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Total quality environmental management: adoption status in the Chinese manufacturing sector

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Abstract

Purpose – To address the critical sustainability challenges currently faced by China, manufacturers in this country have committed to improve their environmental performance. To support this commitment, evidence suggests that Chinese manufacturers have mainly turned to the implementation of environmental management approaches such as ISO 14001, cleaner production, green supply chain management, circular economy and green lean. However, the adoption of other approaches such as total quality environmental management (TQEM) by Chinese manufacturers is less clear. The purpose of this paper is to fill this gap by providing light into fundamental issues regarding the implementation of TQEM in the manufacturing sector of China.

Design/methodology/approach – A survey-based exploratory study was conducted based on 119 Chinese manufacturing companies, and the data obtained were analysed using a combination of descriptive and inferential statistics.

Findings – The results revealed that in general, there is less awareness of TQEM in the Chinese manufacturing sector than other environmental and quality/operations improvement approaches such as green supply chain management, reverse logistics, ISO 9000, Six Sigma and lean Six Sigma. Thus, its degree of implementation is also lower than these approaches as well as ISO 14001. The results also indicate that although a company's size is not associated with the implementation of TQEM, it is mainly large organisations and those that have adopted TQM those which will be mainly aware and have implemented TQEM. The study also reveals the drivers, results and challenges of TQEM implementation.

Originality/value – The paper extends the currently limited knowledge on TQEM, and its results are beneficial for managers who aim at effectively adopting TQEM to simultaneously improve the environmental, operational and financial performance of their organisations. The paper can also motivate organisations not currently embarked on the “green wagon” to contemplate the benefits that implementing TQEM, or any other environmental management approach, may bring to their operations and business.

Keywords China, Manufacturing, EMS, Environmental management systems, Total quality environmental management, TQEM

Paper type Research paper

1. Introduction

China's manufacturing industry has not only become a main driving force of social development and economic growth for this nation (Zeng *et al.*, 2010), accounting for 32.5 per cent of the GDP of this country (Wei and Balasubramanyam, 2015), but it has also transformed the world's economy. For example, nowadays China manufactures about 70 per cent of the world's mobile phones, 80 per cent of its air conditioners and 60 per cent of its shoes (*The Economist*, 2015), greatly contributing to the output of “Factory Asia”, which now produces almost half of the world's goods.



Despite its enormous economic contribution, the Chinese manufacturing industry is often criticised for being a major cause of environmental degradation, climate change and natural resource scarcity (Zeng *et al.*, 2008). China's current environmental challenges have been demonstrated by the fact that 16 of the 20 world's most polluted cities are located in China, rendering 8-12 per cent of its annual GDP consumed to manage those issues (Economy, 2011). According to Wang *et al.* (2004), 40 per cent of water pollution and 80 per cent of air pollution in this country are generated by its manufacturing industry. In addition, Liu *et al.* (2016) found that products manufactured in China are associated with significantly higher CO₂ emissions than the same goods produced elsewhere. These characteristics accentuate the environmental challenges currently faced by the Chinese manufacturing industry and the sustainable balance that it must achieve between serving as an engine of economic and social development while still preserving the environment.

In recent years, many Chinese manufacturing companies have committed to improve the environmental performance of their operations and actively respond to environmental regulations (Tseng *et al.*, 2009). To support this commitment, the scholarly literature shows that Chinese manufacturers have adopted environmental management approaches and practices related to ISO 14001 (e.g. Zhang *et al.*, 2014; Zhu *et al.*, 2012), cleaner production (e.g. Chung *et al.*, 2016; Geng *et al.*, 2010), green supply chain management (e.g. Zhu *et al.*, 2008; Zhu *et al.*, 2005), circular economy (e.g. Zhu *et al.*, 2010; Yuan *et al.*, 2006), reverse logistics (e.g. Abdulrahman *et al.*, 2014) and green lean (e.g. Zhan *et al.*, 2016). However, the adoption of other also well-known environmental management approaches such as total quality environmental management (TQEM) is less clear. TQEM is a method which integrates total quality management (TQM) principles and environmental strategies to eliminate waste and pollution to improve environmental performance (Curkovic *et al.*, 2008). Empirical evidence suggests TQEM as an effective approach to improve the environmental performance of organisations by contributing to the elimination of waste and pollution as well as to achieve compliance with environmental regulations and quality strategies (Curkovic *et al.*, 2008; Hanna *et al.*, 2000). Additionally, the adoption of TQEM practices has also been associated with the achievement of cost savings by conserving and recycling energy as well as lowering future costs by mitigating environmental problems in advance (Curkovic *et al.*, 2008).

