A socio-technical view of performance impact of integrated quality and sustainability strategies

Chaudhuri, Atanu; Jayaram, Jayanth

Published in:
International Journal of Production Research

DOI (link to publication from Publisher):
10.1080/00207543.2018.1492162

Publication date:
2019

Document Version
Accepted author manuscript, peer reviewed version

A Socio-Technical View of Performance Impact of Integrated Quality and Sustainability Strategies

Abstract

This research seeks to examine the direct effects of social and technical integration, on deployment of quality and sustainability management programmes and the indirect effect of those on quality and sustainability performance. We also seek to test the spillover effects of quality and sustainability management programmes on sustainability and quality performance respectively. Socio-technical systems theory is used to test the role of social and technical integration on quality, and sustainability management programmes. The framework of integrated management system, as supported by both socio-technical systems and complementarity theory, is used to test the direct and spillover effects of quality, and sustainability management programmes. A large multi-country sample is used to empirically test our theory-induced hypotheses. The findings support that social and technical integration are indeed significant enablers for the positive relationships that quality and sustainability programmes have on quality performance and sustainability performance. Specifically, the results show that while social integration has both direct and indirect effects on quality and sustainability performance, technical integration impacts quality and sustainability performances only through the mediation effect of the respective programmes. The results do not support the spillover effects of quality and sustainability management programmes on sustainability and quality performance. Implications of the findings on academic knowledge and managerial practice is offered.

Keywords: Quality Management, Sustainability, Socio-Technical Systems Theory, Complementarity Theory, Integrated Management Systems Framework, Empirical Study, Spillover Effects.

1. Introduction

Both quality and sustainability movements are based on strategic interventions. The commonalities include long term focus, continuous improvement, employee empowerment, multi-functional approach (Rusinko, 2005), development of systems and metrics, focus on elimination of waste (Klassen and McLaughlin, 1993) and the pursuit of standards such as ISO 9000 and ISO 14000. Also, they share a commonality with respect to tools and techniques that are prevalent in both domains (Isaksson, 2006). Industry leaders have also acknowledged this commonality as is evident from the quote below:

> *"Programmes like Total Quality Management (TQM) and the Toyota Production System came along, and they were able to show that you could simultaneously improve both quality and productivity by preventing problems and waste. In essence, when we talk about sustainability, we're talking about a similar concept: that we can simultaneously improve business performance and environmental and social performance with similar techniques of preventing value chain issues, cutting waste and reducing pollution. Talking about sustainability as part of a new quality paradigm can help make it an easier sell, and can facilitate introducing incremental aspects of sustainability – within quality programmes – across the business." –Tim Lindsey, Global Director of Sustainable Development at Caterpillar (Leous, 2015).*

As this quote also indicates, there appears to be a need to tap into the common features of quality and sustainability management to see how they influence performance. In this context, we define sustainability management for a manufacturing plant as initiatives related to environmental and social certification, sustainability related communication, resource consumption and pollution reduction, occupational health and safety and work-life balance of employees. Quality management includes practices related to quality improvement and control i.e., TQM programmes, six sigma projects, availability of equipment through Total Productive Maintenance (TPM) programmes, and benchmarking assessments. Quality management practices have been considered as prerequisites for successful implementation of environmental management practices (Curkovic, 2008). Alves and Alves (2015) proposed an integrated model combining lean manufacturing and sustainability supported by organisational culture. But, Longoni and Cagliano (2015) noted that companies that simultaneously adopt lean manufacturing and pursue environmental and social sustainability need to understand how to align these efforts to avoid contradictory effects. Thus, companies would also like to understand to what extent can quality management programmes help them in achieving higher levels of sustainability performance, and in parallel, how sustainability management programmes could improve quality performance. However, there is limited research that focused on interactions of quality management and sustainability practices, and even within this literature, the focus is primarily on environmental sustainability, and not on social practices (Wiengarten and Pagell, 2012). For example, Wiengarten and Pagell (2012) showed that the impact of environmental practices on cost, flexibility and delivery performance were high when investments in quality management practices were also high. However, they did not find a significant interaction effect of quality and environmental management on quality performance. Bernardo et al. (2009) studied the extent of integration of environmental and quality management systems in a sample of 435 firms and found that 86% of the firms in the study had achieved integration of the above management systems. But, the above study did not consider social sustainability nor did it analysed the impact on performance. Despite a possible synergistic focus and interdependencies between quality management and sustainability management (Klassen and McLaughlin, 1996), there is limited empirical support for the positive effect of sustainability management on quality performance. In a review of the benefits of integrated quality and environmental management systems, Bernardo et al. (2015) do point out benefits in terms of improved quality and reliability and improved teamwork but do not consider social sustainability. Thus, whether the combined effect of quality management and sustainability management improves both quality and sustainability performance remains unclear.

One possible way to address this research gap is to analyse the role of enablers for quality and sustainability management programmes in explaining quality and sustainability performance. Organizational work practices covering both social integration and technical integration can be considered as one set of enablers. Organizational work practices (Samson and Terziovski, 1999; Karuppusami and Gandhinathan, 2006; Psomas et al., 2014) and technical integration through efforts such as concurrent engineering, quality function deployment (QFD) (Ahire and Dreyfus, 2000) have been reported to have a significant positive impact on quality performance. Similarly, employee empowerment, employee suggestions and management's effort to involve employees in decision-making have been reported to be useful for sustainability efforts (Kitazawa and Sarkis, 2000). Also, the use of technical tools like life-cycle analysis, design for environment, safety, disassembly, and recycling (Kleindorfer et al., 2005) form key tenets of an organization's sustainability philosophy (Sarkis, 2001).

Along this line of discussion, in this research, we seek to explain how social and technical integration influence quality management and sustainability management programmes and in turn quality and sustainability performance.

The specific questions addressed in this research are as follows:

- What impact does social and technical integration have on quality management and sustainability management programmes in manufacturing plants?
- Do social and technical integration influence quality and sustainability performance of manufacturing plants, via the above programmes (in other words through mediating or indirect effects)?
- Are there any spillover effect of quality and sustainability management programmes on sustainability and quality performance respectively?

The paper is organized as follows. The support for our framework including hypotheses development is laid out in Section 2. Section 3 describes our research methodology and Section 4 reports our findings. Section 5 provides a discussion of findings along with their implications. The conclusion and opportunities for future research are stated in Section 6.

2. Theoretical background and hypotheses development

Manz and Stewart (1997) demonstrated how Socio-technical systems (STS) and TQM can be combined to simultaneously achieve organizational stability and flexibility. STS theory posits that every organization comprises of a social system (people) and a technical system (tools, techniques, and knowledge) to produce goods or services that are valued by customers. The technical system encompasses tools, techniques, devices, methods, procedures and knowledge, while the social system captures the people who work in the organization and how they interact with each other (Pasmore, 1988). This theory suggests that the extent of fit between the social and technical systems, and how it aligns with the demands of the external environment, determines an organization's effectiveness (Pasmore, 1988). The demands of the external environment include producing good quality products as per customer needs. Similarly, environmental and social responsibilities of a manufacturing organization are shaped by the environmental and social challenges in the environment. For example, whether or not a firm is proactive or reactive with respect to regulations. Attaining high levels of performance in quality and on environmental and social performance will require organizational work practices that ensure an alignment between social and technical systems underlying the improvement initiatives undertaken by a manufacturing firm. The attractiveness of using STS is that the social core and technical core can be blended to investigate their concomitant effects on performance. Thus, STS can be considered as an appropriate theoretical lens to study the effects of social and technical integration on quality and sustainability management programmes and on quality and sustainability performance. Moreover, there is prior support for this line of thinking in operations management literature. Liu et al. (2006) linked work-design practices with mass-customization ability using STS as the theoretical foundation. Zeng et al. (2015) show that soft QM has an indirect effect on innovation performance via its effect on hard QM, implying that performance depends directly on hard QM, which can be promoted by soft QM.

Another theoretical perspective, which can be relevant for this research, is the two-component complementarity theory (Bresnahan et al., 2002). Two types of integration are complementary to one another with respect to given manufacturing capabilities if they are adopted together by manufacturing plants, and exhibit synergies with respect to the specified manufacturing capabilities. Considering quality and sustainability as separate manufacturing capabilities, complementarity of social and technical integration and their synergies could have been tested. A similar approach has been adopted by Narasimhan et al. (2010) to test the complementarity of product-process-technology and supply chain integration. Moreover, a synergy among efforts exists when "doing more of one thing increases the returns to doing more of another" (Milgrom & Roberts, 1995, p. 181). Such synergies may be observed between quality and sustainability management programmes in influencing quality and sustainability performance.

Literature also proposes an Integrated Management Systems (IMS), combining quality, environment and safety management systems into an integrated whole (Ferreira et al., 2014). We posit that a combination of STS theory with precepts of complementarity theory informs the framework of IMS. The underlying logic behind IMS is that people that work on environmental management programmes use approaches similar to those employed in quality progams (like quality circles) and this ensures that effective quality management principles also align with with the goals of environmental management. For example, an emphasis on continuous improvement which has long been argued as being to pivotal to the success of quality management programs is just as effective in sustainability programs. This argument is in line with a study that found that actions that are carried out to achieve quality are also needed to achieve effective environmental management (Ferreira et al., 2014). Similarly, the goal of safety programs such as occupational health and safety systems is to ensure safe working environments. Accordingly, a continuous improvement approach coupled with quality tools that measure outcomes can result in in workers have high health levels, protecting from accidents, illness or discomfort in the workplace. These desirable safety outcomes also increases the efficiency of work processes, and leads to employees having a positive perception of their working environment (Tsai and Chou, 2009). Thus, in an IMS, there can be direct effects of quality and sustainability management programmes on quality and sustainability performance and spillover effects on sustainability and quality performance respectively.

