> *Normal science testing of steady-state management accounting practice, based on standard economic theory, is certainly worth-while. But this methodology should hardly be the only paradigm to guide our research. The relationship of management accounting to social sciences, such as economics, psychology, sociology, and anthropology, should be like the relationship of engineering to the physical sciences (Kaplan, 2006, p. 129-130).*
>
> *To accomplish this expanded research agenda, management accountants will partner more with their organizational behavior colleagues than with their economists or finance colleagues . . . (Kaplan, 2006, p. 134).*

Two general observations were made by Hopwood and Kaplan about the nature of accounting studies. First, there have been few cross-disciplinary studies involving managerial accounting. Second, the use of longitudinal studies has been sparing. Because the use of longitudinal studies helps to move toward a better understanding of causation (Galbraith & Nkwenti-Zamacho, 2005; McInnes, 1990; Tsikriktsis, 2007), calls for longitudinal studies to provide information on the long term "impact of management decisions" abound in the literature (Galbraith & Nkwenti-Zamcho, 2005, p.429). To date the majority of the existing cost accounting literature has examined the strategic factors surrounding organizations at a specific point in time. These cross-sectional studies, while providing valuable information, do not provide important information that can help demonstrate causality. The purpose of this study is to fill the void in these types of accounting research by demonstrating how managerial accounting concepts can be integrated in a longitudinal, cross-disciplinary format.

In a 1988 field study, Harris examined four high-tech manufacturing firms in Massachusetts to determine whether the information provided by their cost accounting systems had an impact on their success. The findings of that study demonstrated that firms with established cost accounting systems that provide robust information in order to make both long and short term decisions were more favorably positioned to succeed over a long period of time (p. 209). Subsequent research has further analyzed the importance of providing proper information in the analyses of firms and has introduced other important strategic factors.

Since the original study was completed, three of the four manufacturing firms no longer exist as they were in 1988. Only one of the original companies studied has remained in its original form and thrived. Thus, the following questions arise: Did the cost accounting system of the surviving company contribute to the implementation of its successful strategies? How were its systems and strategies different from those of the other three companies researched? What contextual factors contributed to the success of the surviving organization? The purpose of this study is to provide some answers to the above questions, using a longitudinal case study approach.

In the present study, the methodology used in the original Harris study will be expanded. An integrated, longitudinal review of the companies originally examined will be presented in order to determine whether the quality of the information systems did, in fact, have an impact on the long-term survival of the original four companies. In the first part of the study, the nature of the cost accounting systems will be discussed followed by a review of the relevant literature. Then, a longitudinal review of the four high tech firms will be presented. Finally, a set of conclusions and implications from the research results are offered.

COST ACCOUNTING SYSTEMS

Historically, the primary goal of accounting systems has been to provide financial information regarding the economic activities of an organization. Financial accounting systems provide information for external purposes through financial statements such as the balance sheet and the income statement. Cost accounting systems were originally subsystems of these financial accounting systems. Traditionally, the function of cost accounting systems in manufacturing firms has been to provide the financial information necessary to determine the cost of products for inventory valuation and the derivation of a cost of goods sold figure. For those purposes, the original structure of cost accounting systems was considered adequate. However, over time, other uses for cost accounting information have been established. With the evolution of management accounting systems, the role of cost accounting has been expanded to include the provision of information to management for decision making purposes, especially in the areas of organizational planning and control.

One objective of the cost accounting system is to provide management with information regarding the production function so that planning and control decisions within the production activity and across the organization as a whole can be facilitated. Edwards (1985) suggests that the basic purposes of the cost accounting system are to identify resource costs, measure resource consumption, and monitor performance. Additionally, Nanni, Miller, and Vollmann (1988) suggest that the cost accounting system must identify costs and benefits from the 'point of view' of the goal for which they are observed.

Exhibit 1 displays the types of decisions traditionally considered to use cost accounting information within the firm's various functions. For example, top management can use cost accounting information for financial planning purposes, such as planning and budgeting, as well as for performance evaluation and control. Also, cost accounting information can be used by the marketing function in order to assist in establishing prices, define the mix of products to be sold, and calculate break-even points, as well as to determine the profitability of the products sold. It should be noted that the substance of the cost accounting information relies on the requirements and the 'point of view' of the function for which it is being generated. In more general terms, the requirements of the cost accounting system are contingent upon the context within which the system resides.

