The Emerald Research Register for this journal is available at
http://www.emeraldinsight.com/researchregister

The current issue and full text archive of this journal is available at
http://www.emeraldinsight.com/0144-3577.htm

An initial assessment of the influence of IT on TQM: a multiple case study

Frank W. Dewhurst
Manchester School of Management, UMIST, Manchester, UK
Angel Rafael Martínez-Lorente
Facultad de Ciencias de la Empresa, Universidad Politécnica de Cartagena, Paseo Alfonso XIII, Cartagena, Spain, and
Cristóbal Sánchez-Rodríguez
Wilfrid Laurier University, Waterloo, Ontario, Canada

Keywords *Information technology, Total quality management, Case studies, Methodology, Spain*

Abstract *Information technology (IT) and total quality management (TQM) have significantly impacted on most organizations and each has been widely researched. However, there is little well-founded empirical research on the relationship between the two, particularly on the way in which TQM is influenced by IT. This paper presents an initial investigation of such relationships through an interview survey of 14 companies based in Spain. The cases indicate that there is a framework underpinning this relationship. The paper concludes with a proposal for this framework and an instrument for testing the conjectured linkages within the framework.*

Introduction

Information technology (IT) is increasing in importance for companies and its effects on global trading are becoming widely felt (Mahan and Gotlieb, 1992; Chandler, 1998). It is frequently argued that IT is the most important factor in increasing productivity and reducing costs (e.g. Kagan, 1994; Weston, 1993), although some studies show contradictory results (Mahmood and Mann, 1993; Willcocks and Lester, 1997). Evidence of positive and significant returns from IT investment can be found in Brynjolfsson and Hitt (1996), Dewan and Min (1997) and Kelley (1994), while Loveman (1994), Powell and Dent-Micalef (1997) and Strassmann (1997) found that IT had no significant effect on productivity or competitive advantage. Using country-level data, Dewan and Kraemer (2000) found that IT investments have a positive and significant effect on gross domestic product (GDP) in developed countries, but not in developing ones.

Various means for improving quality, reducing costs and increasing productivity are being sought and implemented by manufacturers and service providers seeking continuous improvements in business performance. They

International Journal of Operations & Production Management
Vol. 23 No. 4, 2003
pp. 348-374
© MCB UP Limited
0144-3577
DOI 10.1108/01443570310467302

The authors wish to acknowledge the support of the Seneca Foundation in this research.

include total quality management (TQM), total productive maintenance (TPM), business process re-engineering (BPR), manufacturing resources planning (MRP), just-in-time (JIT), etc. Weston (1993) claims that all these interventions rely on IT, which acts as a feedback mechanism to users who are keen to measure productivity and, in addition, they also serve as the means to get rapid and more accurate information, improve communication links, and facilitate the implementation of advanced tools, systems and modelling techniques. There is little doubt that applications of IT affect all sections and functions of a company, therefore, it is argued that IT also must affect TQM. This paper examines the way in which TQM is influenced by IT and its role in TQM interventions to identify the key issues which need to be considered by quality professionals.

Before considering the influence of IT on TQM it is necessary to define what is meant by the term TQM. Several writers have attempted to define the different dimensions that shape TQM including Ahire *et al.* (1996), Dale *et al.* (1994), Flynn *et al.* (1994) and Saraph *et al.* (1989). The key dimensions have been clarified in Martinez-Lorente *et al.* (2000) and are shown in Table I.

Much has been written about how IT might be used to enhance TQM, see for example Ayers (1993), Zadrozny and Ferrazzi (1992), Berkley and Gupta (1994) and Cortada (1995). The key roles that information and IT play in TQM is described by Sobkowiak and LeBleu (1996) and Pearson and Hagmann (1996) while specific IT applications in various aspects of TQM have been described by Miller (1996), Aiken *et al.* (1996), Goodman and Darr (1996), Khalil (1996), Kaplan (1996), Kock and McQueen (1997) and Counsell (1997).

Some studies have considered how IT is related to organisational performance measures. For example Byrd and Marshall (1997) employed causal model analysis to relate IT investment to organisational performance while Rogers *et al.* (1996) examined the relationship between utilisation of IT and performance in the warehouse industry. Although Rogers *et al.* (1996) provided empirical evidence of the importance of IT in quality performance, the role of IT in TQM environments was not investigated. Torkzadeh and Doll (1999) devised and applied a construct to measure the perceived impact of IT on work, which relates to only one of the TQM dimensions.

The only consideration given to how IT influences TQM is the reference model developed by Forza (1995a) to link TQM practices, information systems and quality performance through empirical research. However, using his own model and associated measures, Forza (1995b) did not succeed in empirically establishing a link between TQM practices and IT and only the use of IT in the quality assurance aspect of TQM was explored. Forza (1995b) proposed that the contribution of IT should be further investigated by developing adequate measures especially with reference to its use.

Dimensions	Description
Top management support	Top management commitment is one of the major determinants of successful TQM implementation. Top management has to be the first in applying and stimulating the TQM approach, and they have to accept the maximum responsibility for the product and service offering. Top management also has to provide the necessary leadership to motivate all employees
Customer relationship	The needs of customers and consumers and their satisfaction have always to be in the mind of all employees. It is necessary to identify these needs and their level of satisfaction
Supplier relationship	Quality is a more important factor than price in selecting suppliers. Long-term relationship with suppliers has to be established and the company has to collaborate with suppliers to help improve the quality of products/services
Workforce management	Workforce management has to be guided by the principles of: training, empowerment of workers and teamwork. Adequate plans of personnel recruitment and training have to be implemented and workers need the necessary skills to participate in the improvement process.
Employee attitudes and behaviour	Companies have to stimulate positive work attitudes, including loyalty to the organisation, pride in work, a focus on common organisational goals and the ability to work cross-functionally
Product design process	All departments have to participate in the design process and work together to achieve a design that satisfies the requirements of the customer, according to the technical, technological and cost constraints of the company
Process flow management	Housekeeping along the lines of the 5S concept. Statistical and non-statistical improvement instruments should be applied as appropriate. Processes need to be mistake proof. Self-inspection undertaken using clear work instructions. The process has to be maintained under statistical control
Quality data and reporting	Quality information has to be readily available and the information should be part of the visible management system. Records about quality indicators have to be kept, including scrap, rework and cost of quality
Role of the quality department	Quality department need access to top management and autonomy and also has to combine the work of other departments

Table I.
TQM dimensions

What is needed is a valid instrument to measure the influence of IT on TQM and company performance. However, to develop a measurement construct it is first necessary to state the hypotheses to be tested and this requires an underlying theoretical framework to be identified. Therefore, the focus of attention of this paper is to identify an underlying framework. To this end a case study methodology was employed and a justification for this approach is given in the next section. The results from analysing these cases in relation to previous studies are presented in a subsequent section while the last section presents an underlying theoretical framework synthesised from this analysis and proposes a construct for testing the framework.

The methodology

Given the investigative nature of the research question, a case study method seemed appropriate (Yin, 1988). Although not without its critics (e.g. Gummesson, 1991), a multiple case study methodology utilizing a "natural" (Hussey and Hussey, 1997) sampling approach employing "snowball" sampling (Arbour, 1993) was considered more appropriate for such an initial investigation. Since the primary objective of the study was to identify or infer a framework to measure the influence of IT on TQM, senior quality managers from companies having well-documented records of TQM were considered the most appropriate source. Personal interviews were conducted in 14 companies chosen at random from Spain's top 500 companies to be representative of their sector, size and nationality as shown in Table II. Ten of the companies had the ISO 9001 certificate and three had the ISO 9002 certificate. Only the pharmaceutical company had no ISO 9000 certificate, but it was subject to strict governmental norms for production procedures.