To summarize, the combined precepts of STS theory and complementarity theory help in developing the IMS framework that combines quality, environment and safety management systems into an integrated whole. Such an IMS exploits the synergies among quality, environment and safety management systems in order to achieve the desired quality and sustainability outcomes (Ferreira et al., 2014). In this research, we are interested in exploring the combined effects of social and technical integration on quality and sustainability management programmes and in turn on quality and sustainability performance. Hence, we use STS as the theoretical lens for testing the above relationships. We also want to explore the complementarities between quality and sustainability management programmes in having direct and spillover effects on performance. For that purpose, we use the IMS framework, supported by both STS and complementarity theory.

2.*1 Hypotheses Development*

Technical integration include design integration between product development and manufacturing through platform design, standardization and modularization, design for manufacturing,
design for assembly, organizational integration through cross-functional teams, job rotation etc, technological integration through use of computer aided design and engineering, product lifecycle management,use of integrated tools and technologies such as Failure Mode Effect Analysis and Quality Function Deployment, rapid prototyping, use of communication technologies and process standardization.

Such technical integration requires strong collaboration between product development and manufacturing. One such source of integration is cross-functional teaming which has been shown to influence technical integration programmes such as design-manufacturing integration (Swink et al., 1996; Paashuis and Boer, 1997). Similarly, high performance work teams with broader responsibility, wide range of tasks and an emphasis on employee education and training have a positive influence on design for manufacturability and introduction of new products (Wilson and Collier, 2000). Moreover, team coordination activities are imperative to overcome stress associated with adopting design for manufacturing methods (Smith and Offodile, 2008). Having an open communication between the workers and managers also enables the flow of ideas, suggestions, facilitates transparency and creates a collaborative environment, which in turn improves the design integration between product development and manufacturing (Swink, 1999). Such open communication can be improved by the usage of appropriate communication technologies. Lean organization also offer flexibility to process standardization for the new and customized product development. For example, if an organization is lean it can relatively easily customize the process and product as per the customer’s requirement thereby strengthening the technological integration between product development and manufacturing. Worker flexibility through training and multiskilling can help in substituting a worker when needed (Ettlie, 1995). In other words, multi skills development helps an organization on long run in terms of organizational integration.

But, the effects of social integration on technical integration is not uniformly positive. For example, social integration practices such as hierarchical structures and job specialization were negatively related to technical integration (Liker et al., 1999). This is because product development success and manufacturability are dependent on management relinquishing command and control, and on teams achieving some degree of autonomy.

Hence, the linkage between social integration (and technical integration needs to be studied. Therefore, we hypothesize that:

H1: Social integration is positively related to technical integration

Implementation of quality management programmes are dependent on human resource capabilities such as employee participation, empowerment, teamwork, training, multi-skilling, and employee flexibility (Samson and Terziovski, 1999; Karuppusami and Gandhinathan, 2006; Dahlgaard and Dahlgaard-Park, 2006). In particular, there should be an alignment between human resources management capabilities with process-based improvement activities that typify quality management programmes. Employee empowerment allows more traditional management activities to be delegated along with the necessary authority and capability (through education and training) as part of quality programmes (Dahlgaard and Dahlgaard-Park, 2006). Similarly, involving production associates in maintenance activities has been found to be a key factor for improving equipment availability (Bamber et al., 1999), which is crucial for quality programmes. Training and multi-skilling can allow production personnel to form autonomous team and take up responsibilities of maintenance and quality improvement and control. Continuous improvement programmes in multiple plants help in quality improvement and control and also facilitate benchmarking of performance, which is an important constituent of quality programme deployment. Investments in quality programmes often require employees to work closely with each other (Wiengarten et al., 2011). Thus, successful quality management processes and outputs are strongly linked to its human resource practices (Fotopoulos and Psomas, 2009). Moreover, Mohammad (2014) identified human resource related barriers as the most frequent ones responsible for failures of TQM programmes while Garza-Reyes et al. (2015) noted that employee empowerment and promoting teamwork as some of the challenges in implanting a quality management system. Hence, we can hypothesize that social integration will have a positive effect on quality programme management.

This leads to our next hypothesis as follows:

H2a: Social integration is positively related to quality programme deployment

Technological integration between product development and manufacturing through Computer Aided Design and Analysis and Product Lifecycle Management ensures transparency and common understanding and analysis of product design, thereby facilitating quality improvement and control (Tan and Vonderembse, 2006). Organizational integration cross-functional teams, job rotation, co-location, secondment and co-ordinating managers help in discussing multiple feasible design options and thus integrate different perspectives at the design stage, thereby improving design quality (Swink and Calantone, 2004). Design integration through platform design, standardization and modularization, design for manufacturing, design for assembly also improves product quality as manufacturing considerations are built in early in design (Pasche et al., 2011).

One of the key principles of Total Quality Management is building quality into the product based on customer needs (Bigorra and Isaksson, 2017). Quality Function Deployment (QFD) as a tool for capturing customer needs requires technical integration between different functions (Chaudhuri and Bhattacharyya, 2009). Practices such as concurrent engineering and use of tools like QFD is aimed in ensuring design for manufacturability and at improving design quality (Handfield et al., 1999). Process standardization, such as a stage-gate process, design reviews and performance management brings discipline to the process of developing products and make decision making more objective thereby ensuring quality. But, a meta-analytic study by Nair (2006), reported a lack of relationship between product design management and product quality indicating mixed results at best. Hence, there is a need to test whether design, organisational and technological integration between product development and manufacturing, integrating tools and technologies and process standardization can have a positive effect on quality programme deployment. As majority of studies indicate positive relationship between technical integration and quality management practices, we hypothesize as follows:

H2b: Technical integration is positively related to quality programme deployment

Growing concerns around social and environmental sustainability have led to the development of international environmental standards and norms for work environment. This has forced organizations to develop formal sustainability strategies and programmes. A typical manufacturing facility has a number of environmental waste streams including handling losses, cleaning losses, process losses, scrap and rejects, stock losses, and evaporation (Rooney, 1993). Employee empowerment, their willingness to make suggestions for improvement, and management's effort to induce employee participation in decision-making could be beneficial in handling environmental waste streams (Kitazawa and Sarkis, 2000). Employee empowerment and team-based approaches promotes idea generation, which often relies on a team of production workers who are likely to be most knowledgeable about the causes of waste and potential solutions for waste reduction (Kitazawa and Sarkis, 2000). Worker participation and training have been reported to positively relate to environmental improvement (Rothenberg et al. 2001). Similarly, continuous improvement programmes like kaizen can help in reducing the environmental effects like disposals to landfill, use of energy and water and in reducing material consumption (Garza-Reyes et al., 2018). Thus, successful implementation of environmental management systems could depend on human resource factors such as top management support, employee empowerment, training, teamwork and rewards (Daily et al., 2001). Adoption of environmental practices also requires organizational commitment to such efforts (Cantor et al., 2013). Implementation of a sustainability programme without proper consideration of foundational processes required for employees and other firm members to embrace and accept change can lead such programmes failing to achieve the desired objectives (Hoffman and Bazerman, 2007). Longoni and Cagliano (2015) showed that cross-functional executive involvement and worker involvement positively affect the strategic alignment of the lean manufacturing with environmental and social goals and practices. Hence, employee empowerment through delegation, teamwork demonstrated by autonomous teams, enhancing knowledge of workers through training and continuous improvement programmes are expected to have a positive effect on deployment of sustainability programmes. Worker flexibility in terms of multi-tasking and multi-skilling and working in autonomous teams allow production workers for example to actively participate in efforts to reduce energy and water consumption reduction (Pampanelli et al., 2014), pollution reduction, waste recycling and in improving ergonomics of their work stations thereby facilitating improvement in occupational health and safety (Conti, 2006) . Thus, a well-trained autonomous team, which is empowered to improve the performance of their production line, can become responsible for the performance of their line not only in terms of quality, delivery and cost but also environment and safety.

Therefore, we argue that:

H3a: Social integration is positively related to sustainability programme deployment

Technical capabilities are important for redesigning products that influence sustainability goals such as reducing material content, to develop substitutes for nonrenewable inputs, and to reduce energy consumption during manufacturing (Kleindorfer et al., 2005). Design integration in terms of modular designs facilitate remanufacturing and support achieving sustainability objectives (Krikke et al., 2003). Platform design with standardization and modularization can help in deciding optimal number of parts being used across product lines potentially reducing material consumption. Similarly, design integration through design for manufacturing and assembly with sustainability considerations can reduce the number of steps in manufacturing and assembly, thereby supporting reduction in energy and water consumption (Mayyas et al., 2012)

Firms can use tools such as life-cycle analysis, design for environment, safety, disassembly, and recycling, and eco-logistics to develop sustainable products (Kleindorfer et al., 2005). Similarly, design for environment and Life Cycle Assessment (LCA) minimizes the product's harmful effects on the environment in every stage of its product life cycle (Hart, 1995). Tools like Failure Mode Effect Analysis (FMEA) can be deployed in pollution reduction programmes of firms (Sekhar and Mahanti, 2006). The goal of product stewardship requires organizational integration between manufacturing and product design and development (Sarkis, 2001). Romli et al. (2015) demonstrated how integrated eco-design decision making using QFD and LCA can lead to development of products with minimal environmental impact. Thus, use of integrating tools and technologies and standardized processes may help in identifying the most suitable initiatives to improve the sustainability performance. Use of communication technologies like teleconferancing, web meetings etc avoid unnecessary travels and can thus reduce the overall environment impact (Houston and Reay, 2014).