Thus, in the design of cost accounting systems, the organizational contexts in which they reside should be considered. In addition, the model in Exhibit 2 implies the difficulty in relying on one structure for all cost accounting system. If there is a change in one of the top layers of the prism, all of the bottom layers will have to be changed as well.

Exhibit 1: Traditional Uses of Cost Accounting Data

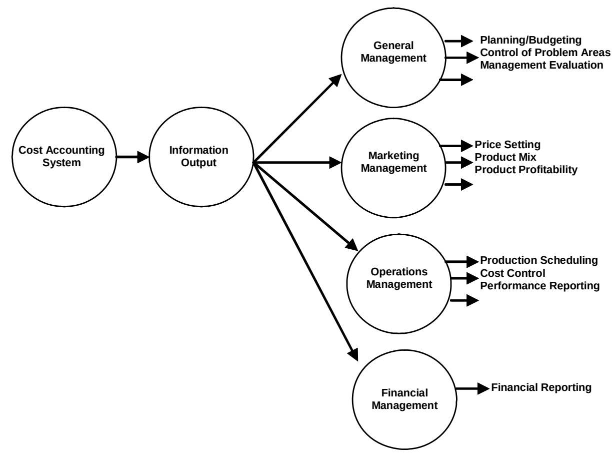
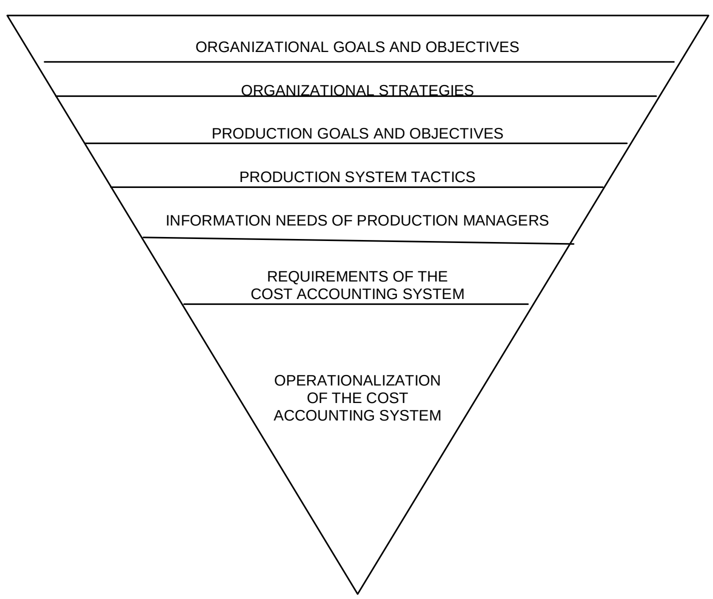


Exhibit 2
Logical Flow Analysis for the
Formulation of the Cost Accounting System



LITERATURE REVIEW

Prior to the 1980s, there had been little research related to the appropriateness of traditional cost accounting theory. In 1983, Kaplan published an article exhorting his colleagues to study cost accounting measurements, since manufacturing technologies had changed so much over the years. Follow-up articles by the same author (Kaplan 1983, 1984, 1986) continued to urge researchers to perform field studies and formulate possible changes from traditional cost accounting. Kaplan strongly believes that the current lack of relevancy in cost accounting can be traced to the failure of researchers to observe, first hand, how management accounting functions in organizations. For example, he states:

> *...If management accounting is to be a central discipline in the design and evaluation of information and control systems of corporations the field will need to expand its vision beyond summary financial measures of manufacturing operations. Much time will need to be spent at factory sites to gain first-hand knowledge of the revolution in manufacturing technology that is occurring in many U.S. corporations. (1983, p. 700)*
> *...the recent academic management accounting literature is devoid of references to actual organizations (1984, p. 407).*
> *...changes in accounting procedure lag far behind changes in the real production phenomena they are supposed to represent. Indeed, the cost accounting operations, much less for the new production processes being introduced by innovating companies. (1986, p. 193).*

The literature posits several sources of the problem with traditional cost accounting. For example, Krommer and Muir (1983) state that, historically, cost accounting systems have not been considered an integral and dynamic part of the management control and measurement process, even though they are the primary barometer of the effectiveness and efficiency of the various operating functions of an organization. The source of the problem, they conclude, is that cost accountants do not understand how cost accounting contributes towards organizational effectiveness.