Company	Sector	Number of employees	Nationality
A	Chemical	1,200	USA
B	Car manufacturer	12,500	EU
C	Pharmaceutical	1,100	EU
D	Textile	1,700	EU
E	Electronics	1,800	Japan
F	Printing	1,678	EU
G	Truck manufacturer	2,200	EU
H	Components	300	EU
I	Tractor manufacturer	800	USA
J	Machinery	5,300	EU
K	Aircraft manufacturer	3,500	EU
L	Electronics	1,000	EU
M	Food	672	EU and Switzerland
N	Food	1,900	EU

Table II. Company characteristics

Because many companies compete on quality, access to the appropriate data was considered "closed" (Hornsby-Smith, 1993) which, together with the nature of the research questions, suggested an interview approach (Hussey and Hussey, 1997). Rather than taking verbatim notes, which are prone to errors and bias (Fielding, 1993), an interview protocol checklist was employed (see Appendix 1) on which notes and annotations were made as the interview progressed. The interviews lasted on average 1.5 hours, ranging from 35 minutes to 2.5 hours and were written up by the following day.

A simple construct to measure the intensity of use of IT was developed similar to those used in previous studies (e.g. Bailey and Pearson, 1983; Bakos, 1987) and was completed during the interviews. This construct included 28 items (see Table III). The means of every company are shown in Table IV. Since company D worked with clients' designs it did not apply CAD and this question was not used to calculate its IT usage mean.

Use of information technologies		1 no use, 5 intensive use				
1.	Word processors	1	2	3	4	5
2.	Accounting programs	1	2	3	4	5
3.	Invoicing and stocks management	1	2	3	4	5
4.	Payroll management	1	2	3	4	5
5.	Databases	1	2	3	4	5
6.	Fax	1	2	3	4	5
7.	Mobil phones	1	2	3	4	5
8.	Internet access	1	2	3	4	5
9.	Advertising by a company web page	1	2	3	4	5
10.	Direct sales by a company web page	1	2	3	4	5
11.	E-mail	1	2	3	4	5
12.	Electronic data interchange with suppliers or clients	1	2	3	4	5
13.	Spreadsheets	1	2	3	4	5
14.	Cost accounting	1	2	3	4	5
15.	Decision support systems	1	2	3	4	5
16.	Group working with electronic information interchange	1	2	3	4	5
17.	CAD	1	2	3	4	5
18.	CAM	1	2	3	4	5
19.	Numeric control machines with computer control	1	2	3	4	5
20.	Robots	1	2	3	4	5
21.	Electronic systems of product identification	1	2	3	4	5
22.	Electronic systems of quality control	1	2	3	4	5
23.	MRP systems	1	2	3	4	5
24.	ERP (Enterprise Resource Planning)	1	2	3	4	5
25.	Data analysis	1	2	3	4	5
26.	Forecasting	1	2	3	4	5
27.	Storage automated systems	1	2	3	4	5
28.	Presentation graphics software	1	2	3	4	5

Table III.
Construct to measure use of IT

Company	Mean use (1 no use, 5 intensive use)
A	3.14
B	4.75
C	4.14
D	2.74
E	3.86
F	4.57
G	4.64
H	4.71
I	4.36
J	4.79
K	4.64
L	4.79
M	4.54
N	3.68
Mean	4.24
Standard deviation	0.652

Table IV. Information technologies mean use

Analysis of the cases

The cases are discussed in relation to the existing literature under each of the nine TQM dimensions presented in Table I.

Top management support

The support of senior management is necessary both for the success of TQM and the introduction of IT. Zuboff (1983) outlines how the introduction of a new IT intervention may generate some uncertainty within the workforce and how the support of senior management is vital in maintaining the continuous improvement process. Sometimes, the introduction of IT has created problems with the workforce and other members of the staff (Wilson, 1994), so top management has to be very cautious and avoid contradictions between the new IT requirements and the TQM policy being followed at the time. Dismissals due to introducing IT occurred in only three of the 14 companies, but these companies tried to avoid workforce problems by anticipated retirements. None of the companies perceived that IT introduction caused problems with employees or that the TQM policy was affected. IT was considered as a supporting the introduction of TQM in 11 of the 14 companies.

Only three of the companies used IT to increase control over employees and did not perceive that this caused problems. Some perceived workforce problems were identified (i.e. stress due to automation and fear of new things). On the other hand, ten of the 14 companies considered that IT facilitated TQM dissemination, but mainly because IT helps to manage information on quality which in turn helps in the task of TQM application and consequently helps to persuade people of TQM benefits.

Customer relationship

The development of IT may help to improve relationships with customers in several ways. IT can lead to a direct relationship between companies and customers, helping in the interchange of information. IT enables organisations to reach customers who are geographically remote (Quelch and Klein, 1996), providing opportunities, in particular, for small to medium-sized enterprises (SMEs).

It is important that organisations understand the speed and extent of the shift to electronic commerce conducted between businesses, homes and countries and starts to put into place the means of controlling such invisible processes. For example, companies can offer their products through the Internet, including explanations of the characteristics of the products, and clients can procure products and services through this means and feedback opinions about the characteristics of the products/services through the e-mail system (Chandler, 1998; Finch and Luebbe, 1997). The results of a study by Stone *et al.* (1996) indicate that in the future, customers will increasingly seek to manage the relationship themselves, using new technologies and that companies need to prepare themselves for this.

Companies can also use these aspects of IT by undertaking customer surveys the results from which can be saved in electronic databases and be used for targeting specific consumers and products. IT systems also allow sophisticated analyses of consumer needs, expectations and behaviour.

All the surveyed companies used the Internet to interchange information with customers. The Internet was used to sell products (four companies), to receive customer requirements (13 companies), to receive customer complaints (11 companies) and to undertake customer surveys (four companies). Industrial companies made an intensive use of e-mail to communicate with clients but consumer goods companies did not use the Internet in an extensive way, although they had plans to do it. A total of 12 companies used statistical software to analyse data obtained from customer surveys.

All companies experienced improvements in their relationships with customers due to the investment and use of IT. The use of electronic data interchange (EDI), Internet, and intranet with customers allowed them to maintain effective communications with respect to product specifications, maps, complaints, surveys and general information. Special attention should be given to the influence of IT on quality information sharing with customers.

Three companies had well-developed links with customers. Customers of company G were able to send real-time data and pictures of defective components, and the main customers of company H reported defects per million in real-time production. Company L was able to identify through their customer's intranet which radio-phone cards were causing problems at the customer site. Therefore, IT has become a crucial instrument in managing relations with customers and improving quality.

Supplier relationship

As with customers, IT systems can help to develop improved communication links with suppliers through EDI systems. EDI can be used to place orders, send product specifications, design details, etc., along with confirmation of invoices and paying for suppliers (Jonscher, 1994). Teague *et al.* (1997) outline how suppliers can be involved earlier in the design process by the use of IT. In some cases, companies can access the inventory systems of their suppliers and place orders automatically and there can also be access to production scheduling systems. Mukhopadhyay *et al.* (1995) report the considerable savings achieved by Chrysler using EDI systems with suppliers. Encouraging vendors to use EDI significantly improved organisational efficiencies (Banerjee and Sriram, 1995).

