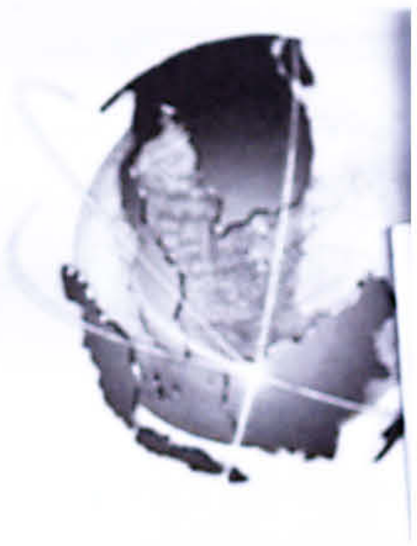
The 3rd International Conference on Information Technology in Asia



Transforming Knowledge into Insight

Organised by

Faculty of Computer Science & Information Technology
Universiti Malaysia Sarawak

In Collaboration with

Information & Communication Technology (ICT) Unit,
Chief Minister's Department of Sarawak
&
Global Information & Telecommunication Institute (GITI)

In Conjunction with

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The 3rd International Conference on Information Technology in Asia

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EDITORIAL PREFACE

The 3rd International Conference on INFORMATION TECHNOLOGY IN ASIA

These are the Proceedings of the 3rd International Conference on Information Technology in Asia (CITA'03), held between 17th -18th July 2003 in Kuching Malaysia. The CITA'03 conference is organized by Universiti Malaysia Sarawak in collaboration with the ICT Unit, Chief Minister's Department of Sarawak and the Global Information and Telecommunication Institute, Japan.

It is the aim of the conference to showcase applications of Information and Communications Technology (ICT) in the Asian region while fostering the exchange of ideas and research results with researchers worldwide. The focus on Knowledge Management, is in line with our efforts to highlight the emerging trends and technologies that will help both organizations and nations to stay ahead in a dynamic and challenging environment.

We are pleased to have received a good response of over 120 submissions from over 12 countries. We have selected 48 papers under 5 major tracks: Community Informatics, Knowledge Management and Systems, E-learning, Intelligent Systems and Knowledge Infrastructure. The range of topics cover the pervasive nature of ICT applied to the broad area of Knowledge Management.

It is hoped that this conference will provide a platform to bring together researchers and practitioners to share their knowledge and experiences in addressing issues of creating, using and disseminating knowledge leading to invaluable insights.

We would like to acknowledge and thank the many people who have contributed greatly to the conference. I wish to thank the members of the programme committee for reviewing the papers against a tight schedule, effort and hardwork. We extend our sincere appreciation to all sponsors for the generous contributions.

We wish you all an enjoyable conference with fruitful deliberations and bid you all a warm "Selamat Datang" to the Land of the Hornbills.

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WEBSITE QUALITY IN THE AUSTRALIAN ELECTRONIC MARKETSPACE: APPLICATION OF THE WEBQUAL™ INSTRUMENT

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ABSTRACT
The issue of assessing the quality of a Website has received growing attention from academics and practitioners. This study applies the newly developed WebQual™ framework developed by Loiacono *et al.* (2002), to empirically assess if the quality of Australian Website's impact the purchase intentions and site revisit intentions in electronic markets across three industry groups. The study further highlights relevant managerial implications for managing Website quality, and directions for future research are discussed.

Keywords
Website quality, WebQual™, Service encounters, TAM

1. INTRODUCTION
The quality of a Website has now emerged as an issue of strategic importance to effectively communicate and transact with consumers. As the development of Internet technology continues, coupled with the flux of online competition with a click of a mouse enough for an online customer to select a new provider [43], the measurement of Website quality has forced academics and practitioners to develop rigorous and reliable methods. The conceptualization and the measurement of Website effectiveness, or quality, have now received growing coverage within the Information Systems (IS) and marketing literature. Previous measurements of Website quality/effectiveness have been developed in business consulting and the popular press for sometime [see 34], however, these measures are *ad hoc* which have not been statistically validated and tested for reliability, potentially leading to poor management decisions [52]. In academia, previous measures of Website quality within the IS and marketing disciplines have been either conceptual in nature or primitive in their analysis and methodological development. Limited scales have been published that captures the holistic multi-dimensional attributes of Website quality in a rigorous and psychometrically sound way [52]. [39] supports the scarcity of research claiming that research on electronic services is in its infancy with no generally accepted theories for customer evaluations of online service offerings.

The purpose of this research is to contribute to the advancement in the theory development of Website quality. The study applies the WebQual™ instrument by [31], to assess three industry sectors in the Australian online commerce setting: 1) airlines, 2) e-retail and 3) computers. The results of this study will be used to compare Website quality dimensions between each industry category examined, as well as to contrast the findings in similar research efforts by [5] and [31]. This paper adopts an interdisciplinary approach to the study with the findings presented in three key sections. First, a review of the relevant literature within the domain of information systems and services marketing is presented. In the second section, details of the methodology and results of the analysis are highlighted. Thirdly, conclusions and managerial implications are discussed with directions for future research suggested.

2. LITERATURE REVIEW
2.1 Internet and the Service Encounter
Service encounters have been defined as the moment of interaction between a customer and a firm [8, 42], which are considered as critical moments of truth in which customers often develop enduring impressions of a firm providing the service [6]. The infusion of technology in the service encounter, such as the Internet, has been dramatically changing the nature of customer relationships and interactions [7]. More specifically, Websites are now considered a strategic tool with the capability to influence a customer's perception of the firm [46]. Website administrators and e-marketers must now continuously innovate and "engineer" branded customer experiences of their online service offering, that both differentiates from competitors and strengthens customer relationships [10, 18].

2.2 Self-Serving Technologies
Recent research has begun to emerge that examine the factors underlying satisfaction in technology-based service encounters [32]. These types of encounters involve customers interacting with Internet based service encounters, automated phone services, kiosk services and services delivered via CD or video technology. These technology-based service encounters are referred to as *self-service technologies* because the customer essentially provides his or her own service [50]. [7] asserts that these encounters can occur in non-human interactions such as the Internet, where each encounter is an opportunity for a firm to sell itself, to reinforce its offering, and to satisfy the customer. As [17] notes "...an e-service is an interactive, content centered and Internet-based customer service, driven by the customer and integrated with related organizational customer support processes and technologies with the goal of strengthening the customer-service provider relationship" (p.

186). The Internet has now become one of the most significantly used self-service technologies available, which enables the customer to become intimately involved in the service encounter. This self-serving nature of the Web allows consumers to search for information, products and services and converse (e.g. obtain advice or comments from peers) with other members in virtual communities [25, 4].

2.3 An Integrated View of Website Quality

Invariably the mechanics of Website development is based on the literatures surrounding both the information systems and marketing fields. Much of the Website implementation could be directly tied to the field of information systems while the content development is in parallel to the marketing arena. While both academic and practitioner researchers have begun to conceptualise and measure Website quality, limited attention is given to providing definitions of their theoretical domains.

Two dominant theoretical models have begun to emerge from the IS and marketing literature to assess the quality of the Website, these include: (1) Technology Acceptance Model (TAM), and (2) Service Quality (SERVQUAL). The Technology Acceptance Model (TAM) was first conceived by [15], to explain and predict the individual's acceptance of information technology. TAM is based on Theory of Reasoned Action (TRA) [25], which suggest that social behaviour is motivated by an individual's attitude toward carrying out that behaviour. The TAM model posits that the actual use of a technology can be predicted by user's behavioural intention and his or her attitude towards its use, which in turn are influenced by a technology's perceived ease of use and perceived usefulness. Applications of the TAM model include e-mail, voice-mail, word processing, spreadsheets and internal company computer systems [15, 38, 16]. The model has since been modified and extended within the context of the online environment [see 3, 41, 29, 31] and has also been applied within the marketing literature examining TAM as viable predictors of adoption of the Internet for retail usage [22].