Edwards and Heard (1984) and Edwards (1985) state that there is a tremendous problem in cost accounting today because management does not understand how to use cost accounting outputs properly. Furthermore, they feel that traditional, formal cost accounting systems have been found wanting since they do not provide information with the proper qualities. Among the deficiencies that they mention is the fact that cost accounting systems do not accurately measure resource consumption or realistically assign resource costs. Also, these authors state that the cost accounting systems present information that is unintelligible and irrelevant to the manufacturing process and does not provide a basis for either the planning or scheduling of future production. Therefore, cost accounting systems must be studied in order to make them more relevant and appropriate.

Similarly, Chalos and Bader (1986) state that new manufacturing technology has "blurred neatly defined demarcations between job systems and process systems and actual or standard costing" (p. 108). They suggest that some form of hybrid costing model be developed, sharing the characteristics of all these systems. Howell and Soucy (1987a), after reviewing new production technologies introduced in manufacturing firms, state that these changes demand management accountants to reassess traditional methods of process control and product cost determination. Also, they feel that the traditional methods by which a company's performance has been analyzed should be altered to reflect the changing fundamental characteristics of the business. In a subsequent article (1987b), these same authors suggest more specific ways in which cost accounting systems might be modified in the determination of product cost and the management and control of costs. Similarly, Seed (1984), Dilts and Russell (1985), Drucker (1985), Holbrook (1985), Schwarzbach (1985) and Vangermeersch (1983), and Keys (1985) demonstrate how the introduction of new production technologies has necessitated a change in cost accounting measurements.

Perhaps, the most significant technological change relates to the adoption by many manufacturing firms of Just-in-Time (JIT) manufacturing processes. In this regard, Mcllhattan (1987) suggests that JIT techniques and the associated changes in manufacturing structure have led to the need for the measurement of 'cost drivers' (process time, inspection time, move time, queue time, and storage time) rather than concentrating on only the traditional costs of manufacture. Sadhwani et al. (1987) also discuss the implications of adopting Just-In-Time techniques on inventories, the work environment and processes, as well as information requirements. Foster and Horngren (1987) examine how cost accounting is affected by the introduction of Just-In-Time methodology and suggest that "there is not a single blueprint for cost accounting and cost management that all organizations are adopting as Just-In-Time is implemented (p. 25).

Nanni, Miller, and Vollmann (1988) attribute the shortcomings of the traditional cost accounting model to its inability to measure performance vis a vis the strategic goals of the firm. They state that a cost accounting system should be able to identify costs, benefits and the 'point of view' from which they are observed. Thus, a viable cost accounting system should allow for the partitioning of a plan according to the desired benefits as well as possess the ability to monitor the amount spent to achieve that particular end. Also, the cost accounting system should be able to identify variances through the cost and benefits, as defined by strategic goals.

McNair and Mosconi (1987) also feel that the key elements in manufacturing strategy must be captured in designing a cost accounting system and that all performance measurements should ensure that attainment of company goals.

Brimson (1986) and Littrell (1984) suggest that when the cost accounting models were originally developed, the information required by management was based upon the premise that products had a long life, spent mostly in the stable mature and declining stages of the product life cycle. Now, however, with the introduction of high technology products, which are characterized by a relatively short life-span, spent mostly in the dynamic start-up and growth stages of the product life cycle, information needs have changed dramatically (i.e., the need to produce information for non-routine decisions).

Moores and Yuan (2001) were interested in the challenges faced by the organization's accountants in adapting to management needs across the various stages of its life. They propose that information must be relevant, accurate and timely as the organizations develop. The shorter product life cycles faced by high technology companies exacerbates the problems managers encounter. In the production process, Rabino and Wright (2002) were concerned with the traditional cost accounting's focus on labor as the major cost component. They suggest that cost accounting should be concerned with the rapidly changing technological and competitive environment. Analyzing design and development costs is the emphasis suggested by Ben-Arieh and Qian (2003). The real answer seems to lie in the information needed by management as opposed to the information developed by the organization's financial accountants Indeed, Bernheim (1983) suggests that the only way in which to properly design cost accounting systems is to determine what types of information is needed by the decision makers. The objective of this study is to investigate the relationship between the strategic factors of manufacturing firms and the structure and substance of their cost accounting systems. The review of the literature above suggests that a variety of strategic factors, including the environment, organization goals and strategies, and technology, affect the appropriateness of cost accounting systems.