Nevertheless, despite the relatively high degree of adoption of TQEM by Western manufacturing organisations (Harrington *et al.*, 2008; Florida, 1996), there is very limited evidence of the level of implementation of this specific environmental management approach by Chinese manufacturers. Therefore, the main contribution of this paper lies in filling this research gap by providing evidence of the degree of adoption of TQEM in the Chinese manufacturing sector. In addition, TQEM seems to have received less attention in the academic literature, especially when compared to the relatively high volume of publications on other environmental management approaches such as green supply chain management, reverse logistics, ISO 14001 and, lately, green lean and circular economy. For this reason, this paper also contributes by expanding the limited body of knowledge on TQEM found in the academic literature when compared to that of other environmental management approaches. To achieve this, the paper addresses the following fundamental research questions:

- RQ1. What is the degree of awareness of TQEM among Chinese manufacturing organisations?
- RQ2. What is the degree of adoption of TQEM among Chinese manufacturing organisations?
- RQ3. What has stopped Chinese manufacturing organisations from more widely adopting TQEM?

The rest of the paper is divided as follows: Section 2 discusses previous works conducted regarding the adoption of TQEM and highlights the limited volume of scholarly research carried out in this area; Section 3 presents the research methodology followed to address the formulated research questions; the results of the study are outlined and discussed in Section 4, whereas Section 5 presents the concluding remarks, limitations of the research and future research.

2. Literature review

Manufacturing organisations have been traditionally driven by prevailing objectives that include efficiency, profitability, customer satisfaction, responsiveness and quality (Garza-Reyes, 2015). In particular, quality has been widely considered a determinant factor for the success and competitiveness of manufacturing companies (O'Neill *et al.*, 2016; Garza-Reyes, Rocha-Lona, and Kumar, 2015). However, despite the importance of quality, and other operational objectives, environmental regulations and customer demands for greener products and services have forced manufacturing organisations to rethink these objectives by also considering the environmental impact of their operations. Thus, sustainable and green objectives are now well embedded as part of the corporate agenda of many manufacturing organisations, and these are hence required to be balanced with the traditional objectives. In this context, the academic literature suggests the existence of some synergy between some of the traditional organisational objectives, e.g. quality, and environmental sustainability. For instance, various authors such as Wiengarten and Pagell (2016), Narasimhan and Schoenherr (2012), Curkovic and Sroufe (2007) and Curkovic *et al.* (2000) have highlighted the importance of quality management systems and practices as facilitators of environmental management systems and as enablers to obtain higher returns from environmental management practices. The synergies between quality and environmental objectives, and the natural evolution of the quality and environmental management systems fields have contributed for these two fields to “intersect” and propose approaches which have evolved from previous evolutionary stages and both fields (see Figure 1). In this line, TQEM is an approach which has evolved from TQM and to support sustainability/environmental initiatives. Thus, TQEM intends to synergise the implementation and effects of quality management and environmental management systems to overcome common challenges when implemented separately, for example, conflicts for resource allocation and priority attention (Griffith, 2002).

TQEM was developed in 1992/1993 by the Global Environmental Management Initiative (GEMI), a group of then 21 companies formed in 1990, including IBM, AT&T and Kodak, to foster environmental excellence in businesses (GEMI, 2017; Love *et al.*, 2000). In this context, TQEM was born from the GEMI's intention of applying TQM principles and approaches to corporate environmental strategies. TQEM is therefore considered to have evolved from the

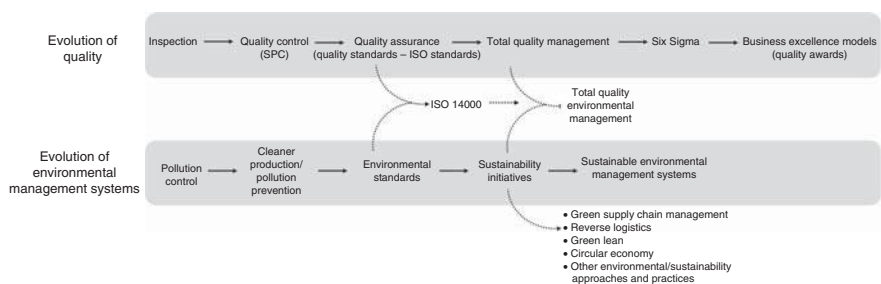


Figure 1.
Evolution of the
quality and
environmental
management
system fields

Sources: Adapted from Beecroft (2004) and Khalili and Duecker (2013)