This leads us to infer the following hypothesis:

H3b: Technical integration is positively related to sustainability programme deployment

Quality management programme results in improved internal process quality thus resulting in fewer defects, scrap and rework, and hence better conformance quality (Sousa and Voss, 2002). Positive linkage of TQM practices as part of overall quality management programme on product quality has been well-established (Samson and Terziovski, 1999; Kaynak, 2003; Prajogo and Sohal, 2006). Focus on quality improvement ensures reliability of processes and equipments which results in superior quality performance (Jayaram et al., 2014). Six sigma projects implemented as part of quality management programmes reduce process variation and defects and thus minimize deviation from conformance quality and increase overall product quality and reliability (Kumar et al., 2007; Patyal and Koilakuntla, 2017). Regular equipment maintenance through Total Productive Maintenance (TPM) also positively contributes to product quality by improving machine reliability and reducing interruptions in production (Ho et al., 1999). As part of quality management programme, firms also engage in benchmarking. Successful organizations realize the importance of such benchmarking efforts by collecting and analyzing accurate and timely information on best practices of various processes affecting product and process quality (Brown et al., 1994) which can help identify opportunities for continuous improvement in quality. Recently, Parvadavardini (2016) demonstrated the significant positive impact of quality management on quality performance of Indian manufacturing organisations. Thus, quality management programme with focus on quality improvement and control, equipment reliability and availability and benchmarking is expected to improve quality performance. Therefore, we offer the following hypothesis:

H4: Quality programme deployment is positively related to quality performance

Quality and environmental problems can have similar causal factors and can be managed with similarly structured reporting systems, facilitated by benchmarking and self-assessment. Pil and Rothenberg (2003) report that processes targeted at improving quality had the additional benefit of enhanced environmental performance. Improving quality can make the process more sustainable due to a reduction in waste, rework, and increased efficiency (Chun and Bidanda, 2013). Cherrafi et al. (2017) report that integrating Lean Six Sigma and Green helped the case organisations to reduce their resources consumption and minimise the cost of energy.

Quality management programmes involve training on principles of quality management and six sigma, which have positive effect on employee morale and motivation (Lang Cheng, 2012) and job satisfaction (Scho¨n et al., 2010). A six sigma improvement programme can also help in identifying opportunities to save energy for example investing in insulation, repairing damaged equipment, reducing the usage of lighting and using energy-saving lighting (Lee et al., 2014), thereby by helping in reducing energy consumption. Ensuring equipment availability through Total Productive Maintenance also ensures optimal energy usage as breakdowns and stoppages may lead to wasted energy from heating, cooling, and lighting during production downtime (Raouf, 2009) and may also lead to increased energy consumption for restarting the equipment. Minimal breakdowns and stoppages of equipments may result in less stress on employees to maintain production targets.

Thus, focus on quality improvement and control and equipment availability are expected to have a positive impact on sustainability performance. But, De Menezes (2012) found no significant link between quality management and social sustainability and specifically on employee job satisfaction which is considered as part of sustainability performance in this research. Hence, the linkage between quality programme deployment and sustainability performance still needs to be established.

Thus, we suggest that:

H5: Quality programme deployment is positively related to sustainability performance

Ergonomics and organizational health and safety contribute to product conformity as these ensure that conditions necessary for thoroughly carrying out work tasks are met and companies could potentially benefit by linking their quality, environmental protection, occupational health and safety programmes in their management systems (de Oliveira Matias and Coelho, 2002). Pullman et al. (2009) find support for improvement in quality performance with increased adoption of social sustainability practices but not with environmental sustainability practices in food industry. Better environmental performance can be a driver of improved quality performance (Pil and Rothenberg, 2003). Pan, 2003 find positive effect of ISO 14000 certification on quality only for Taiwan. This can possibly be explained from the fact that good environmental practices results in a better clean room environment for electronics manufacturing, thereby improving product quality. Though there are some evidences, it needs to be tested whether sustainability management programme focusing on waste reduction, environmental management systems and occupational, health and safety programmes can have a positive effect on quality performance.

Hence, we hypothesize that:

H6: Sustainability programme deployment is positively related to quality performance

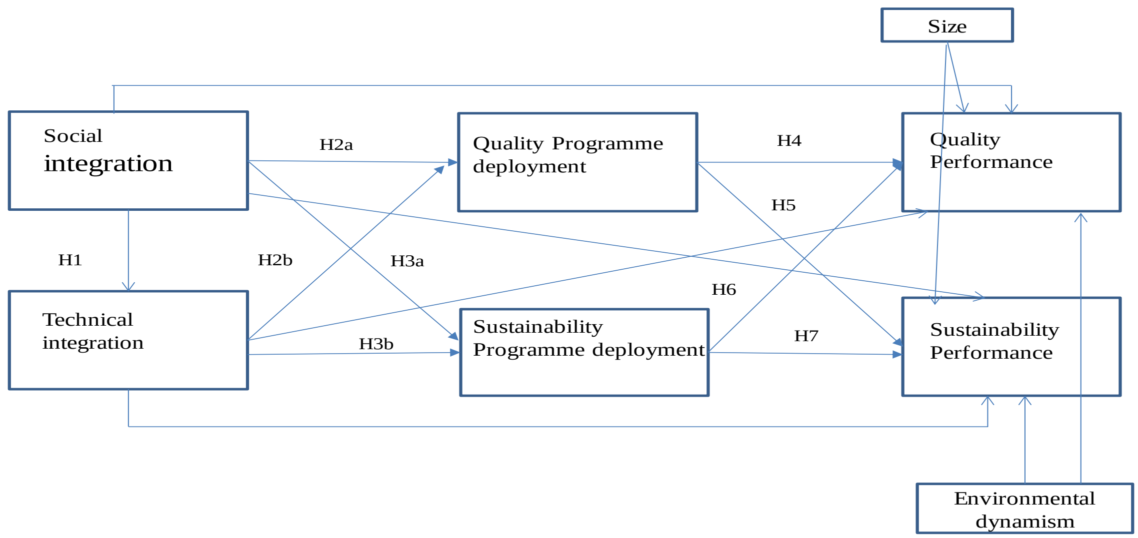
The Natural-Resource-Base View (Hart, 1995) links environmental programmes to environmental performance. Theyel (2000) finds that environmental management practices (such as pollution prevention and employee pollution prevention training programme) are significantly and positively related to improved environmental performance (reduction of chemical waste). Thus, adoption of internal environmental programmes leads to better environmental performance (Zhu and Sarkis, 2004 and Zhu et al., 2005). Investments in worker safety and work conditions result in less absenteeism and accidents (Gimenez et al., 2012) and thus improves workers' motivation and satisfaction. Thus, significant positive effects of environmental and social sustainability programmes on environmental and social sustainability performance can be observed (Zhu et al. , 2012; Golini et al., 2014; Yu and Ramanathan, 2015). One reason for the above results is that sustainable manufacturing practices such as reducing emissions and waste recycling not only results in improved environmental performance but also results in improved worker health and safety (Abdul-Rashid et al., 2017).

Hence, sustainability programme consisting of environmental and social certifications, sustainability communication, pollution prevention, water and energy consumption reduction and occupational health and safety is expected to have positive impact on sustainability performance.

H7: Sustainability programme deployment is positively related to sustainability performance

Our overall model that included all seven hypotheses is summarized in Figure 1.

Figure 1: Conceptual Model



3. Methodology

3.1. Sampling and data collection

Manufacturing plants are appropriate units of analysis for this research as quality, sustainability management programmes as well as work practices are implemented at the plant level, and their effect on quality and sustainability performances can be observed at the manufacturing plant level. In this paper the proposed hypothesis were tested by using the data from the sixth version of International Manufacturing Strategy Survey (IMSS VI). For IMSS, a common survey instrument and data collection protocol for the global study of manufacturing and supply chain management was developed by a global network of institutions that collaborate with each other and manufacturing companies. The IMSS VI data was collected from June 2013 to June 2014. The sample was designed to consider the population of assembly manufacturing plants with more than 50 employees. The sample companies were further selected from public or private local databases based on ISIC code (ISIC 25-30 classifications, i.e. machinery, electronics, metal products, transport equipment and motor vehicles industrial sectors). As a result, 7167 companies from the different countries were selected (Cheng et al., 2016). The original questionnaire was developed in English, and later translated by national researchers using double- and reverse-translation procedures, in a coordinated manner for countries with similar languages (Vanpoucke et al., 2014). Before the official launch, the questionnaire was extensively pre-tested with company managers. In addition, this research used IMSS data from sixth iteration, ensuring that the IMSS research instruments have already been verified and known to researchers as demonstrated by numerous research publications (e.g. Gimenez et al., 2012; Golini et al., 2014; Chaudhuri and Boer, 2016; Cheng et al., 2016; Chaudhuri et al., 2018) using different versions of the IMSS survey. A common methodology was followed in each country to ensure uniformity in the data collection process. In all countries, the survey respondent was usually operations, production, supply chain or plant manager/director, who demonstrated knowledge and awareness towards both operational and strategic decisions. The potential respondents, agreeing to participate, received the questionnaire by ordinary mail, fax or email. The returned questionnaires were handled on a case-by-case basis for missing data usually by contacting the plant again. Every local research group also controlled the gathered data for late respondent bias, company size and industry (Cheng et al., 2016). Finally, checks for errors and outliers were conducted, and all the data were summarised into a unique database through central coordination by the Politecnico Di Milano (Cheng et al., 2016). A total of 2586 questionnaires were distributed across the different countries. After excluding cases with much missing data, the final IMSS VI sample consisted of 931 companies from 22 countries in Europe, The Americas and Asia (see Table 1). The overall response rate was 36% (931/2586) (Cheng et al., 2016).