METHODOLOGY

In 1988 the original Harris field study of four high-tech manufacturing firms was conducted. Exhibit 3 identifies the general financial characteristics of the 4 high technology companies. On-site, in-depth interviews were conducted with controllers and line production managers of four electronics manufacturing firms in Massachusetts. The format of the interviews was semi-structured. A schedule of structured, open-ended questions was designed to assist in the identification of the traits of the manufacturing firms' cost accounting system and the environmental, technological, and organizational contextual factors of the firms.
The output from this part of the study consisted of data relating to:

1) Management's stated goals for the cost accounting systems;
2) The contextual factors of the manufacturing firms;
3) The structure of the cost accounting systems;
4) The substance of the cost accounting systems.

In addition, the study consisted of analyzing the data accumulated in the interview phase. A classification system suggested by the relationships between the structure and substance of the cost accounting systems and the environmental factors surrounding the firms studied in this research and those reported in a prior cost accounting study (Kaplan, 1986) was devised.

Since the research conducted for this study was of an exploratory nature, the relatively unstructured methodology of grounded research development was selected. The immediate objective of this part of the original study was to determine what types of cost accounting systems currently existed in the sampled firms Exhibit 3) and to identify the contextual factors impacting the firms (Exhibit 4).

Exhibit 3: General Company Financial Characteristics (1988)

	Mass Comp	Prime Computer	Analog Devices	Sprague Electric
Product	Computer Systems	Micro-Computer Systems	Integrated Circuits/Semi-conductors	Integrated Circuits/Capacitors
Sales	860,000,000	45,000,000	335,000/243,000 I/C	446,000,000
Operating Income	63,000,000	(2,000,000)	40,000,000/41,000,000 I/C	(23,200,000)
Income as % of Sales	7%	-4%	12%	-5%
Assets	700,000,000	64,000,000	369,000,000/243,000,000 I/C	496,000,000
Product Type	Individually Designed	Individually Designed	Commodity	Commodity
Inventories	96,000,000	14,000,000	79,0000,000	N/A
Inventory % of Assets	14%	22%	24%	N/A
Return on Investment	11%	Negative	6%	Negative

Exhibit 4: Contextual Factors (1988)

Contextual Factors	MASS COMP	Prime Computer	Analog Devices	Sprague Electric
Competitive Environment	Dynamic	Dynamic	Variable	Dynamic
Customers	Relatively Stable- *Captive Industry*	Unstable	Stable	Relatively Stable One Large Customer (17%)
Vendors	Few-Short Term	Many-Short Term	Few-Long Term	Few-Long Term
Importance of Customer Service	Very	Very	Very	Very
Dependence on External Economy	Yes	Yes	Yes	Yes
Number of Competitors	Many	Many	Few	Few
Product Technology	Dynamic	Dynamic	Variable	Relatively Stable
Product Life Cycle	Developmental	Mainly developmental/some mature products	Mainly mature/some evolutionary new products	Mainly mature/ Some evolutionary new products
Process Technology	Mainly stable for a given product/ dynamic with introduction of new products	Mainly stable for a given product/ dynamic with introduction of new products	Dynamic	Mainly stable
Product type	Individually designed	Individually designed	Commodity	Commodity
Organization Stability	High	Medium	High	Low
Formalization of Relationships Between Accounting and Manufacturing	Relatively high	Low	Low	High
Attitudes Between Accounting and Manufacturing	Good	Good	Excellent	Good

A comparative analysis was conducted relating the strategic factors affecting the manufacturing firms to the structure and substance of their cost accounting systems. The analysis was based upon the information gathered in the first part of the study. As an aid in the analysis process, a classification system was developed which identified how cost accounting systems differed among the firms.

Specifically, the data from this study described:

1) The cost accounting variables in use at the manufacturing firms;
2) How these variables were utilized in the accumulation of production costs; and
3) The contextual factors impacting the firms.