Currently, there is a debate in the service marketing/management literature as to whether existing measures of service quality (e.g. initially developed by [37]) apply in electronic environments. According to [45], the five SERVQUAL dimensions (reliability, responsiveness, assurance, empathy, and tangibles) are relevant and important in a Web-based environment. However, [36] (2000, p. 171) suggest that research is needed on whether "the definitions and relative importance of the five service quality dimensions change when customers interact with technology rather than with service personnel". Research efforts utilising the SERVQUAL framework are now beginning to emerge into the literature [see 28, 35, 48]. However, these initial research efforts suffer from the generalizability of results with more research needed to improve and refine the quality dimensions.

A critical concern of both Information System (IS) and e-marketing researchers has been how to measure the quality of a Website. Although Website quality has received limited studies attention in the literature, empirical academic research is beginning to emerge. Table 1 presents a summary of previous studies examining the measurement of Website quality.

Table 1: Previous empirical studies measuring Website quality

Author(s)	Context	Factors	Items	Alpha
Loiacono, et al. (2002) (MKTG & IS)	B2C Websites	Informational fit-to-task	3	.86
		Tailored communications	3	.80
		Trust	3	.90
		Response time	3	.88
		Ease of understanding	3	.83
		Intuitive operations	3	.79
		Visual appeal	3	.93
		Innovativeness	3	.87
		Flow/emotional appeal	3	.81
		Consistent image	3	.87
		On-line completeness	3	.72
		Relative advantage	3	.81
		TOTAL	**36**	
Janda, Trocchia and Gwiner (2002) (MKTG)	E-retail Websites	Performance	6	.72
		Access	4	.78
		Security	4	.83
		Sensation	4	.61
		Information	4	.80
		TOTAL	**22**	
O'Neill, Wright and Fritz (2001) (MKTG)	Library Websites	Reliability	4	.71
		Contact	4	.86
		Tangibles	5	.73
		Response	4	.68
		TOTAL	**17**	
Barnes and Vigden (2001) (IS)	B2C Websites	Information Quality	8	.88
		Interaction Quality	8	.89
		Usability	6	.81
		TOTAL	**22**	
Wolfinbarger and Gilly (2001) (MKTG)	E-retail Websites	Website design	5	.83
		Fulfilment/reliability	3	.84
		Privacy/security	3	.79
		Customer service	3	.88
		TOTAL	**14**	
Chen and Wells (1999) (MKTG)	B2C Websites	Informativeness	6	.92
		Organisation	6	.84
		Entertainment	4	.94
		TOTAL	**16**	

MKTG: Marketing literature
IS: Information Systems literature

[22] and [31] argue that to provide value to businesses, an instrument measuring Website quality must identify in more detail the specific aspects that cause a Website to be easy to use or useful to consumers since this clarification of quality dimensions is conceptually important to empirically prove that some aspects of quality are more important than others in determining online consumer behaviour. Although previous research efforts have provided valuable insight and advancement into what dimensions constitute Website quality, most instruments are either limited in the development and refinement of the instrument, narrowly focused or highly domain specific to a particular sector of the Internet (e.g. e-retailing or library sites). As a result of the unique properties of the Internet [27], a holistic instrument is required to effectively capture the success dimensions of a Website.

WebQual™ [31] has emerged into the marketing literature as a highly reliable and valid instrument to assess the perceived quality of Websites. The instrument is grounded in the Theory of Reasoned Action (TRA) [25, 2], and Technology Acceptance Model (TAM) one of the most widely cited pieces of IS research [44]. These theories provide a strong conceptual

basis for a link between user beliefs about a Website and the behavioural intentions of reusing the Website at a later time. The WebQual™ instrument consists of 12 core dimensions: *informational fit-to-task, tailored communications, trust; response time, ease of understanding, intuitive operations, visual appeal, innovativeness, flow/emotional appeal, consistent image, on-line completeness* and *relative advantage*. These 12 dimensions further collapse into 4 second order latent variables: (1) Usefulness, (2) Ease of use, (3) Entertainment, and (4) Complimentary relationship. [31] argue that the instrument is able to support a range of important IS and marketing studies as researchers attempt to understand what contributes to success in the electronic marketspace.

3 METHODOLOGY

3.1 Sample Frame

There are numerous ways to evaluate the quality of a Website [see 13]. Data collection of the WebQual™ [31] model is based on the online questionnaire method of Website users. To gather a comfortable target population, our study required respondents with previous experience in the e-commerce area. The respondents for the survey were undergraduate and post-graduate students enrolled in an electronic commerce and electronic marketing subjects at a large Australian university. Since the topic of Website evaluation was part of their syllabus, they were considered to be an ideal target population. Prior to the actual study, the students were asked to browse and evaluate several sites such as dell.com.au, ibm.com.au, sony.com.au, flightcentre.com.au, qantas.com.au, virgin.com/blue and dstore.com.au during their tutorials. This process allowed respondents to trial the Websites before its subsequent evaluation. The decision to choose which Websites for the study, were derived after an informal survey consisting of 120 students. The students were asked to choose a representative Website from the three industries. Almost more than two-thirds of the students chose Qantas.com.au, Dell.com.au and dStore.com.au to represent their respective industries.

3.2 Survey Design and Administration

The survey used for this study was hosted online using an independent server – *surveypro.com*. Internet-survey responses hold an advantage over other types of survey, as they are known for their speed and low cost in addition to its anonymity. The URL of the questionnaire was given to all the respondents. The respondents were directed to the start page of the survey where a set of instructions briefed on the survey prior attempting. The questionnaires were designed to auto-check on the validity of the answers before submission, which helped the survey to gather 502 valid responses. The survey was hosted for one month from October to November 2002 and is comprised of two key sections. The first section consisted WebQual™[31] and the latter was concern with purchase intention and Website revisit. Respondents were invited to evaluate each of the sites using a 7 – point scale (as in similar studies). The questions were anchored as 1 = "Very strongly disagree" and 7 = "Very strongly Agree".

4 DATA ANALYSIS

4.1 Survey Data in Brief

Table 2 depicts the summarised data, which accounts for 502 responses. The table shows the mean and standard deviation scores across all the questions. Each construct was represented by several questions unerringly following WebQual™ [see 31]. On the whole, the computer industry represented by Dell.com.au outperformed the other industries (Airline and E-retail). Measured using WebQual™, Dell.com.au was found to have an upper hand on the constructs related to *fit to task (5.53), trust (4.85), response time (4.41), ease of understanding (5.51),* and *consistent image (5.63)*. The Qantas.com.au Website was somehow rated below for almost all the constructs except for *tailored communications (5.40)*. While, dStore.com.au was having high scores on constructs such as *intuitive operation (5.73), visual appeal (4.99), online completeness (5.73),* and *relative image (5.46)*. Meanwhile on questions related to *purchase intention*, dStore.com.au was way ahead with a score of *6.54*, followed by Dell.com.au *(5.48)* and Qantas.com.au *(4.89)*. However, this result was totally in contrast with the intention for *Website revisit*. Qantas.com.au recorded the highest score at *4.96*, follwed by Dell.com.au *(4.78)* and dStore.com.au *(4.21)*.

Table 2: Mean and standard deviation scores for each industry.