Table 1: Respondent profile

Demographic dimension		IMSS VI sample	
		Number	Percentage (%)
25	Manufacture of fabricated metal products, except machinery and equipment	282	30.29
26	Manufacture of computer, electronic and optical products	123	13.21
27	Manufacture of electrical equipment	153	16.43
28	Manufacture of machinery and equipment not elsewhere classified	231	24.81
29	Manufacture of motor vehicles, trailers and semi-trailers	93	10.00
30	Manufacture of other transport equipment	49	5.26
	Total	931	100.00
Europe	Belgium	29	
	Denmark	39	
	Finland	34	
	Germany	15	
	Hungary	57	
	Italy	48	
	Netherlands	49	
	Norway	26	
	Portugal	34	
	Romania	40	
	Slovenia	17	
	Spain	29	
	Sweden	32	
	Switzerland	30	
	Total	479	51.45
Asia	China	128	
	India	91	
	Japan	82	
	Malaysia	14	
	Taiwan	28	
	Total	343	36.84
North America	Canada	30	
	USA	48	
	Total	78	8.38
South America	Brazil	31	3.33
	Total	31	3.33
Total		931	100.00

3.2. Measures

In IMSS VI, the literature was reviewed to identify valid measures and existing sales were adapted, wherever necessary for related constructs. In the absence of no reliable and valid existing measures, new measures were developed based on the understanding of the constructs and the round-table discussions of the survey design team. To operationalise the constructs related to social integration, technical integration, quality programme deployment and sustainability programme deployment, quality performance, social and environmental performance, multi-item, reflective indicators (Bollen, 1989) were used. The items for each construct were measured used five-point Likert scales, where higher values indicated higher levels of implementation or better performance with respect to main competitors.

Social integration construct consists of delegation and knowledge of workers (e.g. empowerment, training, encouraging solutions to work related problems, pay for competence or incentives for improvement results) (Kaynak, 2003), open communication between workers and managers (information sharing, encouraging bottom-up open communication, two-way communication flows) (Boudreau et al., 2003), lean organization (e.g. few hierarchical levels and broad span of control), continuous improvement programmes through systematic initiatives (e.g. kaizen, improvement teams, improvement incentives) (Bhuiyan and Baghel, 2005), autonomous teams (e.g. team responsible for planning, execution and control, workers sharing experience, knowledge and skills, formalization of team composition and responsibilities, work group incentives) (Sveiby and Simons, 2002), and workers flexibility (e.g. multi-tasking, multi-skilling, job rotation) (Cagliano et al., 2014). The above items can be mapped to STS principles. For example, delegation and autonomous teams can be mapped to compatibility which ensures that employees are involved in the planning process and minimal critical specifications. Open communication is related to information flow, worker flexibility is related to multi-functionality and lean organization is related to boundary location which ensures that boundaries should not be drawn to impede sharing of information, knowledge and learning.

Technical integration is defined as a construct involving integration between product development and manufacturing. It is a multi-faceted construct and involves the following items- design integration, technological integration, organization integration between product development and manufacturing, integrating tools and techniques, communication technologies and process standardization. Design integration includes platform design (Robertson and Ulrich, 1998), standardization (Dröge et al., 2004), and design for manufacturing and assembly (Paashuis and Boer, 1997; Dröge et al., 2004). Organizational integration can be achieved through cross-functional teams (Swink et al., 1996), job rotation, co-location, role combination, secondment and/or coordinating managers (Paashuis and Boer, 1997). Technological integration includes the use of computer-aided design/engineering and manufacturing and product lifecycle management. Internal integration requires the 'bundling' of management tools with such tools (Smith and Reinertsen, 1998). Integrating tools and techniques such as quality function deployment, failure mode and effect analysis and rapid prototyping can be effectively used for design-manufacturing integration (Paashuis and Boer, 1997). Communication technologies such as video-conferencing and web-meetings support information sharing between dispersed staff involved in the development of products. Process standardization includes stage-gate process, design reviews and performance management. In stage-gate processes, each stage consists of a set of well-defined cross-functional and parallel activities (Cooper, 1994).

Quality programme deployment construct consists of quality improvement and control (e.g. TQM programmes, six sigma projects, quality circles) (Zu et al., 2010), improving equipment availability (e.g. Total Productive Maintenance) (McKone et al., 1999) and benchmarking/self-assessment (e.g. quality awards, EFQM model) (Flynn et al., 2006). *Sustainability programme deployment* construct consists of environmental certifications (e.g. EMAS or ISO 14001) (Kitazawa and Sarkis, 2000), social certifications (e.g. SA8000 or OHSAS 18000), formal sustainability oriented communication (Daily et al., 2001), training programmes and involvement, energy and water consumption reduction programmes (Sarkis, 1998), pollution emission reduction and waste recycling programmes (Klassen and Whybark, 1999), formal occupational health and safety management system (Kleindorfer et al., 2005) and work-life balance policies.

In this research, *quality performance* is operationalised in terms of a two-item scale: 1) conformance quality and 2) product quality and reliability. Similarly, *social performance* is operationalised as: 1) worker motivation and satisfaction and 2) health and safety conditions (McKenzie, 2004) while *environmental performance* is operationalised as 1) materials, water and energy consumption and 2) pollution emission and waste production (Gimenez et al., 2012). Finally, to ensure the contextual validity of the results, two control variables namely *plant size* and *environmental dynamism* were employed. Plant size is measured the logarithm of the total number of employees of the business unit that the plant belongs to, which has been widely applied in the existing studies, such as. Environmental dynamism is operationalised in a four-item agreement-disagreement 5-point scale: 1) demand fluctuates drastically, 2) total manufacturing volume fluctuates drastically, 3) mix of products produce change considerably, and 4) supply requirements (volume and mix) vary drastically. The descriptive statistics for our model constructs and control variables i.e. mean, standard deviations and pairwise correlations are shown in Table 2.

Table 2: Descriptive statistics

Variable	Mean	SD	1	2	3	4	5	6	7	8	9
1. Social Integration	3.32	0.75	1								
2. Technical Integration	3.18	0.88	0.55***	1							
3. Qualitymanagement programme deployment	3.17	1.00	0.57***	0.68***	1						
4. Sustainability programme deployment	3.13	0.95	0.54***	0.69***	0.69***	1					
5. Quality performance	3.57	0.70	0.32***	0.32***	0.35***	0.30***	1				
6. Environmental performance	3.17	0.65	0.24***	0.24***	0.24***	0.27***	0.26***	1			
7. Social Performance	3.39	0.68	0.39***	0.36***	0.39***	0.40***	0.47***	0.32***	1		
8. Environmental dynamism	2.65	0.95	0.07**	0.03	-0.002	-0.001	-0.05	-0.03	0.00	1	
9. Size	6.02	1.73	0.19***	0.28***	0.23***	0.31***	0.04	0.05	0.03	-0.02	1

** p<0.05 (two-tailed); *** p<0.01 (two-tailed)

3.3 Reliability and validity

Close collaboration between academics and industry professionals in the development of the measurement items prior to data collection, literature support, executive interviews, and pilot tests ensured content validity (Cheng et al., 2016). After the data collection, multiple analyses were performed to ensure the reliability and validity of the constructs. First, the reliability of each construct was tested. Reliability is an assessment of the degree of consistency between multiple measurements of a variable (Hair et al., 1998). Although Cronbach's alpha was widely used in the existing studies to assess construct reliability, this coefficient alpha is based on the essentially tau-equivalent measurement model. Violation of the assumptions required by this measurement model is often responsible for coefficient alpha's underestimation of reliability (Graham, 2006). Therefore, instead of relying on "rule of thumb", i.e. Cronbach's alpha > 0.70 (Nunnally, 1994), we adopted a two-step approach proposed by Graham (2006) to assess construct reliability (Cheng et al., 2016). In the first step, we selected the appropriate measurement model by conducting chi-square test on difference in fit between the parallel, the tau-equivalent, the essentially tau-equivalent model, and the congeneric model based. In the second step, we estimated reliability based on the best possible model chosen from the first step, by squaring the implied correlation between the composite latent true variable and the composite observed variable. It should also be noted that if in the first step, the tau-equivalent model is chosen, the reliability we calculate in the second step is actually the coefficient alpha (Cheng et al., 2016). The results are shown in Table 3, which allow us to conclude that the reliability of constructs is established.