All the companies considered that IT contributed to improving the management of suppliers and used IT to communicate with their suppliers, although only in six cases IT was used intensively. For example, some companies only used fax but not e-mail to communicate with suppliers. A total of 13 companies used EDI for placing orders and sending product specifications and design details, only ten of which also paid invoices and nine confirmed invoices electronically.

Srinivasan *et al.* (1994) concluded that investments in IT to support both the sharing of JIT schedules and the establishment of integrated information links are related to significant reductions in the level of shipment discrepancies. Bakos and Brynjolfsson (1993) and Stump and Sriram (1997) argued that IT accelerates a reduction in the number of suppliers used by an organisation. Of the companies, 12 had reduced the number of suppliers and most considered that IT had contributed to this reduction.

Company G considered that IT contributed to more efficient management of a smaller number of suppliers and companies I and J said that IT helped in the process of supplier evaluation, but that the reduction in number was not due to IT.

Workforce management

This is one of the areas in which IT systems appear to have more controversial implications, in particular, in terms of the changes in the role of shop floor employees and intermediate managers as a consequence of increased levels of automation. Although some authors (e.g. *Business Week*, 1984; Bradley, 1989) claim that the number of levels of organisational hierarchy will decrease with the use of IT, others (Blau *et al.*, 1976; Pfeffer and Leblebici, 1977) consider that IT may increase the depth of hierarchies by reducing the delays and distortions introduced by the movement of information through the organisation levels. Pinsonneault and Kraemer (1997) found that IT was associated with a decrease in the numbers of middle management in organisations with centralised decision authority, but

in organisations where decision authority was decentralised they increased. Seven companies had reduced the levels in the hierarchy, but none considered that IT had been the cause. Three of these seven considered that IT had facilitated the process because of improved access to information but thought that IT was not the reason for reduced hierarchy depth. Decision was decentralised in these three companies. Company D, a non-decentralised firm with a low level of IT application considered that IT would increase the levels in the hierarchy.

IT may also reduce job satisfaction and diminish skill requirements by: routinising work; subdividing work into small, highly specialised and repetitive tasks; subjecting humans to machine control; replacing low-level clerical jobs with high-skill professional jobs; and automating the more mundane tasks (Attewell and Rule, 1984; Haug, 1977; Wilson, 1994; Zuboff, 1982). From this there are clear arguments both in favour and against IT applications leading to deskilling. Zuboff (1983) and Attewell and Rule (1984) report both and it is difficult to determine which view predominates. There are also arguments both in favour and against the view that IT increases workers' autonomy (e.g. Walton, 1982). These opposing views lie in two possible applications of IT (Eason, 1988). One of them is focused on the use of IT as an agent to control work processes, an argument defended by Beniger (1986) and Wilson (1994). This kind of application leads to deskilling and monitored jobs, with the usual results of higher productivity, increased control and command and inflexibility. The other view is focused on the use of IT as an enabling mechanism. In this case, jobs are enriched and job satisfaction increases. The result of this is not necessarily higher productivity (although it would be unlikely to decrease), but it is expected that performance, employee initiative and flexibility will increase. These two kinds of IT implementation are sometimes applied simultaneously in companies, the first type impacts on clerical staff and the second on professional staff.

If the labour required is more intellectual, autonomous and less mechanically controlled as a result of IT then training become more important, and the content of this should reflect the new knowledge needs. When work becomes more intellectual, the argument put forward by quality management experts is that supervisors should function as coaches rather than giving subordinates' orders. On the other hand, if IT implies less autonomy and intellectual challenging jobs, this conflicts with a number of the TQM principles and practices (e.g. empowerment, trust and discretion and teamworking, in particular, self managing workgroups).

At operative level, IT had lead to more routinised jobs in only two companies, but seven companies reported less routinisation. At managerial level, IT had reduced routine in ten companies and increased it in none. Workers were more subject to machine control in ten companies and more

mundane tasks had been automated in 12. IT increased the need for training in 13 companies, although this training was mainly focused only in the use of IT. Worker autonomy had been increased in three companies and decreased in one and remained the same in the rest. In general, IT increased the control on workers, but also enriched those jobs with more intellectual task, mainly at clerical level. Workers' were required to develop new skills in IT but not for basic tasks. The change in the worker's autonomy appeared to depend more on the company general policy than on the IT application.

All companies used IT to increase process control and all but one used IT as an enabling mechanism. Therefore, the two possible applications of IT are applied simultaneously. Companies increased process control through IT and, at the same time, used IT to enrich jobs, mainly for undertaking new tasks (e.g. statistical process control (SPC)).

Tasks changed for intermediate managers as consequence of IT in seven companies and involved: new tasks, more communication, greater delegation, acting as co-ordinator, more autonomy and new management styles. Although teamwork was used in only ten companies, all considered that IT facilitated teamworking because of better communications and reduced physical presence in meetings (e.g. e-mail).

Employee attitudes and behaviour

When new systems are introduced, based on IT, some organisational restructuring is implied, and the natural resistance of employees to this change may reduce commitment to company goals and objectives. The usual argument that IT applications will lead to a reduction in the number of employees as its protagonists (e.g. Jonscher, 1994; Brynjolfsson *et al.*, 1994), but there are others (e.g. Osterman, 1986) who claim that this may not be the case. Also, when IT implementation results in deskilling and loss of worker autonomy it is likely that motivation will decrease. Wilson (1994) describes a situation where the conflict between the utilisation of IT and the TQM programme generated some ill-feeling among management and staff because the increase of information requirements demanded by top management through the new faster means of communications that IT enabled was contradictory to the demand for improved customer service implied by TQM. On the other hand, when IT is used as an enabler to eliminate boring, dirty and hazardous work, job satisfaction increases. In any case, the change in workforce attitudes that may occur after the introduction of IT needs to be considered in order to prevent decreases in company loyalty, pride in work, ability to work with employees from other departments, job satisfaction and increased stress.

Five companies detected problems with their older employees in adapting to the new technologies. In three of these five companies, motivation increased for younger employees. Of the remaining nine companies, motivation increased after IT implementation in five; and in two of these five, loyalty increased and

in three pride in work had grown. A general decrease in either motivation, loyalty or pride in work after IT implementation was not perceived in any company. On the other hand, ten companies detected an increase in stress. This occurred mainly with intermediate managers and was due to the growth in information, (i.e. too many e-mails and increased data entry). Some older employees indicated a feeling of loosing control and out of touch.

A positive effect of IT is the sharing of information between departments and functions. Nine companies perceived that IT improved inter-departmental information flow. However, the implementation of IT does not mean that people will be more disposed to share information, if they think that they have reasons to believe that this will not be in their best interests then this will not happen. All the companies analysed detected some problems in a reluctance to share information and these problems appeared mainly with older employees.

Product design process

The capacity to innovate increases with the use of IT (Schein, 1994). computer-aided design (CAD) technologies are a fundamental aid in the design process because of faster response to consumer needs and greater innovation. One company did not make its own designs but the remaining 13 used CAD software. An effective new product design and development process requires information from different departments (production, marketing and R&D) and IT may aid the effective and speedy transmission of this information. Hameri and Nihtila (1997) report a case study in which design projects involved numerous teams from various locations and Web-based applications in new-product development provided an effective media for communicating and disseminating information. A total of 12 companies used IT to interchange information on product design issues among different departments.