No	Constructs	Arline (Qantas) n=178	S.D	Computer (Dell) n=150	S.D	E-retail (dStore) n=170	S.D
1	Fit To Task (FIT)	5.39	1.32	5.53	1.16	5.19	1.18
2	Tailored communicaions(TC)	5.40	1.34	5.36	1.33	4.97	1.26
3	Trust (T)	4.53	1.53	4.85	1.42	4.15	1.34
4	Response time (RT)	4.25	1.61	4.41	1.34	4.15	1.49
5	Ease of Understanding (EOU)	5.34	1.30	5.51	1.08	5.41	1.14
6	Intuitive Operations (IO)	5.72	1.34	5.68	0.99	5.73	1.03
7	Visual Appeal (VA)	4.60	1.26	4.90	1.25	4.99	1.35
8	Innovativeness (I)	4.32	1.35	4.71	1.22	4.95	1.28
9	Emotional Appeal (EA)	3.93	1.36	4.20	1.36	4.35	1.34
10	Consistent Image (CI)	5.62	1.33	5.63	1.24	4.96	1.04
11	Online completeness(OC	5.41	1.43	5.58	1.22	5.73	1.17
12	Relative Image (RI)	5.21	1.48	5.17	1.40	5.46	1.26
13	Purchase Intention	4.89	2.70	5.48	3.33	6.54	3.15
14	Website revsit	4.96	1.28	4.78	1.32	4.21	1.50

Figure 1 presents a graphical illustration of the average scores, which show that the computer industry (Dell.com.au) consistently falls on the outer grid for most of the constructs. Further results show a significant difference between industries in constructs related to *trust, tailored communication, consistent image* and *innovativeness*. However, when the constructs were consolidated, the results revealed a slightly different view of the industries. In almost all of the industries examined, the results (as shown in Figure 3 and Table 3) suggest an equal understanding in the importance of securing customer relationships [20, 26], which is seen through the construct *complementary relationship*.

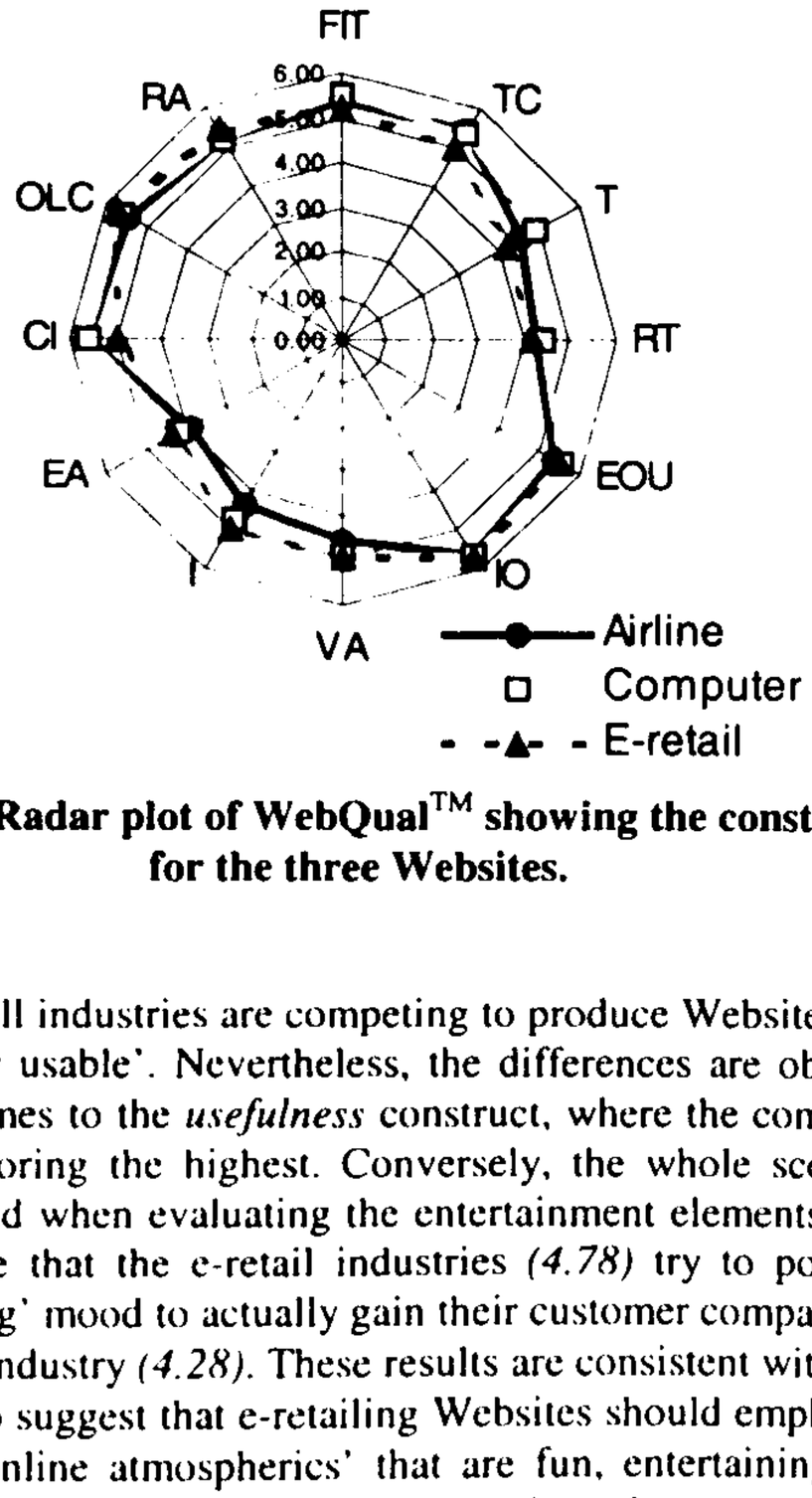

Figure 1: Radar plot of WebQual™ showing the constructs for the three Websites.

Similarly, all industries are competing to produce Websites that are 'readily usable'. Nevertheless, the differences are obvious when it comes to the *usefulness* construct, where the computer industry scoring the highest. Conversely, the whole scenario was reversed when evaluating the entertainment elements. The results state that the e-retail industries *(4.78)* try to pose an 'entertaining' mood to actually gain their customer compared to the airline industry *(4.28)*. These results are consistent with that of [19] who suggest that e-retailing Websites should emphasise facilitate 'online atmospherics' that are fun, entertaining and visually appealing to encourage purchase intentions.

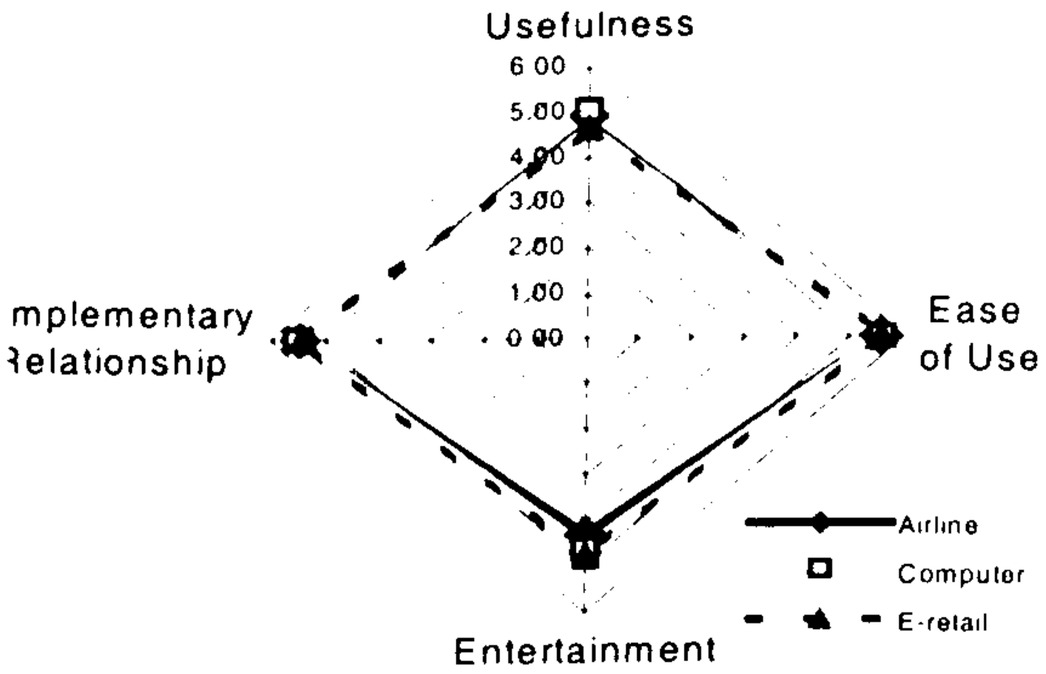

Figure 2: Radar Plot of Webqual's Second Order Constructs

This might explain the intense competition and low entry barrier within the e-retail business, which forces all players in the market to provide a significantly unique experience (eg. entertainment) to the website visitor.