Table 3: Confirmatory Factor Analysis and Reliability of measures

Measurement Items	Standardised factor loadings	Reliability	AVE	Composite reliability
Social Integration				
Delegation and knowledge of workers	0.728	0.813	0.461	0.836
Open communication between workers and managers	0.676			
Lean organization	0.647			
Continuous improvement programmes	0.692			
Autonomous teams	0.726			
Workers flexibility	0.593			
Technical Integration				
Design integration between product development and manufacturing	0.664	0.870	0.527	0.870
Organizational integration between product development and manufacturing	0.707			
Technological integration between product development and manufacturing	0.729			
Integrating tools and technologies	0.785			
Communication technologies	0.689			
Process standardization	0.775			
Quality programme deployment				
Quality improvement and control	0.798	0.839	0.640	0.842
Improving equipment availability	0.823			
Benchmarking/self-assessment	0.779			
Sustainability programme deployment				
Environmental certification	0.645	0.884	0.529	0.886
Social certification	0.698			
Sustainability oriented communication	0.809			
Energy and water consumption reduction programmes	0.771			
Pollution emission reduction and waste recycling programmes	0.777			
Occupational health and safety management systems	0.701			

Work-life balance policies	0.674			
Quality Performance				
Conformance quality	0.799	0.79	0.650	0.788
Product quality and reliability	0.813			
Environmental performance				
Materials, water and energy consumption	0.660	0.693	0.541	0.70
Pollution emission and waste production levels	0.804			
Social Performance				
Workers' motivation and satisfaction	0.715	0.697	0.535	0.697
Health and safety conditions	0.748			
Environmental dynamism				
Demand fluctuates drastically	0.802	0.880	0.650	0.881
Total manufacturing volume fluctuates drastically	0.804			
Production mix changes considerably	0.777			
Supply requirements (volume and mix) vary drastically	0.841			
Sustainability Performance (2nd order construct)				
Environmental performance	0.550		0.518	0.672
Social performance	0.856			

Confirmatory Factor Analysis (CFA) is used test unidimensionality and reliability. Each measurement item was linked to its corresponding construct, and the covariance among the constructs was freely estimated. The model fit indices were χ^2=1441.658, df= 436, GFI=0.907, AGFI=0.887, RMR=0.044, 90% confidence interval for RMSEA= (0.047, 0.053), NFI=0.905, RFI=0.892, IFI=0.932, NNFI=0.922, CFI=0.931. Thus, the model was acceptable (Hu and Bentler, 1999) and CFA factor loadings are listed in Table 3. All items loaded on the construct they were supposed to measure, which demonstrate construct unidimensionality. Average variance extracted (AVE) values and composite reliability values for all the constructs were also calculated. In order to assess discriminant validity, a constrained CFA model was built for each possible pair of latent constructs, in which the correlations between the paired constructs were fixed to 1.0. This constrained model was then compared with the original unconstrained model, in which the correlations were freely estimated (Cheng et al., 2016). A significant difference of the χ^2 statistics between the constrained and unconstrained models indicates high discriminant validity (Fornell and Larcker, 1981). Results show that for each pair, all the differences of the χ^2 between two models were significant at the 0.01 level, providing further evidence of discriminant validity.

4. Results and Findings

Structural Equation Modeling (SEM) was used to estimate the relationships among different constructs and test the research hypotheses by using AMOS 22 with the maximum likelihood estimation method. The goodness of fit indices for our model are χ^2 (df=477) =1852.77, GFI=0.886, AGFI= 0.866, CFI=0.907, NNFI or TLI=0.897, IFI=0.908, NFI=0.879, RMR=0.10, 90% confidence interval for RMSEA= (0.053, 0.058). The results of SEM path analysis are shown in Table 4, which provide supports for all hypotheses except H5 and H6. Moreover, size has significant negative impacts on both quality performance and sustainability performance while environmental dynamism has significant negative impact only on quality performance but not on sustainability performance.

The results show that social integration has a significant positive effect on technical integration satisfying H1, while social and technical integration have significant positive effects on both quality programme deployment and sustainability programme deployment, thus satisfying the hypotheses H2a, H2b, H3a and H3b respectively. While quality programme deployment has significant positive effect on quality performance, thus satisfying H4, sustainability programme deployment has significant positive effect on sustainability performance thus satisfying H7. But, quality programme deployment did not have any significant effect on sustainability performance and sustainability programme deployment did not have significant effect on quality performance. Thus, there was no evidence found for the support of H5 and H6.

Table 4: Parameter estimates and significance level

	Standardised β
H1: Social integration → Technical integration	0.641***
H2a: Social integration → Quality programme deployment	0.273***
H2b: Technical integration → Quality programme deployment	0.644***
H 3a: Social integration → Sustainability programme deployment	0.198***
H3b: Technical integration → Sustainability programme deployment	0.691***
H4: Quality programme deployment → Quality performance	0.252*
H5: Quality programme deployment → sustainability performance	0.212
H6: Sustainability programme deployment → quality performance	0.008
H7: Sustainability programme deployment → Sustainability performance	0.285**
R^2 Technical integration	0.411
R^2 Quality programme deployment	0.715
R^2 Sustainability programme deployment	0.693
R^2 Quality performance	0.254
R^2 sustainability performance	0.511

χ^2 /df= 3.88, CFI=0.907, NNFI=0.897, IFI=0.908, NFI=0.879, RMR=0.10, RMSEA=0.056(0.053, 0.058)

* p<0.10 (two-tailed); ** p<0.05 (two-tailed); *** p<0.01 (two-tailed)

4.1. Mediation analysis

To test the mediation relationships, we adopted the explicit procedure, i.e. bootstrapping for testing mediation effects. Bootstrapping has been demonstrated to have the greatest statistical power to detect significant mediation processes while maintaining acceptable Type I error rates, especially with large samples (Rungtusanatham et al., 2014). Consequently, we used bias-corrected bootstrapping method implemented in AMOS 22 (Preacher and Hayes, 2008), based on the model illustrated in Figure1. Therefore, we report these effects with respect to hypotheses in Table 5 and Table 6 below.

Table 5: Bootstrapping results for mediation relationship tests

	Technical integration	Quality programme deployment		Sustainability programme deployment		Quality performance		Sustainability performance	
		Direct effect	Indirect effect	Direct effect	Indirect effect	Direct effect	Indirect effect	Direct effect	Indirect effect
Social integration	(0.686, 0.876)***	(0.223, 0.439)***	(0.418, 0.597)***	(0.148, 0.371)***	(0.484,0.683)***	(0.075, 0.293)***	(0.099, 0.261)***	(0.102, 0.302)***	(0.135, 0.280)***
Technical integration		(0.549, 0.734)***		(0.641, 0.853)***		(-0.146, 0.220)	(-0.019, 0.262)	(-0.177, 0.139)	(0.057, 0.323)**

Lower bound, upper bound), *** p<0.001, ** p<0.01, * p<0.05 (two tailed significance)

Table 6: Bootstrapping results for mediation effects of specific paths

Relationship	Total effect [confidence interval 95%]	Direct effect [confidence interval 95%]	Indirect effect [confidence interval 95%]
Social integration → technical integration→Quality programme deployment→ quality performance	(0.203,0.462)***	(0.075,0.293)***	(0.018,0.283)*
Social integration →Quality programme deployment→ quality performance	(0.143, 0.340)***	(0.075,0.293)***	(0.009, 0.118)*
Technical integration → Quality programme deployment→ quality performance	(0.015,0.282)*	(-0.146, 0.220)	(0.014,0.226)*
Social integration → technical integration→Quality programme deployment→ sustainability performance	(0.181,0.417)***	(0.102,0.302)***	(-0.020,0.220)
Social integration → Quality programme deployment→ sustainability performance	(0.152,0.329)***	(0.102,0.302)***	(-0.006, 0.091)
Technical integration → Quality programme deployment→ sustainability performance	(-0.055, 0.175)	(-0.177,0.139)	(-0.014,0.180)

Social integration → technical integration → Sustainability programme deployment→ quality performance	(0.056,0.316)**	(0.075,0.293)***	(-0.087,0.105)
Social integration → Sustainability programme deployment→ quality performance	(0.079,0.293)***	(0.075,0.293)***	(-0.029,0.032)
Technical integration → Sustainability programme deployment→ quality performance	(-0.106, 0.186)	(-0.146, 0.220)	(-0.077, 0.096)
Social integration → Technical integration→ Sustainability programme deployment→ sustainability performance	(0.203, 0.448)***	(0.102,0.302)***	(0.028, 0.218)**
Social integration → Sustainability programme deployment→ sustainability performance	(0.145, 0.339)***	(0.102,0.302)***	(0.009,0.076)**
Technical integration → Sustainability programme deployment→ sustainability performance	(-0.037,0.213)	(-0.177,0.139)	(0.024,0.195)*

(Lower bound, upper bound), *** $p<0.001$, ** $p<0.01$, * $p<0.05$ (two tailed significance)

To test the mediation effects of quality programme deployment between social integration and quality performance, both paths – one including technical integration and quality programme deployment and one including only quality programme deployment were tested. Results show that both the direct effects of social integration on quality performance as well as the indirect effects through quality programme deployment (alone as well as with technical integration) are significant. Thus, there is a partial mediation effect of quality programme deployment between social integration and quality performance and hypothesis 4b is supported. But, we find that the direct effect between technical integration and quality performance is not significant but the indirect effect through quality programme deployment is significant. Hence, there is a full mediation effect of quality programme deployment between technical integration and quality performance. Similarly, only the indirect effect between technical integration and sustainability performance mediated by sustainability programme deployment is significant, thereby suggesting a full mediation. Both the direct and indirect effects between social integration and sustainability performance mediated by sustainability programme deployment are significant, signifying partial mediation. The direct effects between social integration and sustainability performance and social integration and quality performance are significant. These findings are in congruence with Daily et al. (2012) who reported positive impact of managers' and employees' empowerment and training on environmental matters to have direct positive impact on environmental performance.