traditional quality-focused TQM (see Figure 1), as it lacked concentration on environmental issues (Griffith and Watson, 2003), which were gaining increasing attention since the mid-1980s. Thus, TQEM focusses on integrating quality and environmental management principles to reduce and eliminate all waste streams within the design of products, their manufacture, utilisation and disposal (Sarkis *et al.*, 2010). Although TQEM does not have a clear set of dimensions or standard definition (Zhu *et al.*, 2012), Khadour (2010) comment that it is centred on four fundamental principles, namely, identification of external and internal customers; continuous improvement; doing the job right first time; and taking a system approach.

A handful of exploratory studies have been conducted to investigate the acceptance of TQEM among industrialists. For example, a survey by Florida (1996) investigating the adoption of TQEM among S&P manufacturing firms in 1995 found that 43 per cent of these companies had adopted TQEM. Similarly, Harrington *et al.* (2008) conducted a study of 462 observations among 254 firms belonging to the S&P500. The results of the study indicated that almost 67 per cent (i.e. two-thirds) of the observations had adopted TQEM. Khadour (2010) explored the implementation of TQEM in the UK construction industry. The result of the study suggested that only 22 per cent of 50 firms surveyed were not aware of TQEM, whereas the main driver for its implementation was found to be compliance to governmental environmental regulations. Khadour (2010) also found that the main benefits that construction companies obtained from the implementation of TQEM were cost savings and measurement of performance, while the main barrier to its implementation was the lack of a clear implementation framework. Finally, Zhu *et al.* (2012) committed to exploring the influence of international pressures and domestic pressures on Chinese firms to be green. To do this, Zhu *et al.* (2012) considered ISO 14001, TQEM and eco-auditing as examples of environmental management approaches. The result of the study indicated that international pressures have a positive impact on the adoption of TQEM and that its degree of impact is higher than that of domestic pressures. The results also revealed that 45.6 per cent of the organisations surveyed had adopted TQEM, although a later study showed that only 22.9 per cent of these companies had adopted TQEM successfully (Zhu *et al.*, 2013). The studies from Zhu *et al.* (2012, 2013), however, have been limited to only explore the adoption of TQEM in China from a point of view of the adopting factors which influence such implementation.

Despite the above evidence, Curkovic *et al.* (2008) suggest that TQEM has not received the same level of acceptance in industry and academia as other approaches such as just-in-time (JIT), TQM and time-based competition. This is also evidenced through the relatively low volume of research publications on TQEM when compared to that of other popular environmental management approaches. This limited volume of research calls for an opportunity to complement the studies of Florida (1996), Harrington *et al.* (2008), Khadour (2010), Zhu *et al.* (2012) and Zhu *et al.* (2013), and expand the very limited body of knowledge currently generated in the field of TQEM. This was the main motivational driver to conduct the research presented in this paper.

3. Methodology

3.1 Survey questionnaire

In order to address the research questions previously formulated regarding the adoption status of TQEM in the Chinese manufacturing sector, a survey questionnaire was considered as the most suitable method for the collection of primary data. In this case, an electronic version of the questionnaire was developed using Qualtrics. This facilitated the respondents' access to the questionnaire via mobile devices and web browsers as well as the easy transfer of the collected data to an Excel spreadsheet for an easy export to IBM SPSS Statistics software version 2015 for statistical analysis (Binti Aminuddin *et al.*, 2016). The questionnaire was adapted from those of Garza-Reyes *et al.* (2012) and Antony and Desai (2009). In this line, due to the similarities of the present research with those conducted

by Garza-Reyes *et al.* (2012) and Antony and Desai (2009), which, respectively, aimed at investigating the implementation status of lean manufacturing and Six Sigma in India, the questions formulated for their instruments were used as a basis to convey the questions of the instrument employed by this research. Thus, the questionnaire instrument designed for this research consisted of 13 questions divided into three sections that intended to collect information regarding the demographics of the participants and their companies, their awareness of TQEM and implementation of TQEM in their organisations. Figure 2 presents an overview of the research's structure and questionnaire's logic and questions.