In 2007, a longitudinal review was initiated to determine the progress of the four firms since the initial field study in 1988. As suggested by Miller and Friesen (1984), Zhu and Nakata (2007), and Tsikriktsis (2007) the value of a longitudinal study is to look at the environment and structures over time to begin to establish or show evidence for causality. A search and analysis of the subject companies was conducted in order to better determine whether quality of information systems did, in fact, have an impact on the long term survival as was postulated in 1988. Since this is a study of a single industry, use of secondary data is appropriate (Venkatraman & Ramanujam, 1986). A thorough search of the financial press, company annual reports and other business publications was conducted to assist the authors in reviewing the progress of the firms that were originally studied. The authors analyzed original interview documents and triangulated secondary data as suggested by Yin (2003).

FINDINGS

As a result of the review of the financial records of the four companies and the related financial press, it was determined that only one of the four companies studied, Analog Devices still exists in its original form. Since the original study, Analog Devices has thrived, but not by being sedentary. Throughout the years, the strategic goals of the company have changed in order to meet new customer requirements. New products have continuously been developed to meet its customers changing needs. The company maintains very close relations with its customers to ensure proper input into its information systems. Production process development is also an integral part of the business model. Financial and fiscal responsibility is continuously stressed by management. In their annual reports from 1988-2008, management has emphasized the need for appropriate information systems to ensure the continued success of the organization.

Ray Stata (1989), Chairman and President of Analog Devices, suggests the following:

> *A problem with management information systems is that they are strongly biased toward reporting financial information to stockholders and government agencies. Unless quality improvement and other fundamental performance measures are elevated to the same level of importance as financial measures, when conflicts arise, financial considerations win out (P.1).*

Perhaps his emphasis on the importance of quality improvement and the other fundamental performance measures like reliable cost accounting information help explain why Analog Devices is a viable organization today. The other companies in this study did not achieve similar success. Analog Devices supplies a wide range of analog signal processing ICs throughout the world. According to its website, in 2007, Analog Devices had in excess of 9000 employees and annual sales exceeding $2.5 billion. For 40 years its historic net income has been 14%. (http://www.analog.com/en/corp/)

It was noted by Harris (1988) that Analog Devices (Exhibit 4) competed in a more stable competitive environment and that they had a customer base consisting of firms that they had conducted business with for many years. Changes in product technology were more evolutionary in nature and thus their focus was therefore on process technology. Furthermore, Harris (1988) noted that Analog Devices had a stable management team with low employee turnover. Of particular interest was that Harris (1988) noted that the company had very cooperative and congenial relationships between the cost accounting and manufacturing areas of the firm and that because of the firms stability, the managers had worked together closely for a number of years. Also, the 1988 study pointed to the "highly informal communications network" (Harris, 1988, p. 183) that enabled the quick resolution of problems.

None of the three other companies originally studied continues to exist in any semblance of its original format or organization. MASSCOMP, formerly Massachusetts Computer Corporation (established in 1972), could not adapt itself to the changing consumer market. It did not have the organizational structure or information systems necessary to make significant changes in the computer hardware and software that it had been offering. In 1989, in a leveraged buyout (junk bonds) MASSCOMP purchased Concurrent Computer Corporation and assumed the latter's name. By 1992, only the software portion of the company remained. Since that time, the company has merged with another software organization, a spin off of Harris Computer Systems Corporation. Only small traces of the original business exist (http://www.curr/sorp_companyhistoryasp?h=1).

A very similar situation existed with Prime Computer with a life span from 1981 to 1989. According to the New York Times (1992), the saga of the demise of Prime Computer was a classic leveraged buyout (LBO) with an unhappy ending. As Prime Computer recognized that its market was shifting toward lower price systems, it purchased Computer Vision to meet the changing demand. Then to avoid a hostile takeover by Bennett LeBow's MAI/Basic Four, J.H. Whitney & Company organized a second LBO. This eventually ruined the company and Whitney took tremendous losses. The original product line of specialty computers became obsolete and the company could not support the introduction of new products nor compete with similar computer manufacturers. Parts of the organization were absorbed by a third entrepreneurial company and a new, unrelated software business was created. Perhaps focusing on internal controls instead of financial manipulations would have saved the company (Aug, 1992). Interestingly, Harris (1988) noted in the original study that "top management is constantly attempting to solidify its management team, organizational style, and organizational structure" (p. 164). Employee turnover was high and that "binding relationships which lead to more informal exchanges of information do not as yet exist within this company" (p. 179). It was also noted that the company appeared to be "fighting for its economic life" (Harris p. 178)