To summarize the findings, we can state that our model using STS suggests that the socio and technical facets of organizational work practices positively influence both quality and sustainability improvement programmes. These programmes in turn positively influences quality performance and sustainability performance. Technical integration positively influence quality performance only through the mediation effect of quality programme deployment and positively influence sustainability performance only through the mediation effect of sustainability programme deployment. Social integration positively influence quality and sustainability performance both due to its direct effect as well through the mediation of the respective improvement programmes deployment. But, the results show that there is no spillover effect of quality and sustainability management programmes on sustainability and quality performance respectively.

5. Discussion and Implications

The results show that building on STS theory, social and technical integration indeed have a positive effect on deployment of quality and sustainability management programmes. Significant direct effects of social integration on technical integration and on quality performance and sustainability performance suggest the strategic direction provided by initiatives related to communication between managers and workforce, delegation, training, autonomous teams and worker flexibility etc has an important role to play in influencing quality and sustainability performance. Manufacturing plants, which excel in such healthy work practices can also strengthen technical integration through design-manufacturing integration. Such plants will not only find it easier to deploy quality and sustainability programmes but can also get some improvements in quality and sustainability even without the above programmes. Such a result is also supported by Dubey et al. 2015, who reported a significant positive effect of employee involvement on environmental and social performance. Thus, the impact on superior quality and sustainability performance is magnified when the quality and sustainability programmes are implemented along with conducive work practices. Technical integration help in deployment of quality and sustainability management programmes and can influence quality and sustainability performance only through those programmes.

The social and technical enablers combined with the notion of complementarity theory allow us to theoretically explain the IMS framework. We hypothesized that within an IMS framework, there can be both direct and spillover effects of quality and sustainability management programmes. While the direct effects are supported, the results do not indicate any spillover effect of quality programmes on sustainability performance or of sustainability programmes on quality performance. This result is to a certain extent consistent with the findings from Pullman et al. (2009) who reported that environmental sustainability programmes did not seem to improve quality though social sustainability programmes indeed had a positive effect on quality.

5.1 Implications for research

Contrary to findings in the literature, this study did not find positive relationship between quality management programme and sustainability performance. Curkovic et al. (2000) identified that firms with already developed capabilities in TQM are more likely to develop the capabilities necessary for environmental sustainability. But, de Menezes (2012) found no significant link between quality management and employee job satisfaction which is considered as part of sustainability performance in this research. Thus, a possible explanation for the above result can be that we have considered a broader definition of sustainability considering both environmental and social performance. But, our results confirm with those of Wiengarten et al. (2012) who studied the interaction effects of quality management and environmental management practices and found no significant interaction effect of the above in explaining quality performance.

Interestingly both control variables of size and environmental dynamism had negative and statistically significant effects. It is interesting that the pattern points to the advantages stemming to small size firms and firms facing stable or less environmental dynamism. The fact the smaller firms have conducive work practices in terms of less hierarchy, open communication and delegation may possibly explain which can be difficult to put in place in larger firms may possibly explain the negative impact of firm size as reported in this research.

5.2 Implications for practice

Manufacturing firms have to continuously strive to improve quality, environmental and social sustainability performance. Many firms have attempted to implement programmes for quality and sustainability. Results suggest that healthy work practices developed on the foundations of social integration through open communication, having autonomous teams, delegation and investing in knowledge and training of workers act as drivers for technical integration between design and manufacturing.

In fact, social integration alone can also result in improved quality and sustainability performance and its effect gets magnified due to the mediating effect of quality programmes and sustainability programmes respectively. Technical integration can have effects on quality and sustainability performance only through the mediating roles of the respective programmes. Thus, firms should be aware that technical integration alone may not be sufficient to achieve superior performance on quality and sustainability. Also, manufacturing plants developing plans to improve sustainability performance may not rely only on their quality management programmes and must develop distinct sustainability management programmes. Such programmes together with social integration may help them to improve overall sustainability performance.

6. Conclusion and Future Research

We use STS theory, complementarity theory to provide theoretical support to the IMS framework and offer a fresh perspective on how organisational work practices that pay due attention to human dimensions and tools and techniques help in deployment of quality and sustainability management programmes, thereby enhancing quality as well as sustainability performance. Data from a large multi-country sample of firms was used to empirically validate our framework. Our findings add new knowledge to the academic thought processes on quality management as well as make vital contributions to practicing managers on how to exploit the synergies of the social and technical aspects thereby facilitating implementation of quality and sustainability programmes and in turn impacting quality and sustainability performance.

Our study has limitations. For example, our study largely uses scales that are subjective. Also, multi-country samples could mask within country differences. Nevertheless, we believe that for an initial investigation of emerging trends, multi country samples afford the opportunity to unravel new trends. Similarly, patterns in this study have identified new opportunities for future research. For example, an area which is ripe for future research is the across country comparisons of work practices and their impact on quality and sustainability performances. For instance by extending the work of Wiengarten et al. (2011), a comparison can be made between emerging economies such as India and China versus developed economies of Germany and USA or between two countries within BRICS with varying rates of economic growth. This may be quite relevant to understand the influence of national culture or human development indices on the linkages between social and technical integration facets on improvement programmes in quality and sustainability and their ensuing effects on performance. We leave and other related areas as possible opportunities for future research. The extent of fit between social and technical dimensions could influence quality and sustainability outcomes. While, we have not explicitly verified this fit linkage, it can be an interesting area of future research. For example, the alignment between social and technical dimensions can be one way of assessing fit. Using profile deviation scores could be a method to operationalize fit in the sense that higher deviation from the 'ideal' could constitute poor alignment. We leave these promising areas of research for future inquiry.

References

Abdul-Rashid, Salwa Hanim; Sakundarini, Novita; Raja Ghazilla, Raja Ariffin; Thurasamy, Ramayah. 2017, The impact of sustainable manufacturing practices on sustainability performance. *International Journal of Operations & Production Management*. 37(2): 82-104.

Ahire, S. L., & Dreyfus, P. 2000. "The impact of design management and process management on quality: an empirical investigation." *Journal of Operations Management* 18(5):549-575.

Alves, J. R. X., & Alves, J. M. 2015. "Production management model integrating the principles of lean manufacturing and sustainability supported by the cultural transformation of a company." *International Journal of Production Research*, 53(17): 5320-5333.

Bamber, C. J., Sharp, J. M., & Hides, M. T. 1999. "Factors affecting successful implementation of total productive maintenance: a UK manufacturing case study perspective." *Journal of Quality in Maintenance engineering* 5(3): 162-181.

Bernardo, M., Casadesus, M., Karapetrovic, S., & Heras, I., 2009. "How integrated are environmental, quality and other standardized management systems? An empirical study." *Journal of Cleaner Production*, 17(8): 742-750.

Bernardo, M., Simon, A., Tarí, J. J., & Molina-Azorín, J. F. 2015. "Benefits of management systems integration: a literature review." *Journal of Cleaner Production*, 94: 260-267.

Bhuiyan, N., & Baghel, A. 2005. An overview of continuous improvement: from the past to the present. *Management decision*, 43(5): 761-771.

Bigorra, Martí A., & Isaksson, O. 2017. "Combining customer needs and the customer's way of using the product to set customer-focused targets in the House of Quality." *International Journal of Production Research*, 55(8): 2320-2335.

Bollen, K. A. 1989. A new incremental fit index for general structural equation models. *Sociological Methods & Research*, 17(3):303-316.

Boudreau, J., Hopp, W., McClain, J. O., & Thomas, L. J. 2003. “On the interface between operations and human resources management.” *Manufacturing & Service Operations Management*, 5(3), 179-202.

Bresnahan, T. F., Brynjolfsson, E., & Hitt, L. M. 2002. “Information technology, workplace organization, and the demand for skilled labor: Firm-level evidence.” *Quarterly Journal of Economics*, 117(1): 339–376.

Brown, M.G., Hitchcock, D.E. and Willard, M.L., 1994.*Why TQM Fails and What to Do About It*, Irwin Professional, New York, NY.

Cagliano, R., Caniato, F., Longoni, A., & Spina, G. 2014. “Alternative uses of temporary work and new forms of work organisation.” *Production Planning & Control* 25(9): 762-782.

Cantor, D. E., Morrow, P. C., McElroy, J. C., & Montabon, F., 2013. “The role of individual and organizational factors in promoting firm environmental practices.” *International Journal of Physical Distribution & Logistics Management* 43(5/6):407-427.

Chaudhuri, A., & Bhattacharyya, M. 2009. “A combined QFD and integer programming framework to determine attribute levels for conjoint study.” *International Journal of Production Research*, 47(23): 6633-6649.

Chaudhuri, A., Boer, H. 2016, “The impact of product-process complexity and new product development order winners on new product development performance: The mediating role of collaborative competence”, *Journal of Engineering and Technology Management*, 42(4): 65-80

Chaudhuri, A., Boer, H., & Taran, Y., 2018, “Supply chain integration, risk management and manufacturing flexibility”, *International Journal of Operations & Production Management*, 38(3):690-712.