To further compare and contrast between the industries, an exploratory factor analysis was conducted. Factor analysis is known for identifying the core structure (variables) that is latent by summarising the data set [24]. Furthermore, to ensure that the research instrument has high reliability, each dimension was measured using Cronbach alpha [12].

Table 3: Average dimensional scores for each industries.

Dimensions	Airline	Computer	E-retail
Usefulness	4.89	5.04	4.62
Ease of Use	5.53	5.59	5.57
Entertainment	4.28	4.60	4.76
Complementary Relationship	5.41	5.46	5.39

For all three data sets, Varimax rotation, Eigen value more than 1.0, with a factor loading excess of more than 0.55 was retained for significant results [24]. The results of the factor analysis in Table 4 revealed the latent dimensions that were core of our study. The results suggest that the airline industry appeared to be divergent from the other two industries. The *usefulness* and *ease of use* dimensions explained 55% of the data. Whereas, the dimensions *entertainment* and *complimentary relationship* explained 56.5% of the computer industry, and 50% of the e-retail industry data. Even though Table 3 and Figure 2 illustrate almost a different average result, however internally the score for each industry is revealed by the factor analysis test.

Table 4: Latent dimensions for the three Website's.

Categories	Industry		
	Airline	Computer	E-retail
Variance explained	78.5%	77.3%	79.5%
Factor description	7 factors (2 dominant factors with 5 weak factors)	6 factors (2 dominant factors with 4 weak factors)	6 factors (2 dominant factors with 4 weak factors)
Latent dominant dimensions	Usefulness and Ease of Use	Entertainment and Complimentary Relationship	Entertainment and Complimentar y Relationship

The purpose of this is to access the stability and consistency of responses to related items measured where an alpha value above 0.60 is acceptable [33]. Table 5 shows the Cronbach alpha value showing all the dimensions were highly reliable with all scores raking above 0.8.

Table 5: Cronbach alpha scores of the dimensions across industries.

	Cronbach Alpha		
Dimensions	Airline	Computer	E-retail
Usefulness	0.86	0.84	0.84
Ease of Use	0.94	0.91	0.92
Entertainment	0.94	0.95	0.94
Complementary Relationship	0.92	0.94	0.89
Overall	0.96	0.96	0.95

5. CONCLUSIONS, MANAGERIAL IMPLICATIONS & LIMITATIONS

The aim of this paper was to apply the WebQual™ model within the context of Australian online commerce across three Australian industries i.e. Airline, Computers and E-retail. The

WebQual™ approach has been found to be a powerful benchmarking tool against competitors. While the model used in this study falls short of prescribing how an organisation can improve its Website, it can however, report the current state of an organization's Website. The results of the study indicate that the intention to purchase from the Website is highly correlated with elements related to visual appeal, online sales ability, ease of use and navigability. However, the intention to revisit the Website is linked to elements related to customization of information, which has been the underlying principle of customer relationship management (CRM). As a result of the increasing volume of online companies, it is now strategically imperative for organisationations to develop consumer focused Websites to increase market share.

Consistent with [5], respondents have hinted that 'effective information' is closely related to trust which is one of the key issues in determining a Website's success. The Dell.com.au Website had the highest score of *trust*, which could be explained by the overall 'superiority' of the Website. This could also be a result of external factors such as customer's previous experiences with service and high brand-image [1, 5] that Dell has earned within the Australian market. In essence the Australian Websites namely the airline, computer and e-retail industry are concerned with issues such as customer relationship, trust, Website usability and visual appeal.

This study provides an initial research effort in the theory development and application of Website quality, and as such suffers from two obvious limitations. Firstly, even though respondents of this study were made of university students who were comfortable and familiar with website evaluation. They did not represent the general Australian online population, which would have induced some degree of biasness to the data. Secondly, the numbers of websites used to represent the industries were rather insufficient. Although the websites used for the study were voted to represent the industries, an average score derived from several websites per industry would have been more appropriate.

6. FUTURE RESEARCH DIRECTIONS

As a result of the exploratory nature of the study, a number of directions for future research arise from this paper. First and foremost, further refinement of the WebQual™ technique is required which should use larger randomised sample sizes made up of the general Internet population to avoid bias and to provide more statistical power. Future research should also investigate the higher order effects of Website quality with particular constructs to be used, include, examining customer satisfaction, perceived value of the Website to consumers and loyalty to the Website. Advanced statistical techniques such as structural equation modeling (SEM) could be further employed to investigate these inter-relationships between constructs. Furthermore, the role of Internet experience should also be examined for moderating effects on these prescribed relationships. More research is required across other industry sectors within the Australian context to refine the WebQual™ dimensions with particular attention to the aspect of customer service and delivery. Further critical issues may also include exploring if differences exist between user perceptions based on Internet purchaser vs non-Internet purchaser characteristics and the role demographic information. Finally, future research efforts should include testing the generalisability of the WebQual™ instrument in a global context to capture the moderating effects of country culture on perceptions of performance and importance of quality dimensions. Such research would provide fruitful information to compare and contrast the different elements that are critical to Website quality in the international setting.

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DETERMINANTS OF DYNAMISM IN SOFTWARE PRODUCTION IN HIGH-TECHNOLOGY CLUSTRES: A STUDY OF BANGALORE, SOUTHERN INDIA

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ABSTRACT
Production of ICTs tends to concentrate in clusters of small firms, specialising in complimentary technologies, networking with each other and benefiting from agglomeration economies. Promotion of such high-technology clusters therefore constitutes a key element of policy-making in low-income countries seeking to bridge the digital divide. The software cluster in Bangalore is one of the few clusters in low-income countries that have revealed considerable dynamism in the global IT sector. The factors that have contributed to its dynamism and which condition its prospects for continued sustenance therefore deserve attention. We compare and contrast the key organisational features of dynamic clusters in technology intensive sectors with those prevailing in Bangalore to derive implications for future trajectory of the cluster. This would lead to lessons learned for policy making elsewhere as well.

Keywords
Information and Communication Technologies (ICTs), Knowledge Economy, High Technology Clusters.

1. INTRODUCTION
The rise of information and communication technology (ICT) based sectors, as a lead sector in high-income economies portends challenges and opportunities for low-income, technologically less equipped countries. The high growth potential of this sector and a relative lack of resources to participate in this sector may lead to a possible aggravation of economic disparities within and between countries (World Development Report, 1998). Simultaneously, there is widespread belief that ICT provides an opportunity for such economies to 'leapfrog' and 'catch-up' with the industrially advanced nations (Perez and Soete, 1988). Since the technologies are new and not matured yet, economies may more easily learn and build up competence in this sector. Further, since important segments of ICT production like software are more skill-intensive than capital-intensive, economies with good build-up of human capital base are likely to gain from growth of the 'knowledge economy'.

Accompanying this process of 'informatisation' is a greater integration of domestic input and output markets with that of the world market, rendering competitiveness in the world market to be critical for growth prospects of countries. There are however, few low-income regions that have taken advantage of this opportunity. India is one such country, and has established itself as an important player in the world software services industry. Though a few other economies like Taiwan, Brazil and South Korea have built up comparable technological capability in the electronics industry (Mathews and Cho, 2000; Sridharan, 1996), in the software services segment, India is an exemplar with a global presence unmatched by most low-income countries. Understanding the sources of such competence is therefore vital.