IT is also useful in design of experiments (Mezgar *et al.*, 1997), failure mode and effects analysis (FMEA) (Webber, 1990) and quality function deployment (QFD) (Rangaswamy and Lilien, 1997; Zhang *et al.*, 1996). In all these cases, IT does not change the way that these quality tools and techniques are applied but it helps to facilitate their application and open up new ideas. Eight companies implemented design of experiments all supported through IT; 11 companies applied FMEA, supported by IT in only ten and four companies applied QFD all being supported by IT.

Process flow management

IT was found useful in the task of process flow management. Only one company did not apply IT in the production process.

IT can assist maintenance through the use of automated systems to detect the need for machine maintenance and diagnose what needs to be done and this can be carried out at a location remote from the machine (Dilger, 1997; Krouzek, 1987). This is applied in nine of the 14 companies.

Automation helps to reduce process variance, because machines usually demonstrate less variability than workers and results in increased speed of production processes with a significant quality enhancement (Freund *et al.*, 1997). All the companies achieved improved process control through the use of IT. However, this does not mean that the need for quality management disappears; on the contrary, automated machines require components and raw materials of high quality (Karatsu, 1988). Seven companies had increased the quality of components and raw materials from suppliers and this explained some of the observed reduction in the number of suppliers.

Both electronic detection and signalling devices also help to reduce process variance. These types of applications lead to the reduction and eventual elimination of a number of inspection type activities (Litsikas, 1997). Classical inspection has been reduced in eight companies. They have reduced the number of inspectors but have increased both the inspection points and the number of products inspected using automated systems.

SPC may be facilitated, through the automated measurement of product and process parameters and the registration and processing of data (Gong *et al.*, 1997; Kendrick, 1995; Papadakis, 1990). This was observed in 12 companies.

Those companies involved in a process of quality management systems certification, such as ISO 9000, now have access to a variety of software to assist them in the process of implementation and self-assessment (Ward, 1998). All the 13 companies that had ISO 9000 certification considered that IT facilitated its application, mainly in the management of paperwork.

Automation can imply less flexibility but this is not in line with the TQM principles (Schonberger, 1986). However, only one company perceived that automation had reduced its flexibility and nine considered that flexibility had increased (mainly due to following FMS principles).

The design of processes to ensure that outcomes conform to quality requirements is a key issue along with the control of processes in which transactions are conducted on-line. It could be that a new generation of quality control and improvement tools are required in this type of environment. Patterson *et al.* (1997) provide an example of the need for new quality control and improvement tools created as a consequence of the use of computer numerically controlled (CNC) machinery. In relation to this there is a need to develop appropriate algorithms and software interfaces to evaluate the effects of process interfaces and changes to processes and systems, prior to their implementation. However, none of the companies detected a need of new quality management tools as result of IT implementation.

Information on quality costs can be gathered and processed with the help of IT. Only 12 companies measured quality costs and this was supported by IT in all cases.

Role of the quality department

The role of the quality department does not have to change with the introduction of IT. It needs the same autonomy, same access to top management and has to work with other departments in a facilitating role. Quality department managers in this study had not perceived that IT implementation had changed their role. In most of the cases, their role had changed in the last few years, but not due to IT.

The work of the quality department can be made easier because IT assists in the collection and analysis of data and transfer of information to other departments. The quality department in conjunction with senior management will be responsible for providing answers to questions which arise from the implementation of IT in a TQM environment. Ten quality department managers considered that IT had facilitated their work. Tasks such as data collection, data analysis, SPC and paperwork of ISO should be improved through the use of IT. However two quality managers considered that their work was now more difficult, mainly due to the increase in information and they felt under increased pressure to take decisions about a large quantity of data, which had not previously been necessary. On the other hand, two of the previous ten quality managers considered that, although more data implied more work and responsibility, decisions were better informed and tasks had been simplified.

Conclusions

This paper has employed a multiple case study methodology to investigate whether there is an underlying framework linking the extent of use of IT and TQM dimensions that have been suggested or partially investigated in previous studies. A detailed study of 14 companies suggests that there is some relationship.

Any effect of IT on TQM could appear by two ways:

(1) through a negative impact of IT introduction in employees' motivation; and

(2) through the use of IT as an enabler mechanism to everyday work with TQM.

Our study suggests that the negative impact has been low because, although the introduction of IT has generated dismissals and more stress in some companies, motivation, loyalty and pride in work has not been reduced significantly, mainly among younger employees.

IT was found to support TQM in:

- improving costumer and supplier relationship;
- increasing process control;
- facilitating teamwork;

- facilitating inter-departmental information flow;
- improving design process and skills;
- applying preventive maintenance;
- introducing ISO 9000;
- measuring quality costs; and
- improving the decision process in quality departments.

An interesting observation was that IT application reduced the need of inspectors and increased the number of automated inspection points, presumably reducing the inspection cost per unit. This may have implications for the use of sample inspection and SPC. Since IT reduces inspection costs, some companies might increase reliance on inspection than prevention. Although prevention probably is the most effective measure to offer high quality at low cost, inspection is easier to apply and consequently managerial interest in TQM might decline.

The evidence from the literature and cases supports the view of Weston (1993). In all cases IT was considered as supporting TQM and that TQM dimensions had been affected by IT. In some cases TQM had driven the introduction of IT while in others IT introduction had been taken on board to support TQM applications.

Clearly, the extent of use of IT has an impact on the dimensions of TQM and the application of TQM, each of which will have an effect on company performance. However, the extent of use of IT also has a direct impact on company performance and it is of interest to identify the extent of these direct and indirect effects. This is summarised in the general framework shown in Figure 1. Further investigation is also required to identify the extent of these impacts.

Although the sample covered most industrial sectors any generalisations and conclusions drawn from this study are limited by the relatively small sample size. Although all the case companies were located in Spain most were subsiduries of multi-nationals and subject to international working practices and standards.

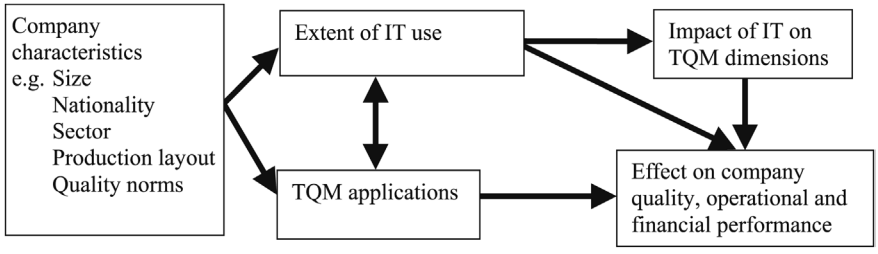

Figure 1.
Proposed IT-TQM framework

To explore these issues further a larger survey is required to investigate the extent of the perceived use and impact of IT directly and indirectly through the TQM dimensions and applications on company performance. A questionnaire construct has been designed for this purpose (see Appendix 2) and is currently being distributed to 2,000 companies.

References

Ahire, S.L., Golhar, D.Y. and Waller, M.A. (1996), "Development and validation of TQM implementation constructs", *Decision Sciences*, Vol. 27 No. 1, pp. 23-56.

Aiken, M., Hasan, B. and Vanjani, M. (1996), "Total quality management: a GDSS approach", *Information Systems Management*, Vol. 13, Winter, pp. 73-5.