Cheng, Y., Chaudhuri, A., & Farooq, S. 2016, “Interplant coordination, supply chain integration, and operational performance of a plant in a manufacturing network: a mediation analysis”, *Supply Chain Management: An International Journal*, 21(5): 550-568.

Cherrafi, A., Elfezazi, S., Govindan, K., Garza-Reyes, J. A., Benhida, K., & Mokhlis, A. 2017. “A framework for the integration of Green and Lean Six Sigma for superior sustainability performance.” *International Journal of Production Research*, 55(15): 4481-4515.

Chun, Y., & Bidanda, B. 2013. “Sustainable manufacturing and the role of the International Journal of Production Research.” *International Journal of Production Research*, 51(23-24):7448-7455.

Conti, R., Angelis, J., Cooper, C., Faragher, B. and Gill, C. 2006. “The effects of lean production on worker job stress”, *International Journal of Operations & Production Management*, 26(9): 1013-38.

Cooper, R.G. 1994. “Perspective third-generation new product processes.” *Journal of Product Innovation Management*, 11 (1): 3-14.

Curkovic, S., Melnyk, S.A., Handfield, R.B., Calantone, R.J. 2000. “Investigating the linkage between total quality management and environmentally responsible manufacturing.” *IEEE Transactions on Engineering Management* 47 (4): 444–464.

Curkovic, S., Sroufe, R., & Landeros, R. 2008. “Measuring TQEM returns from the application of quality frameworks.” *Business Strategy and the Environment*, 17(2): 93.

Dahlgaard, J. J., & Mi Dahlgaard-Park, S. 2006. “Lean production, six sigma quality, TQM and company culture.” *The TQM magazine*, 18(3):263-281.

Daily, B.F. and Huang, S. 2001. “Achieving sustainability through attention to human resource factors in environmental management.” *International Journal of Operations & Production Management* 21(12): 1539-1552

Daily, B. F., Bishop, J. W., & Massoud, J. A., 2012. “The role of training and empowerment in environmental performance: A study of the Mexican maquiladora industry.” *International Journal of Operations & Production Management* 32(5): 631-647.

de Menezes, L. M. 2012. “Job satisfaction and quality management: an empirical analysis.” *International Journal of Operations & Production Management* 32(3): 308-328.

De Oliveira Matias, J. C., & Coelho, D. A., 2002. “The integration of the standards systems of quality management, environmental management and occupational health and safety management.” *International Journal of Production Research*, 40(15): 3857-3866.

Dröge, C., Jayaram, J. and Vickery, S.K. 2004. “The effects of internal versus external integration practices on time-based performance and overall firm performance.” *Journal of Operations Management* 22 (6): 557-573.

Dubey, R., Gunasekaran, A., & Chakrabarty, A. 2015. “World-class sustainable manufacturing: framework and a performance measurement system.” *International Journal of Production Research,* 53(17): 5207-5223.

Ettlie, J. E. 1995. “Product-process development integration in manufacturing.” *Management Science,* 41(7): 1224-1237.

Ferreira Rebelo, M., Santos, G., & Silva, R. 2014. “A generic model for integration of quality, environment and safety management systems.” *The TQM Journal*, 26(2): 143-159.

Fornell, C., & Larcker, D. F. 1981. “Evaluating structural equation models with unobservable variables and measurement error.” *Journal of Marketing Research*, 39-50.

Fotopoulos, C.B. and Psomas, E.L. 2009. “The impact of ‘soft’ and ‘hard’ TQM elements on quality management results.” *International Journal of Quality and Reliability Management* 26(2):.150-163.

Flynn, B.B. and Saladin, B. 2006. “Relevance of Baldrige constructs in an international context: A study of national culture” *Journal of Operations Management* 24(5), 583-603.

Garza-Reyes, J. A., Rocha-Lona, L., & Kumar, V. 2015. “A conceptual framework for the implementation of quality management systems.” *Total Quality Management & Business Excellence*, 26(11-12): 1298-1310.

Garza-Reyes, J. A., Kumar, V., Chaikittisilp, S., & Tan, K. H. 2018. The effect of lean methods and tools on the environmental performance of manufacturing organisations. *International Journal of Production Economics*.

Gimenez, C., Sierra, V., Rodon, J., 2012. "Sustainable operations: their impact on the triple bottom line.” *International Journal of Production Economics* 140(1), 149–159.

Golini, R., Longoni, A., & Cagliano, R. 2014. “Developing sustainability in global manufacturing networks: The role of site competence on sustainability performance.” *International Journal of Production Economics*, 147(x): 448-459.

Graham, J. M. 2006. “Congeneric and (essentially) tau-equivalent estimates of score reliability what they are and how to use them.” *Educational and Psychological Measurement,* 66(6):930-944.

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., 1998. *Multivariate Data Analysis*. Prentice Hall, New Jersey.

Handfield, R., Jayaram, J., Ghosh, S. 1999. "An empirical examination of quality tool deployment patterns and their impact on performance." *International Journal of Production Research* 37 (6):1403–1426.
Hart, S.L. 1995. "A natural-resource-based view of the firm." *Academy of Management Review* 20(4): 986-1014.
Ho, D.C.K., Duffy, V.G., Shih, H.M. 1999. "An empirical analysis of effective TQM implementation in the Hong Kong electronics manufacturing industry." *Human Factors and Ergonomics in Manufacturing*
9(1): 1–25
Hoffman, A.J. and Bazerman, M.S. 2007. "Changing practice on sustainability: understanding and overcoming the organizational and psychological barriers to action." In Sharma, S., Starik, M. and Husted, B. (Eds). *Organizations and the Sustainability Mosaic,* Edward Elgar, Cheltenham, 84-105.
Houston, K., & Reay, D. S. 2011, "The impact of information and communication technology on GHG emissions: how green are virtual worlds?". *Carbon Management*, 2(6): 629-643.
Hu, L. T., & Bentler, P. M. 1999. "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives." *Structural equation modeling: a multidisciplinary journal*, 6(1): 1-55.
Isaksson, R. 2006. "Total quality management for sustainable development: Process based system models." *Business Process Management Journal* 12(5), 632-645.
Jayaram, J., Oke, A., & Prajogo, D. 2014. "The antecedents and consequences of product and process innovation strategy implementation in Australian manufacturing firms." *International Journal of Production Research*, 52(15):4424-4439.
Karuppusami, G., & Gandhinathan, R. 2006. "Pareto analysis of critical success factors of total quality management: A literature review and analysis." The TQM magazine 18(4):372-385.
Kaynak, H., 2003. "The relationship between total quality management practices and their effects on firm performance." *Journal of Operations Management* 21(4):405-435.
Kitazawa, S. and Sarkis, J., 2000. "The relationship between ISO 14001 and continuous source reduction programs." *International Journal of Operations & Production Management* 20 (2): 225-248
Klassen, R. D., & McLaughlin, C. P. 1993. "TQM and environmental excellence in manufacturing." *Industrial Management & Data Systems* 93(6): 14-22.
Klassen, R. D., & McLaughlin, C. P. 1996. "The impact of environmental management on firm performance." *Management science*, 42(8): 1199-1214.
Klassen, R.D. and Whybark, D.C. 1999. "The Impact of Environmental Technologies on Manufacturing Performance." *Academy of Management Journal* 42(6): 599-615.
Kleindorfer, P. R., Singhal, K., & Wassenhove, L. N. 2005. "Sustainable operations management." *Production and Operations Management* 14(4): 482-492.
Krikke, H., J. Bloemhof-Ruwaard, L. N. Van Wassenhove. 2003. "Concurrent design of closed loop supply chains: A production and return network for refrigerators." *International Journal of Production Research* 41(6): 3689–3719
Kumar, M., Antony, J., Antony, F. J., & Madu, C. N. 2007. Winning customer loyalty in an automotive company through Six Sigma: a case study. *Quality and Reliability Engineering International*, 23(7): 849-866.
Lang Cheng, J. 2012. "Examining the implementation of Six Sigma training and its relationships with job satisfaction and employee morale." *Asian Journal on Quality*, 13(1):100-110.

Laosirihongthong, T., Teh, P. L., & Adebanjo, D., 2013. “Revisiting quality management and performance.” *Industrial Management & Data Systems* 113(7): 990-1006.
Lee, J., Yuvamitra, K., Guiberteau, K. and Kozman, T.A. 2014, “Six-Sigma approach to energy management planning”, *Strategic Planning for Energy and the Environment*, 33(3): 23-40.
Leous, JP. 2015 “Q&A with Caterpillar’s Tim Lindsey: How Can Sustainability Drive Innovation?”, http://www.wri.org/blog/2015/03/qa-caterpillar%E2%80%99s-tim-lindsey-how-can-sustainability-drive-innovation, accessed May 9, 2017
Liker, J. K., Collins, P. D., & Hull, F. M., 1999. “Flexibility and standardization: test of a contingency model of product design–manufacturing integration.” *Journal of Product Innovation Management* 16(3): 248-267.
Liu, G., Shah, R., Schroeder, R., 2006. “Linking work design to mass customisation; A socio-technical systems perspective” *Decision Sciences*, 37(4): 519-544.
Longoni, A., & Cagliano, R. 2015. “Cross-functional executive involvement and worker involvement in lean manufacturing and sustainability alignment.” *International Journal of Operations & Production Management,* 35(9): 1332-1358.
Manz, C.C., Stewart, G.L., 1997. “Attaining Flexible Stability by Integrating Total Quality Management and Socio-technical Systems Theory” *Organization Science,* 8(1): 59-70.
Mayyas, A., Qattawi, A., Omar, M., & Shan, D. 2012. Design for sustainability in automotive industry: A comprehensive review. *Renewable and Sustainable Energy Reviews*, 16(4):1845-1862.
McKenzie, S., 2004. *Social Sustainability: Towards Some Definitions*. Hawke Research Institute, University of South Australia, Magill.
McKone, K.E., Schroeder, R.G. and Cua, K.O., 1999. Total productive maintenance: a contextual view, *Journal of Operations Management* 17, 123-144
Milgrom, P., & Roberts, J. 1995. Complementarities and fit strategy, structure, and organizational change in manufacturing. *Journal of Accounting and Economics*, 19(2–3): 179–208.
Mohammad M. A., 2014. “Why TQM programmes fail? A pathology approach.” *The TQM Journal*, 26(2): 160-187.
Nair, A., 2006. “Meta-analysis of the relationship between quality management practices and firm performance—implications for quality management theory development.” Journal of Operations Management 24(6):948-975.
Nunnally, J.C., 1994. Psychometric Methods, McGraw–Hill, New York, NY.