Technology-intensive production tends to concentrate in spatially agglomerated clusters of firms networked with each other, and with other support institutions like universities and research institutes, financial firms, etc. The Indian software industry too is primarily concentrated in a few spatial agglomerations in the metropolitan cities, the Bangalore software cluster being the most important of them. The latter's dynamism has even drawn comparisons with the Silicon Valley high-technology district of the USA (Balasubramanyam and Balasubramanyam, 2000). Home to over 900 software firms comprising of subsidiaries of multinationals, joint ventures, domestic start-ups and large firms, it caters to multiple segments of the ICT sector. Here, we seek to understand the factors contributing to the growth of the Bangalore software cluster and prospects for a sustained 'high road' trajectory.

Existing studies seek to explain the success of Bangalore software cluster through an explication of the role of government policies in conjunction with its participation in the global value chain on account of its low wage costs (Parthasarathy, 2000; Heitzman, 1999; Lateef, 1997). Nevertheless, these explanations are confined to understanding Bangalore's ability to enter the global value chain and do not concern with factors conditioning its subsequent growth pattern and possible trajectory. For instance, the pattern of learning that firms go through as a result of their exports may influence the nature of subsequent growth. More importantly, earlier studies fail to account for the role played by organization of software production prevalent in the cluster. There is a growing body of literature that seek to understand cluster specific factors, especially in knowledge-intensive production, that are deemed critical to a high growth trajectory (Coombs et. Al, 1996; Saxenian, 1994). Here, we address this dimension by comparing characteristics observed in high technology clusters elsewhere with those prevailing in Bangalore software cluster. The study is based on information drawn from both secondary literature and case studies of selected firms wherever required. Interviews with key informants like industry experts and members of producer associations and financial institutions are undertaken to cover gaps in secondary literature. The diffusion of 'secrets of industry in the air', as is the wont of industrial districts, renders key informants as an important source of information.

The paper is organised as follows. Firstly, we identify key variables that are considered critical to innovation-based high-technology cluster development. Secondly, we delineate the pattern of growth of Bangalore software cluster. We then move on to examine the prevalence of relevant variables identified within the Bangalore software cluster and their contribution to the region's dynamism. Finally, we draw inferences for policy intervention in promotion of IT based clusters.

2. CLUSTERING AND KNOWLEDGE-INTENSIVE PRODUCTION

Many studies examine the role played by clustering in sustaining innovation in dynamic sectors. The static effects of clustering such as agglomeration economies and external economies ought to be distinguished from its dynamic effects. Firms in clusters benefit from economies of sourcing inputs and in use of infrastructure like transport, communication, power and finance. Agglomeration also improves information flows between producer firms, user firms and employees, thereby reducing transaction costs and promoting knowledge diffusion. Importantly, clustering enables firms to network with each other, which in turn fosters inter-firm division of labour with firms specializing in specific stages of the production process and thereby building up competencies in respective processes.[1] In clusters that successfully compete, networking is observed to play a critical role (Humphrey and Schmitz, 2000). Porter (1990) and Best (1991) also stress the importance of a strong interactive relationship between suppliers and firms that may diffuse technical knowledge within the cluster. An interactive relationship between users and producers too is increasingly critical, as mass customisation trends in markets warrant a finer understanding of differentiated customer needs.

Often, networks in clusters are not confined to the economic realm. Rather, they are embedded in social and cultural institutions of the region, fostering a high degree of trust that enable firms to minimise transaction costs as well as share information essential to build up of innovative capacity. Such factors are especially important in high technology clusters where spillover effects play an important role in organisational learning. Studies show that *collective learning* is facilitated by interactions between entrepreneurs and inter-firm mobility of employees that diffuse critical tacit knowledge pertaining to new products, processes or markets (Saxenian, 1994).[2] Such an 'innovative milieu' is also supported by institutions like universities, design centres and laboratories apart from local institutions that provide 'real services' that enable small firms to access resources that would otherwise be beyond their reach.[3] Radical innovations[4] require a threshold level of financial, technical and organisational resources that would fall far beyond the scope of small firms. In IT based sectors, initial production involves considerable sunk costs in research and development while subsequent reproduction can be undertaken at almost nil costs. Apart from sunk costs involved in R&D, marketing of the new product or service also involves considerable costs. Hence access to risk capital is essential to firms undertaking innovative activity.

Labour markets too influence the pattern of development of clusters. Though theoretically well recognised, it has received little attention in literature on clustering.[5] A strong labour organisation can resist competing through lowering of wage costs, forcing organisations to compete through innovation, facilitating the cluster to move on a 'high-road' trajectory. More importantly, high technology clusters require access to a skilled labour force with an ability to keep abreast of new technologies, and contribute to the innovative activity of firms. Institutional intervention to ensure continuous production of a skilled workforce therefore constitutes another key factor in sustaining such clusters. In sum, the presence of a strong inter-firm division of labour, a cooperative environment, conducive labour markets and access to technological, financial and other infrastructural resources are key requisites for upgrading in industrial districts.

The importance of these variables may vary according to the nature of specialization, and level of evolution of the cluster. Brusco's typology of clusters with different levels of institutional intervention and support is an attempt to capture this dimension (1990). Thus, inter-firm division of labour and/or nature of institutional support may not be an immediate outcome of clustering, but may result over time due to increases in scale economies and growing technological complexity or growth performance. Understanding the evolution of clusters and the accompanying institutional dynamics therefore becomes important. Bangalore is however, one of the few clusters in low-income economies that are commended for dynamism in a high technology sector.

Despite an early realisation of the role that ICT would come to play in the economy, India has been able to gain some leverage in the global market only in the software sector.[6] In terms of initiatives, this can be best attributed to an indirect consequence of state intervention, especially in the initial stages. Scholars contend that policies geared to indigenise software development for imported computing systems and the vacuum created by the forced exit of IBM led to the creation of a team of skilled software

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[1] "For a firm to increase or deploy its own knowledge effectively, it may have to compliment this knowledge with that of other firms; and more often than not, by way of some kind of collaborative agreement." (Dunning, 2000).

[2] We use the term 'collective learning' as opposed to the rather static term 'collective efficiency' to capture the importance of dynamic learning process to a high technology cluster.

[3] The notion of real services was introduced by Brusco, 1992, by which he refers to services provided by local organisations in real terms as opposed to provision of financial assistance to firms to acquire the same. Information on technical change, raw material prices, market trends and equipment testing facilities are examples of 'real services' provided in dynamic clusters.

[4] Innovations that involve a quantum leap in the production frontier or creation of new frontiers.

[5] Two works that explicitly comment on the role of labour organisations in influencing the source of competitiveness of industrial clusters are Best, 1991 and Schmitz and Musyck, 1994.

[6] The different trajectories that different segments of ICTs like telecom and software have assumed and the role of government policy in this regard has been narrated by Parthasarathy, 2000.

developers (Heeks, 1996).[7] Hence, when personal computers enhanced the diffusion of computers and related software development needs, Indian software developers took advantage of the opportunity. This process was also facilitated by policy measures to build a pool of highly skilled labour (Heeks, 1998). This set of initial conditions aided by the accidental prevalence of English as a medium of communication and training, led to India establishing a first mover advantage in software development where low cost but relatively skilled workforce is critical. Having said that, we need to nevertheless understand the factors that led to clustering of software development firms in Bangalore rather than other centres in India.

3. EVOLUTION OF BANGALORE AS AN INDUSTRIAL DISTRICT

Bangalore's urbanization and industrialization patterns, ever since the early 20th century, has been strongly state-led. Being a part of the erstwhile princely state of Mysore, it benefited immensely from the industrialization efforts undertaken by the state, which included establishment of a polytechnic and a few state-owned factories. Even the premier research centre, Indian Institute of Science was set up during that period. Subsequently, in the period 1950s-1970s, its dust-free environment proved conducive for setting up of large public sector undertakings specialising in sectors like electronics, aerospace, machine tools and telephone equipment, apart from a few national defence research laboratories. This spawned a number of upstream and downstream activities, predominantly SME ventures that supported these firms.