Arbour, S. (1993), "The research process", in Gilbert, N. (Ed.), *Researching Social Life*, Sage, London, pp. 32-50.

Attewell, P. and Rule, P. (1984), "Computing and organisations: what we know and what we don't know", *Communications of the ACM*, Vol. 27, pp. 2184-92.

Ayers, J.B. (1993), "TQM and information technology: partners for profit", *Information Strategy: The Executive's Journal*, Vol. 9 No. 3, pp. 26-31.

Bailey, J.E. and Pearson, S.W. (1983), "Development of a tool for measuring and analysing computer user satisfaction", *Management Science*, Vol. 29 No. 5, pp. 530-45.

Bakos, J.Y. (1987), "Dependent variables for the study of firm and industry-level impacts of information technology", in *Proceedings of the Eighth International Conference on Information Systems, Pittsburgh, PA, December*, pp. 10-23.

Bakos, J.Y. and Brynjolfsson, E. (1993), "Information technology, incentives, and the optimal number of suppliers", *Journal of Management Information Systems*, Vol. 10 No. 2, pp. 37-53.

Banerjee, S. and Sriram, V. (1995), "The impact of electronic data interchange on purchasing: an empirical investigation", *International Journal of Operations & Production Management*, Vol. 15 No. 3, pp. 29-38.

Beniger, J.R. (1986), *The Control Revolution: Technological and Economic Origins of the Information Society*, Harvard University Press, Cambridge, MA.

Berkley, B.J. and Gupta, A. (1994), "Improving service quality with information technology", *International Journal of Information Management*, Vol. 14, April, pp. 109-21.

Blau, P.M., Fable, C.M., McKinely, W. and Tracy, P.K. (1976), "Technology and organisation in manufacturing", *Administrative Science Quarterly*, Vol. 21 No. 1, pp. 20-81.

Bradley, G. (1989), *Computers and the Psychosocial Work Environment*, Taylor and Francis, London.

Brynjolfsson, E. and Hitt, L. (1996), "Paradox lost? Evidence on the returns to information systems spending", *Management Science*, Vol. 42 No. 4, pp. 541-58.

Brynjolfsson, E., Malone, T.W., Gurbaxami, V. and Kambil, A. (1994), "Does information technology lead to smaller firms?", *Management Science*, Vol. 40 No. 12, pp. 1628-44.

Business Week (1984), "Office automation", *Business Week*, 8 October, pp. 118-42.

Byrd, T.A. and Marshall, T.E. (1997), "Relating information technology investment to organisational performance: a causal model", *Omega*, Vol. 25 No. 1, pp. 43-56.

Chandler, K. (1998), "Quality in the age of the networked society", *Quality Progress*, Vol. 31 No. 2, pp. 49-52.

Cortada, J.W. (1995), *TQM for Information Systems Management: Quality Practices for Continuous Improvement*, McGraw-Hill, New York, NY.

Counsell, J. (1997), "Using technology to involve the workforce", *Total Quality Management*, Vol. 8 No. 2 and 3, pp. 5126-9.

Dale, B.G., Boaden, R.J. and Lascelles, D.M. (1994), "Total quality management: an overview", in Dale, B.G. (Ed.), *Managing Quality*, Prentice-Hall International, London, pp. 3-40.

Dewan, S. and Kraemer, K.L. (2000), "Information technology and productivity: evidence from country-level data", *Management Science*, Vol. 46 No. 4, pp. 548-62.

Dewan, S. and Min, C. (1997), "The substitution of information technology for other factors of production: a firm-level analysis", *Management Science*, Vol. 43 No. 2, pp. 1660-75.

Dilger, K. (1997), "To protect and preserve", *Manufacturing Systems*, Vol. 15 No. 6, pp. 22-8.

Eason, K. (1988), *Information Technology and Organisational Change*, Taylor and Francis, London.

Fielding, N. (1993), "Qualitative interviewing", in Gilbert, N. (Ed.), *Researching Social Life*, Sage, London, pp. 135-53.

Finch, B.J. and Luebbe, R.L. (1997), "Using Internet conversations to improve product quality: an exploratory study", *International Journal of Quality & Reliability Management*, Vol. 14 No. 8, pp. 849-65.

Flynn, B.B., Schroeder, R.G. and Sakakibara, S. (1994), "A framework for quality management research and an associated measurement instrument", *Journal of Operations Management*, Vol. 11 No. 4, pp. 339-66.

Forza, C. (1995a), "Quality information systems and quality management: a reference model and associated measures for empirical research", *Industrial Management & Data Systems*, Vol. 95 No. 2, pp. 6-14.

Forza, C. (1995b), "The impact of information systems on quality performance: an empirical study", *International, Journal of Operations & Production Management*, Vol. 15 No. 6, pp. 9-83.

Freund, B., Konig, H. and Roth, N. (1997), "Impact of information technologies on manufacturing", *International Journal of Technology Management*, Vol. 13 No. 3, pp. 215-28.

Gong, L., Jwo, W. and Tang, K. (1997), "Using on-line sensors in statistical process control", *Management Science*, Vol. 43 No. 7, pp. 1017-28.

Goodman, P.S. and Darr, E.D. (1996), "Exchanging best practices through computer-aided systems", *Academy of Management Executive*, Vol. 10 No. 2, pp. 7-19.

Gummesson, E. (1991), *Qualitative Methods in Management Research*, Sage, Beverly Hills, CA.

Hameri, A. and Nihtila, J. (1997), "Distributed new product development project based on Internet and World-Wide Web: a case study", *Journal of Product Innovation Management*, Vol. 14 No. 2, pp. 77-87.

Haug, M.R. (1977), "De-professionalization: an alternate hypothesis for the future", in Halmos, P. (Ed.), *Professionalization and Social Change, Sociological Review Monograph*, Vol. 20, pp. 195-212.

Hornsby-Smith, M. (1993), "Gaining access", in Gilbert, N. (Ed.), *Researching Social Life*, Sage, London, pp. 52-67.

Hussey, J. and Hussey, R. (1997), *Business Research – A Practical Guide for Undergraduate and Postgraduate Students*, Macmillan Press, Basingstoke.

Jonscher, C. (1994), "An economic study of the information technology", in Allen, T.J. and Scott Morton, M.S. (Eds), *Information Technology and the Corporation of the 1990s*, Oxford University Press, New York, NY, pp. 5-42.

Kagan, A. (1994), "Information technology seen as key to productivity", *Chemical Week*, Vol. 155 No. 2, pp. 20-2.

Kaplan, C. (1996), "Technology to ease team-based quality assessments", *National Productivity Review*, Vol. 15 No. 3, pp. 65-82.

Karatsu, H. (1988), *TQC Wisdom of Japan. Managing for Total Quality Control*, Productivity Press, Cambridge, MA.

Kelley, M.R. (1994), "Productivity and information technology: the elusive connection", *Management Science*, Vol. 40 No. 1, pp. 1406-25.

Kendrick, J.J. (1995), "SPC on the line", *Quality*, Vol. 34 No. 1, pp. 35-9.

Khalil, O.E.M. (1996), "Innovative work environments: the role of information technology and systems", *SAM Advanced Management Journal*, Vol. 61 No. 3, pp. 32-6.

Kock, N.F. Jr and McQueen, R.J. (1997), "Using groupware in quality management programs", *Information Systems Management*, Vol. 14, Spring, pp. 56-62.

Krouzek, J.V. (1987), "Economies of computerized maintenance management systems", *Engineering Costs and Production Economics*, Vol. 12 No. 1-4, pp. 335-42.