3.2 Questionnaire validity and reliability

Lancaster (2008) indicates that in order to obtain validity and reliability in a survey instrument, it is important to inspect the variables or data from the literature review that constitute the survey in the form of questions before the instrument is distributed. To achieve a valid and reliable instrument, reliability threats such as subject or participant error, subject or participant bias, observer error and observer bias were confronted by conducting a small pilot study as suggested by Robson and McCartan (2016).

For this purpose, the questionnaire was distributed to ten credible participants that included five manufacturing managers from China and five academic experts in the field.

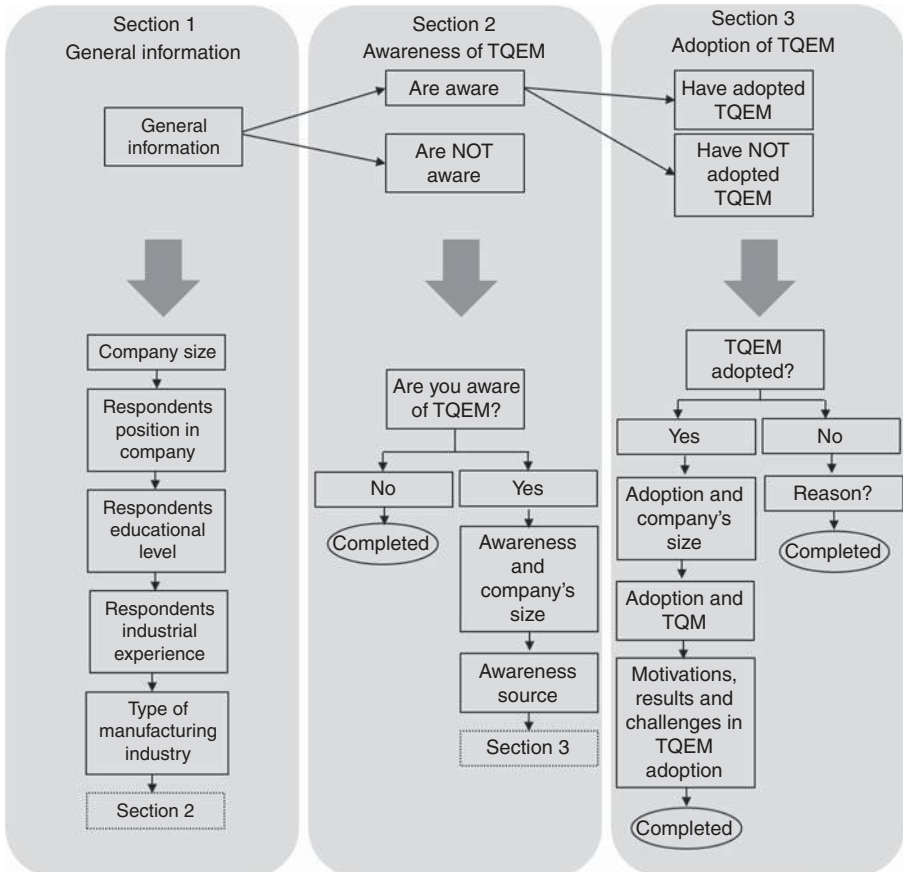


Figure 2. Research's structure and questionnaire's logic and questions

This resulted in the questionnaire instrument being amended and improved to eliminate participants' errors and bias. In particular, the academic experts' feedback was considered to ensure that the questions in the instrument addressed the fundamental research questions and to improve the clarity and comprehensiveness of some of the questions included. Thus, ambiguities when understanding and answering questions and irrelevant questions were eliminated based on the academic experts' feedback. The manufacturing managers' advice was followed by adding extra profile questions such as industrial experience of the participants and size of the company in order to test some correlations among the occurred results.

Since the questionnaire instrument used fixed-alternative questions, these did not require interpretation. Therefore, the last two threats (i.e. observer error and observer bias) were not relevant in this case (Binti Aminuddin *et al.*, 2016).

3.3 Questionnaire distribution

The questionnaire was distributed via e-mail among 150 Chinese manufacturing companies located in various provinces of China. The participant organisations were randomly identified and selected from directories and databases that included Global Sources, LinkedIn, Amadeus and IQS Directory, whereas some others were personal contacts of the authors. The target respondents included top managers, middle-level managers, engineers, front-line managers, etc., from various departments such as production, maintenance, environmental, maintenance, design, purchasing, etc. This contributed to providing information about TQEM from different organisational perspectives. Additionally, these types of respondents, and their backgrounds, were considered to have a deeper and more accurate understanding of the company's operations and performance before and after the implementation of TQEM.