Though the Indian software industry has its origins in Bombay in the 1970s[8], shortage of skilled labour and the rising costs of built-in space led to a search for alternate locations. Bangalore, for reasons mentioned above, apart from lower land prices proved to be a favourable destination. Clustering of electronics-related industries also brought people from all over India to Bangalore, giving the city a very cosmopolitan character and culture, very different from most other cities in India. One interviewee suggested that for these reasons, Bangalore was the only city in India that most multinational corporation expatriates would be willing to live in.

Such factors, especially the low cost pool of skilled labour drew multinational IT firms to Bangalore, Texas Instruments (TI), being the first. TI India, was set up in 1986, to "enhance .. presence in the Asia-Pacific region...". India was selected because of its strong educational system in theoretical sciences and engineering, for large technical manpower" (NASSCOM, 1995) and of course for its very large English-speaking labour force. Bangalore was chosen because it was considered to better suit the lifestyles of TI's international staff. The software development centre of TI had a direct satellite link with its headquarters in Dallas, USA. Excess capacity on that satellite link was to be shared with other businesses that needed such a link. This paved way for entry of smaller domestic software companies to undertake data entry and basic software programming jobs for distant clients. In 1989, Hewlett-Packard also set up a fully owned subsidiary in Bangalore that was 100 per cent export oriented. This influx of foreign investment has steadily increased since then, and Bangalore at present is home to number of wholly owned subsidiaries of IT related TNCs and joint ventures, apart from a large number of Indian software firms undertaking software development work for multinational client firms.

Quite a few entrepreneurs, in the initial years, were erstwhile employees of overstaffed public sector firms, forced to reduce employment due to policy measures seeking to reduce state support for such ventures. Engineer-entrepreneurs also came from Indian Institute of Science (IISc), Central Machine Tools Institute (CMTI) and National Aeronautical Laboratory (Holmstrom, 1998; Heitzman, 1999).[9] The new liberal policy environment also drew entrepreneurs from among the NRI community wanting to relocate, reversing the brain drain to a limited extent. Kumar points out that though at around 20 per cent, Bangalore has the second largest number of firms in India, this is a bit misleading as many firms headquartered in other cities have their production work undertaken in Bangalore (Kumar, 2001). Most of the TNCs and leading Indian firms development centers are concentrated in Bangalore. In Bangalore alone there are approximately 140 TNC development centers. There are approximately 750 large and small domestic IT firms. About 40 per cent of India's total exports of $ 8.3 billion in 2001have come from Bangalore. There are about 60,000 IT professionals employed in Bangalore. Having outlined the evolution of Bangalore as an industrial district, let us look at some of the variables contributing to the region's dynamism.

4. REAL SERVICES

4.1 Infrastructure

Provisioning of services requires, to begin with, appropriate institutional mechanisms to identify needs of a cluster, followed by measures to provide the required services.[10] We already highlighted the role of public sector enterprises in drawing software capital to the cluster, through creation of a pool of skilled labour. Another critical input to software service production is the availability of communication and hardware support. In both respects, the state has had a major role to play. At the state-level, policies fostered private participation in higher education leading to establishment of a number of engineering colleges, thereby enhancing the supply base for labour. Subsequent to the software boom, at the national level, private sector participation in software training is encouraged and at present, training is an important segment of software sector in India (Kumar, 2001).

In terms of physical infrastructure, in the mid-1980s, the Karnataka state government in conjunction with the Department of Electronics (DoE) created an Electronics City. It provided the facilities and infrastructure necessary to promote investment in the electronics industry, including a guaranteed supply of electricity,

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[7] In fact, quite a few of ex-IBM employees moved onto establish small software firms (*ibid*)

[8] The first software export park was set up there in 1991.

[9] "The public sector was, in this sense, a stage in the assembly of capital and human resources that established a critical mass of market opportunities and people, allowing the emergence of an internationally competitive high technology" (Heitzman, 1999).

[10] Role of policy measures has been described by many including Bajpai and Shastri, 1998.

telecommunications facilities and a technical training centre. Financial incentives like cheaper credit and tax-relief were also offered. They were later extended to software when it became apparent that it would be an important source of revenue, enabling firms to undertake offshore projects. While earlier, onsite services comprised of nearly 100 per cent of exports, with the establishment of Software Technology Parks of India (STPI) and accompanying data communication facilities, there has been a steady increase in offshore software development, with the former at present accounting for more than 50 per cent of exports (Parthasarathy, 2000). This movement has definitely helped firms to move into more complex projects, compete at lower prices, and importantly, provide opportunity for creating linkage effects in the cluster.

Apart from STPI, the state government in collaboration with a private firm in Singapore has also built a technology park, which provides excellent data communication and power facilities for software and other high technology firms. Hardware imports too have been liberalised though it must be said that efforts to develop a vibrant hardware sector has been negligible. In terms of communications infrastructure, Bangalore is well connected to other cities in the world through a VSNL gateway located in the city, with one of the highest bandwidths in India. It is also connected to other cities in India through wideband optical fibre and microwave media, though further improvements may be required with the growth in e-commerce related ventures. The next most important requirement in a high technology cluster, is access to capital for innovative ventures. Access to capital for risky innovative ventures like venture capital is a crucial ingredient to a successful high-technology cluster.

4.2 Finance

The need for innovative financial instruments has come into the cluster only of late. Onsite services did not call for much capital investment as it was largely through export of labour. Only with the movement to offshore projects, did the need for physical infrastructure like computers and communication equipment arise. And since in most cases, firms moved into offshore projects from body-shopping, they had the surplus to invest in infrastructure. New firms that sought to move directly into offshore projects nevertheless needed investment assistance. With the growth in offshore processing and attempts by few firms to enter into product development, venture capital (VC) has become important.

Conventional sources like bank loans were difficult to access given the lack of collateral for these firms. Further, the relatively high interest rates prevailing in the economy made traditional means of borrowing inefficient, especially when firms compete internationally to access markets. It is in this context that VC firms began to gain prominence in the Indian software sector. Here, the government's role has been two-fold. In active collaboration with industry experts, it has sought to facilitate the entry of VC firms into the country. On the other hand, government financial institutions and even state industry promotion agencies including those in Karnataka began to set up VC arms of their divisions to promote entrepreneurship. Nationalised banks too began to move into venture funding. More importantly, the last few years have witnessed the entry of foreign institutional investors in this segment which at present constitutes the largest share of VC funding in India (Dossani and Kenney, 2001). Together, these factors have led to a sharp rise in the growth of VC flows into high-technology sectors including software.

Bangalore has been a beneficiary of all these initiatives. In fact, the first venture capital institution in India, Technology Development and Information Co. of India Ltd., (TDICI), a subsidiary of a state owned financial institution ICICI, was established in Bangalore in 1988 (Dossani and Keeney, 2001). TDICI had funded many a venture in the early phases, which includes success stories like Microland, VXL, Mastek Software Systems and even a project for WIPRO (*ibid*, 25). Though Bangalore ranks only third in share of venture capital firms locating their offices in India, it hosts the bigger venture capital firms like Draper International, TDICI and others (*ibid*, 32). Further, Walden International, a leading venture capital firm estimates that Bangalore accounts for the largest share (35%) of the total risk capital flowing into the country (Hari, 2001). To identify the importance of venture capital to the growth of the industry, we undertook a case study of a successful firm that had relied on venture capital, apart from gathering information from key informants.

Funded by an international VC firm, the funds were essentially for services. The entrepreneur with a long stint in a multinational software firm and known in industry circles had no difficulty in getting funds. Interestingly, at that stage, the VC firm drew even the business plan, and all that the former had to do was to recruit the right people and coordinate production. As the VC firm had a global clientele of over 500 firms, it was easy for this start-up to procure orders from clients. The VC's reputation aided by the latter's introduction of their clientele, enhanced access to markets. Once established, the firm decided to launch a product for which it sought another VC firm to fund, once again a MN firm. A new firm was spun off which concentrated solely on sale of the product developed. The reason for opting for a new VC was the new clientele it would bring. The respondent says that since the VC firm knew the success of the earlier venture and given the high demand for such a product at that time, there was no hitch in accessing funds.