Litsikas, M. (1997), "Electronic downloads eliminate inspection audits", *Quality*, Vol. 36 No. 1, pp. 50-4.

Loveman, G.W. (1994), "An assesment of the productivity impact of information technologies", in Allen, T.J. and Scott Morton, M.S. (Eds), *Information Technology and the Corporation of the 1990s*, Oxford Unversity Press, New York, NY, pp. 84-110.

Mahan, M. and Gotlieb, L. (1992), "An automated path to quality, quality comes to the information systems function", *CMA Magazine*, Vol. 66 No. 7, pp. 13-15.

Mahmood, M.A. and Mann, G.J. (1993), "Measuring the organizational impact of information technology investment: an exploratory study", *Journal of Management Information Systems*, Vol. 10 No. 1, pp. 97-122.

Martinez-Lorente, A.R., Dewhurst, F.W. and Gallego-Rodriguez, A. (2000), "Relating TQM, marketing and business performance: an exploratory study", *International Journal of Production Research*, Vol. 38 No. 14, pp. 3227-46.

Mezgar, I., Egresits, C. and Monostori, L. (1997), "Design and real-time reconfiguration of robust manufacturing systems by using design of experiments and artificial neural networks", *Computers in Industry*, Vol. 33 No. 1, pp. 61-70.

Miller, H. (1996), "The multiple dimensions of information quality", *Information Systems Management*, Vol. 13, Spring, pp. 79-82.

Mukhopadhyay, T., Kekre, S. and Kalathur, S. (1995), "Business value of information technology: a study of electronic data interchange", *Management Information Systems Quarterly*, Vol. 19 No. 2, pp. 137-56.

Osterman, P. (1986), "The impact of computers on the employment of clerks and managers", *Industrial and Labor Relations Review*, Vol. 39 No. 2, pp. 175-86.

Papadakis, E.P. (1990), "A computer-automated statistical process control method with timely response", *Engineering Costs and Production Economics*, Vol. 18 No. 3, pp. 301-10.

Patterson, D.W., Anderson, R.B. and Rockwell, H.E. (1997), "Increased use of automated machinery requires changes in quality control procedures", *Forest Products Journal*, Vol. 47 No. 1, pp. 33-6.

Pearson, J.M. and Hagmann, C. (1996), "Status report on quality assurance methods", *Information Systems Management* No. 13, pp. 52-7.

Pfeffer, J. and Leblebici, H. (1977), "Information technology and organizational structure", *Pacific Sociological Review*, Vol. 20, pp. 241-61.

Pinsonneault, A. and Kraemer, K.L. (1997), "Middle management downsizing: an empirical investigation of the impact of information technology", *Management Science*, Vol. 43 No. 5, pp. 659-79.

Powell, T.C. and Dent-Micalef, A. (1997), "Information technology as competitive advantage: the role of human, business, and technology resources", *Strategic Management Journal*, Vol. 18 No. 5, pp. 375-405.

Quelch, J.A. and Klein, L.R. (1996), "The Internet and international marketing", *Sloan Management Review*, Vol. 37 No. 3, pp. 60-75.

Rangaswamy, A. and Lilien, G.L. (1997), "Software tools for new product development", *Journal of Marketing Research*, Vol. 34 No. 1, pp. 177-84.

Rogers, D.S., Daugherty, P.J. and Ellinger, A.E. (1996), "The relationship between information technology and warehousing performance", *Logistics and Transportation Review*, Vol. 32 No. 4, pp. 409-21.

Saraph, J.V., Benson, P.G. and Schroeder, R.G. (1989), "An instrument for measuring the critical factors of quality management", *Decision Sciences*, Vol. 20 No. 4, pp. 810-29.

Schein, E.H. (1994), "Innovative cultures and organizations", in Allen, T.J. and Scott Morton, M.S. (Eds), *Information Technology and the Corporation of the 1990s*, Oxford University Press, New York, NY, pp. 125-46.

Schonberger, R.J. (1986), *World Class Manufacturing: The Lessons of Simplicity Applied*, Free Press, New York, NY.

Sobkowiak, R.T. and LeBleu, R.E. (1996), "Repositioning hr information systems: empowering employees through information", *Information Systems Management*, Vol. 13, pp. 62-4.

Srinivasan, K., Kekre, S. and Mukhopadhyay, T. (1994), "Impact of electronic data interchange technology on JIT shipments", *Management Science*, Vol. 40 No. 10, pp. 1291-304.

Stone, M., Woodcock, N. and Wilson, M. (1996), "Managing the change from marketing planning to customer relationship management", *Long Range Planning*, Vol. 29 No. 5, pp. 675-83.

Strassmann, P.A. (1997), *The Squandered Computer: Evaluating the Business Alignment of Information Technologies*, The Information Economics Press, New Canaan, CT.

Stump, R.L. and Sriram, V. (1997), "Employing information technology in purchasing: buyer-supplier relationships and size of the supplier base", *Industrial Marketing Management*, Vol. 26 No. 2, pp. 127-36.

Teague, P.E. *et al.*, (1997), "Suppliers: the competitive edge in design", *Purchasing*, Vol. 122 No. 7, pp. 32S5-32S23.

Torkzadeh, G. and Doll, W.J. (1999), "The development of a tool for measuring perceived impact of information technology on work", *Omega*, Vol. 27 No. 3, pp. 327-39.

Walton, R.E. (1982), "Social choice in the development of advanced information technology", *Technology in Society*, Vol. 4, pp. 41-9.

Ward, A. (1998), "IT for QS 9000", *Quality Today*, January, pp. 514-6.

Webber, J. (1990), "FMEA: quality assurance methodology", *Industrial Management & Data Systems*, Vol. 90 No. 7, pp. 21-3.

Weston, F.C. Jr (1993), "Weighing 'soft' and 'hard' benefits of information technology", *Manufacturing Systems*, Vol. 11 No. 7, pp. 120-1.

Willcocks, L.P. and Lester, S. (1997), "In search of information technology productivity: assessment issues", *Journal of the Operational Research Society*, Vol. 48 No. 11, pp. 1082-94.

Wilson, F.A. (1994), "Perspectives on computer-based systems and management", doctoral thesis, UMIST, Manchester.

Yin, R.K. (1988), *Case Research – Design and Methods*, Sage, Newbury Park, CA.

Zadrozny, M.A. and Ferrazzi, K.E. (1992), "Building a technology base for TQM", *Chief Information Officer Journal*, Vol. 5 No. 2, pp. 16-21.

Zhang, X., Bode, J. and Ren, S. (1996), "Neural networks in quality function deployment", *Computers and Industrial Engineering*, Vol. 31 No. 3-4, pp. 669-73.

Zuboff, S. (1982), "New worlds of computer mediated work", *Harvard Business Review*, Vol. 60 No. 5, pp. 142-52.

Zuboff, S. (1983), *Some Implications of Information Systems Power for the Role of the Middle Manager*, Working Paper No. 84-29 Harvard Business School, Boston, MA.

Appendix 1. Interview protocol checklist

Your position in the company:

1. President or general manager.
2. General manager in Spain (for multinationals).
3. Plant director.
4. Quality department director.
5. Operations/production department director.
6. Adviser.
7. Operations/production department member.
8. Quality department member.
9. Other.

Number of employees.