Out of the 150 questionnaires distributed, a final total of 119 valid responses were obtained, resulting in a response rate of 79.3 per cent. Based on comparative sample sizes used in similar survey-based studies related to environmental management approaches (e.g. Teixeira *et al.*, 2016; Khor *et al.*, 2016; Khadour, 2010; Vachon, 2007), the sample size of 119 responses used in this study was considered acceptable to conduct an exploratory analysis and draw initial conclusions regarding the implementation status of TQEM in the Chinese manufacturing sector.

4. Results and discussion

4.1 Organisations and participants' profiles

Figure 3 presents an overview of the profile of the organisations and subjects from the Chinese manufacturing industry that participated in the survey. In terms of the organisation's size, see Figure 3(a); the standard Chinese classification was used to categorise the respondents' organisations, i.e. large > 1,000 employees, medium between 300 and 1,000 employees, small between 20 and 299 employees and micro < 20 employees (China Briefing, 2011). Most of the responses came from employees in tactical, i.e. middle level, see Figure 3(b). Middle-level employees represent one of the most valid sources of information, and they normally participate in and lead the adoption and management of new working methods and practices in their organisations (Carter *et al.*, 1998). This characteristic, and the fact that 80 per cent of the respondents had university education (see Figure 3c), and significant years of working experience (see Figure 3d), can be considered factors which support the credibility of this study (Kirkham *et al.*, 2014). Finally, the study was not limited to a specific manufacturing industry but it considered the entire manufacturing spectrum (see Figure 3e). In this case, "others" represented industries such as energy production, steel processing, metallurgical, clothing and fast moving products.

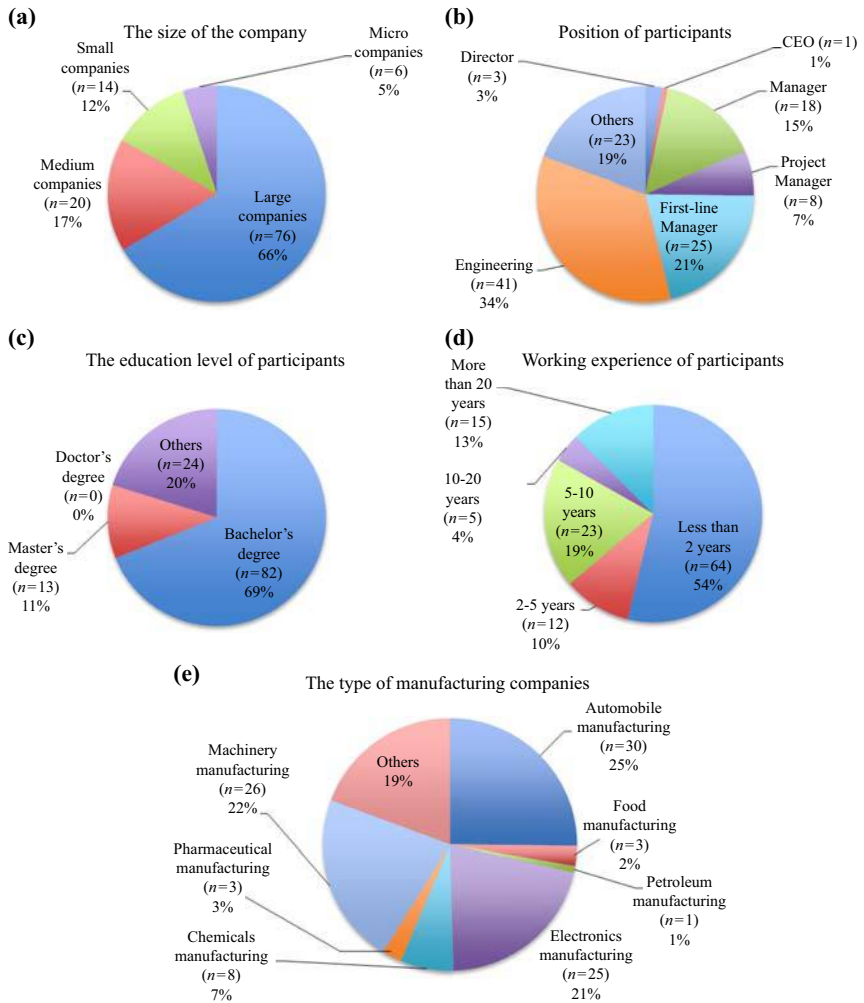


Figure 3.