As most firms specialise in low-end services, VC is required more for marketing and to an extent for scaling up of current operations, rather than for product innovation. Since the primary markets are export markets, a lot of capital is required for personnel to travel, stay abroad and market their firms' capabilities to diverse clients to get orders. Respondents suggest that they prefer funding from reputed multinational firms, as apart from drawing upon a premium clientele, it also helps firms to use the former's reputation as an indication of their firm's ability to deliver. And precisely for the same reason, they seldom approach VC firms set up by government institutions to fund their requirements. In fact, sourcing from the latter may diminish the reputation among foreign clients as it may be seen to reflect their inability to source from premiere MN VC firms with good technology valuation procedures. Further, it is said that the ceiling on venture funding from state institutions are much lower than that allowed by foreign VC firms. However, state supported VC institutions are argued to have a role to play in development of software for the domestic market.

The Government of India has also nucleated a National Venture Capital Fund for Software and IT Industry (NFSIT). Set up in association with various financial institutions and the industry, it encourages entrepreneurship in the areas of software, services, e-commerce and other IT related segments in which India has built up competence. Nevertheless, respondent-entrepreneurs contend that it is difficult for entrepreneurs with truly innovative ideas or products to acquire seed capital as there are hardly any entrepreneurial networks within the cluster unlike in successful clusters like Silicon Valley where substantial venture funding was through high technology based entrepreneurs themselves. In India, most VC funds are from financial institutions less willing to undertake such innovative and risky ventures. Rather, funds have largely gone into funding of service firms that undertake more routine work with almost assured markets. Though such lack of funding may not affect the prospects of firms in the cluster at present, it would definitely pose constraints to move onto a high road path. Finally, exit options were considered to be few, with the general feeling that entrepreneurs were unwilling to sell their start-ups even if it was feasible.

4.3 Technology and Marketing Support Services

Throughout the 1990s, the State Government has been quite successful in marketing Bangalore. It has supported initiatives such as the collaboration between the European Commission and the Department of Electronics of the Government of India called 3SE, Software, Services, Support and Education Centre Limited. The purpose of 3SE is to promote co-operation between the EC and India in the field of computer software. It recognises the fact that the Indian software industry needs to diversify its markets and that European companies have been slower to take advantage of the high quality/low cost software development environment that India provides, in terms of their sourcing activities. 3SE provides information services to European companies looking to outsource or form alliances about Indian software companies in terms of matching needs. It also informs Indian software users of products brought out by EU companies.

Apart from such support in marketing, a few institutions have been established to provide technology and training support to the industry. The Indian Institute of Information Technology, Bangalore and Institute of Bio-Informatics, are novel experiments in public-private partnership that seek to not only train high quality professionals for the software industry, but also encourage interaction between academia and experts from industry.[11] The Software Engineering Institute has been set up as a joint venture between state government, Indian Institute of Science, LG Soft India and Center for Information Systems Engineering of the Carnegie Mellon Research Institute for Information Systems Engineering. This institute also offers advanced training in software engineering. Interaction between academia and industry, which has always been at low ebb due to earlier governmental restrictions on university employees to participate in commercial ventures, has increased in recent years, especially with the formation of Society for Innovation and Development (SID) by the Indian Institute of Science (IISc) in late 1990s. Since then, the number of collaborative projects with the industry has increased to 80 from 10 only three or four years ago (Hari, 2001). The Institute has also been able to incubate a few high technology firms of late.[12] The innovation of 'Simputer' by a set of scientists at the IISc is a case in point. It is purported to be a low cost alternative to the personal computer that can be shared by many users and allows user interfaces based on sight, touch and sound. It is hoped to find diverse applications in rural India where literacy levels are low. The Simputer Trust consists of both academics and members from the industry.

Simultaneously, a number of MNCs have established research labs and development centres focussing on frontier technologies to take advantage of the low-cost highly skilled labour power in the cluster. Hari argues that this would in turn create a pool of skilled labour that can be tapped into by future start-up firms. He cites the case of a high technology venture, which recruited the first 20 technical personnel from within the cluster itself! More definite understanding of the impacts of such foreign investments needs a detailed study. The state, as can be seen, nevertheless continues to play an important role in ensuring that at least a certain degree of important real services are made available to firms in the cluster. While earlier, the role of the state has been rather indirect, with the growth in exports, there has been a concerted effort to improve the competitiveness of the cluster by both state institutions and/or producer associations.

5. IMPLICATIONS

The growth performance of Bangalore software cluster is not easily observed in clusters located in other low-income regions. The establishment of strong networks with clients, investments by numerous subsidiaries of MNCs, return-migration of skilled labour and resultant entrepreneurship in high-technology segments have led to diffusion of skills and knowledge of frontier technologies in software production. This, coupled with competitive pressures has led to improvements in processes, emphasis on quality control, improved employee productivity and limited movement into more value-adding services. The state too has played an important role in ensuring a steady supply of skilled labour, apart from positive interventions in the realm of infrastructure and technology support services. In terms of access to finance, few existing firms studied reveal constraints. Despite presence of such factors that are recognised to contribute to an innovative milieu, the primary basis of competition continues to be one of low wages and a large pool of skilled labour. Attempts to move beyond such low road competition have not met with much success thus far. Further, we observe serious differences in firms' ability to access skilled labour even within the cluster, with the smaller firms unable to compete with established well paying large firms. In terms of access to a workforce amenable to learn and use multiple skills, respondents from small and big firms agree upon tightness of the software labour market (Rothboeck, Vijayabaskar and Gayathri, 2001).

The most important constraint facing the cluster is a relative absence of inter-firm networking, especially with regard to user-producer interaction. The excessive focus on export market

[11] The former has an incubation centre that has already enabled two start-up firms.

[12] In addition, this has also facilitated some faculty members of IISc to invest in equity of a bio-informatics firm (*ibid*).

prevents firms from interacting closely with users so as to understand the latter's needs better, which is turning to be increasingly critical to software development. While firms have definitely built up adequate competence in software development, an inability to move into design prevents them from building up further capability in this sector. The out migration of skilled and experienced labour compounds this inability, as it tends to push firms further away from investing in training and competing on the basis of innovation. Even with regard to financing, though constraints on venture capital flows have eased considerably, such flows tend to be directed mostly to less risky, relatively low-end software development ventures. Funds for product innovation have hardly found their way into the cluster. Once again, this is due to lack of entrepreneurial networking between firms in the cluster. A lack of inter-firm division of labour too retards individual firms' tendency to acquire domain specific competence, or even in complimentary technologies as observed in more innovative clusters.

State policies need to be directed towards promotion of the domestic market and leveraging of this learning in the global market. Provision of tax and credit incentives to export firms and consequent reduction in incentive to produce for the domestic market may undermine the scope for such learning. To overcome limitations, not only is state intervention critical, but so is the 'strategic intent' of lead firms in the cluster. Given that a few big firms dominate the cluster, it is imperative that these firms direct the activities of the cluster in such as a way as to strengthen its innovative capability. Entering into strategic alliances with MNCs in areas like brand-building and marketing may prove to be increasingly critical. Simultaneously they need to work in close collaboration with state institutions to ensure that critical resources are provided. Inability to retain skilled labour, lack of interaction with users and inter-firm networking may however, continue to pose constraints to transition to a 'high road' trajectory.

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RURAL WOMEN AND FARM MANAGEMENT INSIGHTS: DECISION SUPPORT TOOLS IN THE AUSTRALIAN COTTON INDUSTRY

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ABSTRACT

Australian farmers are supplementing traditional practices with innovative strategies in an effort to survive recent economic and environmental crises in the rural sector. These innovative strategies include moving towards a knowledge-based farm management style through the use of technology. Nevertheless, a review of the relevant literature has determined that despite a growing awareness of computers for farm management, there is concern over the limited demand for agricultural decision support systems (DSS). Research also indicates that farm women are hesitant to use computers for decision support and that their decision-making roles in rural society are unclear.