Nationality of the most important shareholders:

1. Spanish.
2. UE other countries different from Spain.
3. Europe different from UE.
4. USA.
5. Japan.
6. Other.

Has your company been certified for some of these quality norms?

1. ISO 9001.
2. ISO 9002.
3. ISO 9003.
4. Other.

Top management support

IT introduction can generate reduction in personnel. Workforce reductions can generate a downturn in motivation. Personnel contribution is basic for TQM. How has top management tried to avoid this problem?

Has IT contributed in any degree to expanding the TQM message in the company?

IT can help to increase management control but this can create stress amongst employees. Has IT been used with this aim? If this is the case, what has been the employees response? Has this damaged the TQM policy?

Customer relationship

How has IT contributed to improve relationships with customers?, e.g.:

- communications with them (sending and/or receiving information);
- selling by Internet;
- receiving clients' requirements;
- receiving complaints and other information;
- undertaking customer surveys.

Is IT used to analyse data obtained from customer surveys?

Supplier relationship

How has IT contributed to improve relationships with suppliers?, e.g.:

- electronic data interchange;
- placing orders;
- sending product specifications and design details;
- confirmation of invoices;
- paying of invoices.

Has IT contributed to reduce the number of different suppliers?

Workforce management

Has IT implementation contributed to increase or decrease the number of levels of organisational hierarchy?

Is decision authority in your organisation centralised or decentralised?

The impact of IT on jobs has been in the sense of:

- routinising work;
- subjecting employees to machine control;
- automating the more mundane tasks;
- increasing/decreasing the need of skilled workers;
- increasing/decreasing workers' autonomy.

Has IT been used to increase the control on the processes?

Has IT been used as an enabling mechanism?

Has the function of supervisors changed after the IT implementation?

Has team-working been affected by IT implementation?

Employee attitudes and behaviour

Has IT implementation implied a reduction in the number of employees?

Has IT implementation implied a decrease/increase in:

- Motivation?
- Loyalty to the organisation?
- Pride in work?
- Ability to work with employees from other departments?
- Stress?

Have problems been detected in the sense of people that are reluctant to make the most of IT and share information?

Product design process

Is design of experiments applied in your company with the help of IT?

Is FMEA applied in your company with the help of IT?

Is QFD applied in your company with the help of IT?

Is IT used to interchange information on new designs between different departments?

Process flow management

Has IT been used in automation of the production processes? If this is the case, then:

- Has automation been applied to detect the need for machine maintenance?
- Has automation been applied to check product adjust to design?
- Has automation contributed to reduce process variance?
- Has automation increased the need of quality raw materials and components?
- Has automation contributed to reduce the need of inspection type activities?
- Has automation facilitated the application of SPC?
- Has automation reduced the flexibility of the process?

Has IT facilitated the implementation and self-assessment of quality management systems certification such as the ISO 9000 series? If they are been applied.

Has IT implementation generated a need of new generation of quality control and improvement tools?

Are quality costs measured in your company? Is IT used to measure them?

Role of the quality department

Has the role of the quality department changed after the implementation of IT?

Is the work in this department easier or more difficult after IT implementation?

Appendix 2

SECTION A	**Your company details** (Please tick or indicate as appropriate)

1. Please indicate your position in the company at this address:

- ☐ President, owner or general manager
- ☐ General manager in Spain
- ☐ Plant director
- ☐ Quality department director/manager
- ☐ Operations/production department director/manager
- ☐ Adviser
- ☐ Operations/production department member
- ☐ Quality department member
- ☐ Other (please specify): ☐

2. How many of employees are there in your company at this address? ☐

3. Please indicate the nationality of the most important shareholders in your company:

- ☐ Spanish
- ☐ EU other countries different from Spain
- ☐ Europe non-EU
- ☐ USA
- ☐ Japan
- ☐ Other (please specify): ☐

4. Please indicate if your company has been certified for any of these quality norms by entering the year of certification, otherwise please leave blank.

☐ ISO 9001 ☐ ISO 9002 ☐ ISO 9003

Other (please specify): ☐ Year: ☐

5. Please indicate how decision authority in your company is structured:

☐ centralized ☐ decentralized ☐ Don't know

(*continued*)

Figure A1.
Proposed questionnaire

6. Please indicate how your company compares to the competition in your industry on a global basis for the following company measures of performance:

	Please circle the response below 1 indicates no competition at all whilst 5 indicates highly competitive				
Unit costs (e.g. of manufacturing)	1	2	3	4	5
Fast delivery	1	2	3	4	5
Flexibility to change volume	1	2	3	4	5
Inventory turnover	1	2	3	4	5
Cycle time (from receipt of raw materials to shipment)	1	2	3	4	5
Defective rates	1	2	3	4	5

7. Please indicate your agreement with the following statements:

	Please circle the response below 1 indicates strongly disagree, whilst 5 indicates strongly agree				
Quality is very important in our markets	1	2	3	4	5
Our customers prefer low price than high quality	1	2	3	4	5
Our customers primarily choose suppliers by quality.	1	2	3	4	5
In our markets we perform well with low quality products	1	2	3	4	5

8. Please indicate, if appropriate, the production layouts used in your company:

- ☐ Process layout (job shop)
- ☐ Assembly line
- ☐ Continuous production
- ☐ Hybrid (cellular)
- ☐ Fixed position

SECTION B	**The use of Information Technologies (IT) in your company**				
This section of the questionnaire concerns the extent to which you use Information Technology (IT) in your company.					
To what extent do you use:	Please circle the response below 1 for no use at all and 5 for intensive use				
Invoicing systems	1	2	3	4	5
Stock control systems	1	2	3	4	5
Payroll systems	1	2	3	4	5
Data bases	1	2	3	4	5
Fax	1	2	3	4	5
Mobile phones	1	2	3	4	5
Internet access	1	2	3	4	5
Advertising by a company web page	1	2	3	4	5
Direct sales by a company web page	1	2	3	4	5
Company intranet (internal web)	1	2	3	4	5
E-mail	1	2	3	4	5

Figure A1.

(*continued*)

Electronic data interchange (EDI) with suppliers	1	2	3	4	5
Electronic data interchange (EDI) with customers/clients	1	2	3	4	5
Spreadsheets	1	2	3	4	5
Cost accounting systems	1	2	3	4	5
Decision support systems (DSS)	1	2	3	4	5
Intelligent Knowledge Based Systems (IKBS)	1	2	3	4	5
Group working with electronic information interchange	1	2	3	4	5
LAN for technical data within company	1	2	3	4	5
Inter company networks	1	2	3	4	5
Computer Aided Design (CAD)	1	2	3	4	5
Computer Aided Manufacture (CAM)	1	2	3	4	5
Computer Aided Engineering (CAE)	1	2	3	4	5
Computer Aided Production Planning (CAPP)	1	2	3	4	5
Numeric control machines with computer control (CNC)	1	2	3	4	5
Computers for controlling the factory floor	1	2	3	4	5
LAN for use on the factory floor	1	2	3	4	5
Robots	1	2	3	4	5
Electronic systems of product identification	1	2	3	4	5
Electronic systems of quality control	1	2	3	4	5
Flexible manufacturing systems (FMS)	1	2	3	4	5
Manufacturing Requirements Planning (MRP)	1	2	3	4	5
Enterprise Resource Planning (ERP) for example SAP	1	2	3	4	5
Data analysis techniques	1	2	3	4	5
Forecasting	1	2	3	4	5
Automated warehousing systems	1	2	3	4	5
Presentation graphics software	1	2	3	4	5