Sprague Electric which was established in the 1920's, could not compete in the 1990's electronics market. According to Vishay's website (2007), since the invention of the ceramic capacitor by R.C. Sprague in 1926, the company evolved to producing resistors and then, transistors. When the second generation of the Sprague family seriously invested in semi-conductors in the 1960s, the company was besieged with competition both on and off shore. As was found in the original study (1988), there was a tremendous amount of organizational instability at Sprague Electric. The decision making and information processes were greatly impeded. Because of huge changes in the electronics field, it was determined that Sprague's main product, capacitors, could not generate sufficient profits any more. Further, its investments in semiconductor manufacturing proved disastrous. Once again, apparently its internal controls and management information systems were not sufficient to compete in the global market. Eventually parts of the company were bought and sold several times, until what was left was absorbed by Vishay Intertechnology (http://www.wishay.com/company/history/,2007).

Harris noted in 1988 that this company did not have a cost accounting and inventory system and was, at that time, in the process of implementing these systems. This firm was originally a family owned and operated organization and the founders felt that there was no need for such formal systems. It was also noted that this firm operated in a dynamic environment and that they relied heavily on sales to one customer instead of having a broad customer base. Most of the income was generated by mature products and, at the time of the original study, the company was going through "significant changes in the firm's organizational structure" (p. 186) as well as a probable reassessment of the firm's strategies.

CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

This study provided a longitudinal view of the importance of using cost accounting systems as a robust information system which enables the firm to make decisions to change and respond to strategic factors in the environment. It also provided information on contextual factors which impacted the firm's long term survival. One of the limitations was that only four firms were studied in a particular geographic area and in a specific industry. Future research should include other industries and other firms using the same longitudinal methodology.

By 2008, three of the four firms originally included in the 1988 study no longer exist in their original form. It is clear from the 1988 study that only one of the original four firms, Analog Devices, did develop systems that provided managers with robust information that enhanced decision making. It appears that the others used the cost accounting systems merely as a financial tool, rather than as an internal information system. It was predicted in the original study that it would be difficult for companies that did not integrate information systems into their strategic decision making process to succeed. This longitudinal study supports that conclusion. The one successful firm, Analog Devices, had an effective cost accounting system in 1988 that was used by management to assess its strategic position. By continuously incorporating and updating this information, the firm was able to adapt and change and to indeed flourish through 2008.

Further, this study does provide evidence that certain contextual factors are important to the firm's success. Not only the external environment, but also the internal environment seemed to impact the way in which information was obtained, shared and used and this appeared to impact the long term survival of these firms. Factors such as the stability of management, employee turnover, communication patterns, and organizational structures were noted to be significant factors.

This longitudinal study demonstrates the value of an effective cross disciplined approach to analysis. It has not only provided evidence of the necessity for an effective information system that provides data for managerial decision making, but it also highlights the importance of internal systems that enable the effective usage of that information. For entrepreneurs, it is suggested that having information is not enough. Establishing the systems and structures that enable usage of the information is of upmost importance. Finally, this study demonstrates the importance of adapting different research techniques (e.g. cross discipline longitudinal studies) to explore the impact of integrated information systems as encouraged by Kaplan (2006) and Hopwood (2007).

REFERENCES

Ben-Arieh, D., & Quian, L. (2003). Activity-based cost management for design and development stage. *International Journal of Production Economics*, *83*(2), 169-183.

Bernheim, R. C. (1983, September). The right way to design a cost accounting system. *Management Accounting,* 63-65.

Brimson, J. (1986, March). How advanced manufacturing technologies are reshaping cost management. *Management Accounting,* 25-29.

Chalos, P., & Bader, A. (1986). High-tech production: The impact on cost reporting systems. *Journal of Accountancy,* 106-111.

Dilts, D., & Grant, R. (1985, April). Accounting for the factory of the future. *Management Accounting,* 34-40.

Drucker, P. (1985, September 20). Automation payoffs are real. *Wall Street Journal*.

Edwards, J. B. (1985, September). At the crossroads. *Management Accounting,* 42-49.

Ewusi-Mense, K. (1981). The external organizational environment and its impact on management information systems. *Accounting, Organizations and Society,* 4, 301-316.

Foster, G., & Horngren, C. (1987, June). JIT: Cost accounting and cost management issues. *Management Accounting*, 19-25.