Paashuis, V. and Boer, H., 1997. “Organizing for concurrent engineering: An integration mechanism framework.” *Integrated Manufacturing Systems* 8 (2):79-89.
Pampanelli, A. B., Found, P., & Bernardes, A. M. 2014. “A Lean & Green Model for a production cell.” Journal of Cleaner Production, 85(12):19-30.
Pan, J. N. 2003. ”A comparative study on motivation for and experience with ISO 9000 and ISO 14000 certification among Far Eastern countries.” *Industrial Management & Data Systems*, 103(8): 564-578.
Parvadavardini, S., Vivek, N., & Devadasan, S. R. 2016. “Impact of quality management practices on quality performance and financial performance: evidence from Indian manufacturing companies.” *Total Quality Management & Business Excellence*, 27(5-6): 507-530.
Pasche, M., Persson, M., & Löfsten, H., 2011. “Effects of platforms on new product development projects.” *International Journal of Operations & Production Management*, 31(11):1144-1163.

Pasmore, W. A., 1988. *Designing effective organizations: The sociotechnical systems perspective*. New York, Wiley.
Patyal, V. S., & Koilakuntla, M. 2017. "The impact of quality management practices on performance: an empirical study." *Benchmarking: An International Journal*, 24(2): 511-535.
Pil, F.K., Rothenberg, S., 2003. "Environmental performance as a driver of superior quality." *Production and Operations Management* 12(3): 404–415.
Prajogo, D. I., & Sohal, A. S., 2006. "The relationship between organization strategy, total quality management (TQM), and organization performance—the mediating role of TQM." *European Journal of Operational Research* 168(1): 35-50.
Preacher, K.J., Hayes, A.F., 2008. "Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models." *Behaviour Research Methods* 40 (3): 879–891.
Psomas, E., Vouzas, F., & Kafetzopoulos, D. 2014. "Quality management benefits through the "soft" and "hard" aspect of TQM in food companies." *The TQM Journal*, 26(5): 431-444.
Pullman, M. E., Maloni, M. J., & Carter, C. R., 2009. "Food for thought: social versus environmental sustainability practices and performance outcomes." *Journal of Supply Chain Management*, 45(4):38-54.
Raouf, A., 2009. Maintenance quality and environmental performance improvement: an integrated approach. *In Handbook of Maintenance Management and Engineering* (pp. 649-664). Springer, London.

Robertson, D. and Ulrich, K., 1998. "Planning for product platforms." *Sloan Management Review* 39 (4):19-31
Romli, A., Prickett, P., Setchi, R., & Soe, S. 2015. "Integrated eco-design decision-making for sustainable product development." *International Journal of Production Research*, 53(2): 549-571.
Rooney, C., 1993. "Economics of pollution prevention: how waste reduction pays." *Pollution Prevention Review* 3(3): 261-76.
Rothenberg, S., F. Pil and J. Maxwell, 2001. "Lean, Green, and the Quest for Superior Environmental Performance." *Production and Operations Management*, 10(3): 228-243.
Rungtusanatham, M., Miller, J. W., Boyer, K. K., 2014. "Theorizing, testing, and concluding for mediation in SCM research: Tutorial and procedural recommendations." *Journal of Operations Management* 32(3): 99-113.
Rusinko, C. A. 2005. "Using quality management as a bridge to environmental sustainability in organizations." *SAM Advanced Management Journal*, 70(4): 54.
Sarkis, J., 1998. "Evaluating environmentally conscious business practices." *European Journal of Operational Research* 107(1): 159–174.
Samson, D., & Terziovski, M. 1999. "The relationship between total quality management practices and operational performance." *Journal of Operations Management* 17(4):393-409.
Sarkis, J., 2001. "Manufacturing's role in corporate environmental sustainability-Concerns for the new millennium." *International Journal of Operations & Production Management* 21(5/6): 666-686.
Schön, K., Bergquist, B., & Klefsjö, B. 2010. "The consequences of Six Sigma on job satisfaction: A study at three companies in Sweden." *International Journal of Lean Six Sigma*, 1(2): 99-118.
Sekhar, H., & Mahanti, R. 2006. "Confluence of Six Sigma, simulation and environmental quality: An application in foundry industries." *Management of Environmental Quality: An International Journal*, 17(2): 170-183.
Smith, A.D., O.F. Offodile, 2008. "Strategic importance of team integration issues in product

development processes to improve manufacturability." *Team Performance Management: An International Journal*, 14(5/6): 269 - 292
Smith, P.G. and Reinertsen, D.G., 1998. *Developing Products in Half the Time: New Rules*, New Tools, John Wiley & Sons, New York.
Sousa, R., & Voss, C. A., 2002. "Quality management re-visited: a reflective review and agenda for future research." *Journal of Operations Management* 20(1): 91-109.
Sroufe, R., 2003. "Effects of environmental management systems on environmental management practices and operations." *Production and Operations Management* 12(3): 416-431.
Sveiby, K. E., & Simons, R. 2002. "Collaborative climate and effectiveness of knowledge work–an empirical study." *Journal of Knowledge Management*, 6(5):420-433.
Swink, M., Sandvig, J., and Mabert, V.A. 1996. "Customizing concurrent engineering processes: Five case studies." *Journal of Product Innovation Management* 13(3): 229-244.
Swink, M. 1999. "Threats to new product manufacturability and the effects of development team integration processes." *Journal of Operations Management*, 17(6): 691-709.
Swink, M. L., & Calantone, R., 2004. "Design-manufacturing integration as a mediator of antecedents to new product design quality." *IEEE Transactions on Engineering Management*, 51(4): 472-482.
Tan, C. L., & Vonderembse, M. A. 2006. "Mediating effects of computer-aided design usage: From concurrent engineering to product development performance." *Journal of Operations Management*, 24(5): 494-510.
Theyel, G. 2000. "Management Practices for Environmental Innovation and Performance." *International Journal of Operations & Production Management* 20 (2): 249–266.
Tsai, W.H. and Chou, W.H. 2009, "Selecting management systems for sustainable development in SMEs: a novel hybrid model based on DEMATEL, ANP, and ZOGP", *Expert Systems with Applications*, 36(2):. 1444-1458.
Vanpoucke, E., Vereecke, A., & Wetzels, M. 2014. "Developing supplier integration capabilities for sustainable competitive advantage: A dynamic capabilities approach." *Journal of Operations Management*, 32(7):446-461.
Wiengarten, F., Fynes, B., Pagell, M., & de Búrca, S., 2011. "Exploring the impact of national culture on investments in manufacturing practices and performance: an empirical multi-country study." *International Journal of Operations & Production Management* 31(5): 554-578.
Wiengarten, F., & Pagell, M., 2012. "The importance of quality management for the success of environmental management initiatives." *International Journal of Production Economics* 140(1): 407-415.
Wilson, D. D., & Collier, D. A. 2000. "An empirical investigation of the Malcolm Baldrige National Quality Award causal model." *Decision Sciences* 31(2): 361-383.
Yu, W., & Ramanathan, R. 2015. "An empirical examination of stakeholder pressures, green operations practices and environmental performance." *International Journal of Production Research*, 53(21): 6390-6407.
Zeng, J., Phan, C.A., Matsui, Y., 2015. "The impact of hard and soft quality management on quality and innovation performance: An empirical study" *International Journal of Production Economics*, 162(4): 216-226.
Zhu, Q., Sarkis, J., 2004. "Relationships between operational programs and performance among early adopters of green supply chain management programs in Chinese manufacturing enterprises." *Journal of Operations Management* 22 (3): 265–289.

Zhu, Q., Sarkis, J., Geng, Y., 2005. "Green supply chain management in China: pressures, programs and performance." *International Journal of Operations and Production Management* 25 (5): 449–468.

Zhu, Q., Sarkis, J., & Lai, K. H. 2012. "Examining the effects of green supply chain management practices and their mediations on performance improvements." *International Journal of Production Research* 50(5):1377-1394.

Zu, X., Robbins, T.L. and Fredendall, L.D., 2010. "Mapping the critical links between organizational culture and TQM/Six Sigma practices." *International Journal of Production Economics* 123(1): 86-106.