This study is a research-in-progress the objective of which is to explore the uses and consequences of technology diffusion that emerge from complex social interactions between institutional structures and social agents by focussing on the relationships between farm women and the use of computers for decision support on Australian cotton farms.

The research strategy is an interpretive approach using multiple case studies of cotton growers and industry professionals as two separate groups. Data collection is through semi-structured interviews, participant observation, and document analysis. The broad conceptual framework to be used in this study is structuration theory. This framework will be used to explore the recursive notions of structure and technology as the duality of structure and technology. Diffusion of innovations theory will be used as a lower-level theory for analysing the characteristics of an agricultural DSS.

The research has theoretical and practical contributions. A theoretical contribution includes acquiring a greater understanding of the constructs that affect rural women's participation in decision-making and farm management, and the use of computers for decision support. The practical justifications are several. They include the potential to improve DSS adoption rates, thereby achieving enhanced sustainable resource management on family farms. These aims would bring significant social, economic and environmental benefits to the rural sector.

Keywords

Decision support systems, farm management, structuration theory, diffusion theory, rural women, cotton industry

1. INTRODUCTION

The literature review focuses on the research domains of gender, technology, and rurality, in order to identify the research objectives and the significance of the study. A theoretical background is required to comprehend the complexity of technology diffusion in the rural sector. This framework uses structuration theory by Giddens [1] as a meta-theory, and innovation diffusion theory by Rogers [2, 3] as a lower level theory. The research design is interpretive using multiple case studies to explore the dynamics of rural women's use of computer-based decision support tools on Australian cotton farms.

2. LITERATURE OVERVIEW

2.1 Gendering of Technology

Alston [4] argues in her study of the lives of Australian farm women that farm roles have developed based on gender stereotypes. Male farmers are participants in the 'more important' public sphere of outdoor work while farm women have become associated with the less visible private sphere of housework and children. This "domestic work has come to be devalued because it is unpaid and not directly geared to agricultural production and the marketplace" [4].

The findings of an Australian report by Bryant [5] into the impact of personal computers (PC's) on farm management suggest that the use of software reflects the traditional gender division of labour on farming properties. Farm women are associated with computer data entry and record keeping, while male farmers analyse and plan the farm business.

Bryant [5] contends, oftentimes the farm woman depends on the male farmer, with his more detailed outdoor farm knowledge, for the input data. If the male farmer is reluctant to provide this data, the farm woman's attempt to use computers for strategic tasks is frustrated. For a more progressive and workable outcome, the report by Bryant [5] recommends that farm men and women work collaboratively to enter data, analyse and interpret it.

Stewart [6] in a case study which analyses the use of interactive communication technologies (ICTs) by men and women on Australian family cotton farms, found that farm women's lack of confidence as controllers of data meant that they often avoided responsibility for developing information systems for decision-making purposes. This was confirmed by Stubbs et al. [7] in research exploring the use of PC's by farmers for the Australian Rural Industries Research and Development Corporation (RIRDC). All the same, there is evidence that many rural women are increasingly aware of the farm management possibilities of computers for decision-making about new and innovative farming practices.

2.2 Farm Management

Kilpatrick et al [8] in Australian studies on the relationship between learning and farm management determine that "to survive, farmers of the future must recognise that farming is more than just a way of life. It is now a high technology, high risk business, requiring access to good information and demanding not only sound business management skills but a higher level of skills than before".

The early emphasis of farm management on production planning and financial budgeting has been deemed too limiting. According to Bamberry et al. [9], a whole of farm approach is now considered to be more appropriate for the multidisciplinary nature of farm management although input from the social sciences still remains limited. Most importantly, good farm management relies on the information processing skills of the whole team.

Rural women are acknowledged as having an ongoing interest in profitable agricultural industries and sustainable resource management [4]. As Rowe [10] asserts in the proceedings from the National Forum on Women in Agriculture and Resource Management in Canberra in 1997, women "continue to see the big picture, to assert that we stand on a three legged stool of environment, economics and society, with all legs important and interdependent".

2.3 Decision Support Software

Despite early promise, the continuing low adoption rates of agricultural DSS are being reported in many Australian studies [11, 12]. Recent research suggests many reasons. A controversial study by Cox [11] claims that the gap between the scientific theory of researchers and the real-world practice of farmers is a cause.

3. JUSTIFICATION FOR THE STUDY

The concern is that both human and technological resources are underutilised. That is, women have untapped potential for greater involvement in farm decision-making. As well, DSS as a tool has the potential to improve farm systems by providing the best information available from scientific research. It is proposed that greater use of DSS by farm women may enhance resource management through the finding of sustainable solutions outside those in existing practice.

3.1 Cotton Industry

Of consequence to the wider community is the well-being of the rural sector. The cotton industry in Australia is a wealthy and developing industry. Cotton is a valuable export worth nearly two billion dollars for the year 2000-2001. Nevertheless, cotton management is becoming increasingly complex: insecticide resistance is growing, water allocations are being reduced, and community concerns about chemical use are rising.

3.2 *CottonLOGIC* Software

The agricultural DSS for the study is *CottonLOGIC*. It is a farm management tool being developed by the Australian CSIRO and the Cotton Cooperative Research Centre (CRC), with support from the Cotton Research and Development Corporation (CRDC). *CottonLOGIC* is a package of decision support software to assist cotton growers and their advisors in the management of cotton pests, soil nutrition, and farm records. It enables the recording and reporting of crop yields, insect populations, weather data, and field operations such as pesticide and fertiliser applications as well as the running of insect density prediction models. *CottonLOGIC* provides the cotton industry with access to the latest research available to improve crop production and sustainability [13].

4. THEORETICAL FRAMEWORK

For this study, it is my intention to use Gidden's structuration theory predominantly for meta-theoretical and conceptual applications. The conceptual model will provide sensitising concepts for understanding the duality of structure and technology. The meta-theoretical use will be as a broad theory within which other theories such as diffusion theory are placed.

4.1 Duality of Structure

According to Giddens [1], "the structural properties of social systems are both medium and outcome of the practices they recursively organise". This central principle of structuration theory refers to the properties of social structures as the result of human actions, which in turn reshape human actions. The mutual dependence of human actions and social structures is implied. The recursiveness of social life, as **duality of structure**, resolves the issue of incommensurability between human interaction and social structure. Essentially, the social reality of cotton farming is constructed and reconstructed when the social institutions[1] and practices of farm management are produced and reproduced. As well, the actor such as the farm women is socially constructed.

4.2 Duality of Technology

IS issues are never directly discussed in Giddens' writings [14]. Moreover, Giddens has much to say about societies and social relationships of individuals but little about organisations and groups of people [15]. Subsequently, Orlikowski [14] developed a structurational model of technology as an extension of Giddens' structuration theory to reconceptualise the nature and role of technology in organisations[2]. While Giddens' model of structuration consists of nine elements within the three dimensions of signification, domination, and legitimation, Orlikowski's model focusses on three components. They are: 1) human agent (technology designers, users, and decision-makers); 2) technology; and 3) institutional properties of organisations including business strategies, ideologies, divisions of labour, expertise, government regulations, and socio-economic conditions.

Orlikowski [14] asserts that "technology is created and changed by human action, yet it is also used by humans to accomplish some action". This recursive notion of technology - termed **duality of technology** - is the critical premise of the structurational model of technology. In essence, an agricultural DSS is both created and changed by human actors such as farm women.

4.3 Diffusion Theory

"Structuration theory is intended as a broad theoretical framework within which other social theories can be located and to which other perspectives can be related" [16]. As already explained, the material aspects of technology in structuration theory remain unresolved. Therefore, diffusion

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1 Giddens 1. Giddens, A., *The Constitution of Society: Outline of the Theory of Structuration*. 1984, Berkeley and Los Angeles: University of California Press. explains **institutions** as the more enduring features of social life.

[2] Giddens 1. Ibid. defines **organisations** as decision-making units.