Galbraith, S. & Nkwenti-Zamcho, E. (2005) The effect of management policies on plant-level productivity: A longitudinal study of three U.S. and Mexican small businesses. *Journal of Small Business Management*, 43, 4, 418-431.

Glaser, B. G., & Strauss, A. (1967). The discovery of grounded theory: *Strategies for Qualitative Research*. Denver, CO: Aldine Publishing.

Harris, J. (1988). *Field study examining the structure and substance of cost accounting systems.* Unpublished doctoral dissertation, Boston University.

Holbrook, W. (1985, Fall). Practical accounting advice for just-in-time production. *Journal of Accounting and EDP*, 42-47.

Hopwood, A. G. (2007) Wither accounting research. *The Accounting Review* 1365-1372.

Howell, R., & Soucy, S. (1987, July). The new manufacturing environment: Major trends for management accounting. *Management Accounting,* 21-27.

Kaplan, R., (1983, October). Measuring managerial performance: A new challenge for managerial accounting research. *The Accounting Review*, 686-705.

Kaplan, R. (1984, July). The evolution of management accounting. *The accounting review,* 390-418.

Kaplan, R. (1984, November). Yesterday's accounting and today's economy. *Journal of Accountancy*, 141-152.

Kaplan, R. (1986, Winter). Accounting lag: the obsolescence of cost accounting systems. *California Management Review*, 174-199.

Kaplan, R., & Johnson, H. T. (1987). *Relevance Lost: The Rise and Fall of Management Accounting*. Cambridge, MA: HBS Press.

Kaplan, R. (1993). Analog Devices: The Half-Life System. *Harvard Business School (Case Study 9-190-06),* 1-26.

Kaplan, R. (2006) The competitive advantage of accounting. *Journal of Management Accounting Research*, 18, 127-134.

Keys, D. E. (1986, November). Six problems in accounting for N/C machines. *Managerial Accounting*, 38-47.

Krommer, E., & Muir, W. (1983). Measuring operating performance through cost accounting. *Price-Waterhouse Review,* 1, 26-31.

Littrell, E. (1984, October). The high tech challenge to management accounting. *Management Accounting*, 33-36.

Mcllhattan, R. (1987, September). How cost management systems can support the JIT philosophy. *Management Accounting*, 20-26.

McNair, C., & Mosconi, W. (1987, July). Measuring performance in an advanced manufacturingenvironment. *Management Accounting*, 28-31.

Miller, D. & Friesen, P. (1984). A longitudinal study of the corporate life cycle. *Management Science*, 30, 10, 1161-1183.

Moores, K., & Yuen, S. (2001). Management accounting systems and organizational configuration: A life-cycle perspective. *Accounting Organizations and Society, 26*(5) 351-389.

Nanni, A., Miller, J., & Vollmann, T. (1988, January). What shall we account for? *Management Accounting*, 42-48.

Rabino, S., & Wright, A. (1993). Accelerated product introductions and emerging managerial accounting perspective: Implications for marketing in the technology sector. *Journal of Product Innovation Management, 10*(2), 126-135.

Sadhwani, T., Sarltan, M., & Camp, R. (1987, January). The impact of just-in-time inventory systems on small businesses. *Journal of Accountancy*, 118-128.

Schwartzbach, H. (1985, December). The impact of automation on accounting for indirect costs. *Management Accounting*, 45-50.

Seed, A. (1984, October). Cost accounting in the age of robotics. *Management Accounting*, 39-44.

Strata, R. (1989). Organizational learning-The key to management innovation. *Sloan Management Review, 30*,3, 63-74.

Tsikriktsis, N. (2007). The effect of operational performance and focus on profitability: A longitudinal study of the U. S. Airline Industry. *Manufacturing & Service Operations Management*, 9, 4, 506-517.

Venkatraman, N. & Ramanujam, V. (1986). Measurement of business performance in strategy research: A comparison of approaches. *The Academy of Management Review*, 11, 4, 801-815.

Waterhouse, J., & Tiessen, P. (1978). A contingency framework for management accounting research. *Accounting, Organizations and Society,* 1, 65-76.

Zhu, Z. & Nakata, C. (2007). Reexamining the link between customer orientation and business performance: The role of information systems. *Journal of marketing theory and practice,* 15, 3, 187-204.