SECTION C	**Total Quality Management (TQM) in your company**				
This section of the questionnaire concerns Total Quality Management (TQM) in your company. If you do **not use** any TQM in your company please tick the box below and move on to Section G We **do not use** any TQM within our company ☐ (If you tick this box please move on to section G)					
Use of TQM	Please circle the response below				
To what extent do you use TQM for:	1 for no use and 5 for intensive use				
Word processors	1	2	3	4	5
Accounting programs	1	2	3	4	5
The management of information	1	2	3	4	5
Workforce management	1	2	3	4	5
The creation of positive work attitudes	1	2	3	4	5
The relationships with suppliers	1	2	3	4	5
The relationships with customers	1	2	3	4	5
New product design	1	2	3	4	5
Process flow management	1	2	3	4	5
Perceived TQM outcomes	Please circle the response below				
To what extent do you agree with these statements:	1 for not at all and 5 for high				
The quality of our products and services is superior to the competition on a global basis	1	2	3	4	5
Our relations are superior to the competition on a global basis	1	2	3	4	5

(*continued*)

Figure A1.

Our customers have been well-satisfied with the quality of our products over the past three years	1	2	3	4	5
In general, our plant's level of quality performance over the past three years has been low, relative to industry norms	1	2	3	4	5

SECTION D	**Overall use of IT to support TQM in your company**				
This section of the questionnaire concerns the overall use of both IT and TQM in your company.					
	Please circle the response below				
Overall in the company:	1 for very low and 5 for very high				
The use of IT applications in our company has been:	1	2	3	4	5
The extent to which IT has been used to support TQM is:	1	2	3	4	5

SECTION E	**Impact of IT on TQM in your company**				
This section of the questionnaire concerns the impact of IT on specific TQM dimensions in your company.					
Leadership	Please circle the response below				
To what extent has IT been used to:	1 for not at all and 5 for greatly				
Make the commitment to TQM visible to staff	1	2	3	4	5
Communicate TQM values to employees	1	2	3	4	5
Facilitate communication between top management and employees	1	2	3	4	5
Encourage employee involvement to improve work processes	1	2	3	4	5
Increase top management control	1	2	3	4	5
Output quality assurance	Please circle the response below				
To what extent has IT been used to:	1 for not at all and 5 for greatly				
Set up quality standards	1	2	3	4	5
Measure quality	1	2	3	4	5
Measure cost reductions	1	2	3	4	5
Apply quality tools	1	2	3	4	5
Apply continuous improvement	1	2	3	4	5
Assess actual performance against established quality standards	1	2	3	4	5
Facilitate implementation of quality norms (e.g. ISO 9000)	1	2	3	4	5
Quality department	Please circle the response below				
To what extent has IT:	1 for not at all and 5 for greatly				
Changed the role of the quality department	1	2	3	4	5
Reduced the workload in the quality department	1	2	3	4	5
Increased the workload in the quality department	1	2	3	4	5
Information and analysis	Please circle the response below				
How much has IT been used in your company to:	1 not at all and 5 for greatly				
Collect data about employees, customers and suppliers	1	2	3	4	5
Collect data about work/production processes	1	2	3	4	5
Maintain quality information systems (e.g. documents)	1	2	3	4	5
Provide DSS, statistical tools, diagrams	1	2	3	4	5
Provide timely information to staff for decision-making	1	2	3	4	5
Provide relevant information to staff that meets their needs	1	2	3	4	5
Improve accuracy of information	1	2	3	4	5

Figure A1.

(*continued*)

Workforce management	Please circle the response below				
To what extent has IT:	1 for not at all and 5 for greatly				
Help to form work teams or quality improvement groups	1	2	3	4	5
Facilitate team working	1	2	3	4	5
Helped solicit suggestions from staff for quality improvement	1	2	3	4	5
Enabled staff to share task-related information	1	2	3	4	5
Supported the planning of staff training on quality issues	1	2	3	4	5
Supported the training of staff on quality issues	1	2	3	4	5
Helped to recognize staff contributions to quality improvement	1	2	3	4	5
Supported staff appraisal in quality improvement programmes	1	2	3	4	5
Routinized work	1	2	3	4	5
Subjected employees to machine control	1	2	3	4	5
Automated mundane tasks	1	2	3	4	5
Workforce structure	Please circle the response below				
To what extent has IT:	1 for decreased and 5 for increased				
Changed the number of levels of organizational hierarchy	1	2	3	4	5
Changed the need for skilled workers	1	2	3	4	5
Changed worker autonomy	1	2	3	4	5
Employee attitudes and behaviour	Please circle the response below				
To what extent has the implementation of IT affected:	1 for decreased and 5 for increased				
The number of non-IT specialist employees	1	2	3	4	5
The number of IT specialist employees	1	2	3	4	5
Employee motivation	1	2	3	4	5
Employee loyalty	1	2	3	4	5
Employee pride	1	2	3	4	5
Employee stress	1	2	3	4	5
Customer relationships	Please circle the response below				
How much has IT helped your company to:	1 for not at all and 5 for greatly				
Identify customers	1	2	3	4	5
Identify customer needs	1	2	3	4	5
Analyze customer surveys	1	2	3	4	5
Measure customer satisfaction	1	2	3	4	5
Improve communications between you and the customer	1	2	3	4	5
Supplier relationships	Please circle the response below				
How much has IT helped your company to:	1 for not at all and 5 for greatly				
Identify suppliers	1	2	3	4	5
Improve ordering	1	2	3	4	5
Improve communications between you and your suppliers	1	2	3	4	5
Improve financial transactions between you and your suppliers	1	2	3	4	5
Reduce the number of suppliers	1	2	3	4	5
The product design process	Please circle the response below				
To what extent has IT support:	1 for not at all and 5 for greatly				
The design of experiments	1	2	3	4	5
FMEA	1	2	3	4	5
QFD	1	2	3	4	5
The exchange of new design information between departments	1	2	3	4	5

(*continued*)

Figure A1.

Process flow management	Please circle the response below				
To what extent has IT:	1 for not at all and 5 for greatly				
Been used to detect the need for machine maintenance	1	2	3	4	5
Been used to check product adjust to design	1	2	3	4	5
Reduced process variance	1	2	3	4	5
Increased need for higher quality raw materials and components	1	2	3	4	5
Reduced the need for inspection activities	1	2	3	4	5
Facilitated the application of SPC	1	2	3	4	5
Reduced process flexibility	1	2	3	4	5

SECTION F	**Your views on reconciling IT and TQM**
1.	It is often claimed that IT and TQM philosophies are in opposition and consequently that IT implementation can damage TQM policy, particularly at the top level. Please provide any evidence from your company to support or refute this statement below
2.	IT is often associated with reductions in staff and personnel and a downsizing of staff can lead to a downturn in motivation. However, the contribution of personnel is considered a key TQM component. Please provide any evidence from your company to show how top management have attempted to deal with this dichotomy below
3.	IT is often associated with an increase in management control and increased control can lead to increased employee stress. Please provide any evidence from your company to show how top management have attempted to deal with this dichotomy below

SECTION G	**Thank you**
We very much appreciate the time and effort that you have put into responding to this questionnaire. If you would like to receive a summary of the results please complete the details below and return this section in the separate enclosed envelope. Thank you.	
I would like to receive a summary of the results and my address is given below:	
Name:	
Company name:	
Address:	

Figure A1.