Profile overview of respondents and their organisations in relation to (a) size of the company, (b) position, (c) educational level, (d) working experience of the participants, and (e) manufacturing industry

4.2 TQEM awareness

The study indicated that 61 per cent ($n = 73$) of the participant organisations were aware of TQEM while 39 per cent ($n = 46$) were not. This suggests that TQEM may be less known in the Chinese manufacturing sector when compared to the UK's construction sector (Khadour, 2010). Due to the limited research of TQEM in the scholarly literature, it is difficult to establish a comparative base between the awareness of TQEM in the Chinese manufacturing sector and other industrial sectors and countries. However, when compared to the awareness of other environmental management approaches, TQEM seems to have gained less acceptance over the years. For example, Zhu *et al.* (2005) suggest that the level of awareness of green supply chain management in China is high. Lau and Wang (2009) also indicate that the awareness of reverse logistics in the Chinese electronic industry has increased. Similarly, Xue *et al.* (2010) found that most Chinese officials working at municipal and county levels have high awareness and understanding of the circular economy concept. The level of awareness of TQEM among Chinese manufacturers found in this study may not be considered low. However, taking into

consideration that TQEM is a relatively mature approach that was first discussed in the academic literature by the beginning of the 1990s and that green supply chain management, reverse logistics and circular economy are more contemporary environmental management approaches, it may be concluded that TQEM has not gained the same level of acceptance in China as these approaches. Considering that the TQEM's predecessor (i.e. TQM) has been widely implemented in China and it has provided the expected results (Yusuf *et al.*, 2007), a higher awareness of TQEM in China would have probably been expected.

When comparing the awareness of TQEM to other quality and operations improvement approaches, its growth also seems to be more limited. For instance, Vouzas and Psychogios (2007) commented that the degree of awareness of ISO 9000 among Northern Irish executives was high, with almost nine out of ten executives (88 per cent) having heard about it. Antony and Desai (2009) found that out of 290 Indian organisations from various industrial sectors 264 (92 per cent) of them were aware of Six Sigma. Lee *et al.* (2013) found that out of 50 UK organisations from various industries, 33 (66 per cent) of them were aware of lean Six Sigma. It is difficult to explain the reasons as to why TQEM has not gained a wider level of acceptance in both industrial and academic circles not only in China but also around the world. However, the abundance of TQM failures published in the academic literature (Soltani *et al.*, 2005) may have contributed to hinder the acceptance and popularity of TQEM.

4.2.1 TQEM awareness and company's size. From the 73 organisations that were aware of TQEM, 50 were large ($50/79 = 63$ per cent), 14 medium ($14/20 = 70$ per cent), 6 small ($6/14 = 43$ per cent) and 3 micro ($3/6 = 50$ per cent). It is common to find a wider implementation trend of best practices such as TQM, JIT, ISO 9000, ISO 14000, kaizen and Six Sigma in larger manufacturing organisations (McLaughlin, 2013). Thus, finding out that 87 per cent of the Chinese manufacturing companies that were aware of TQEM had more than 300 employees can be considered an expected phenomenon.

4.2.2. Source of awareness. In terms of the source of awareness, 62 per cent of the respondents came to know about TQEM from personal education, 32 per cent from top management, 26 per cent from professional publications and 16 per cent from consultancy agencies. Other sources of awareness included customers, business partners and company quality/environmental programmes. In this case, respondents were given the opportunity of selecting more than one source. Determining that personal education is the main source of awareness of TQEM in the Chinese manufacturing sector is unsurprising, considering the fact that almost 500,000 Chinese students carry out their studies abroad (ICEF Monitor, 2015), especially in Western countries where approaches such as lean manufacturing, Six Sigma, supply chain management, TQM, among others, are well embedded within a large range of engineering and business management programmes. Top managers and professional publications serving as important sources of awareness on TQEM is in line with the studies of Garza-Reyes *et al.* (2012) and Antony and Desai (2009), which also found these as relevant sources of awareness on lean manufacturing and Six Sigma in India.

4.3 TQEM adoption

The results of the study showed that out of the 119 organisations that participated in the research, 43 per cent ($n = 51$) had adopted TQEM while the rest 57 per cent ($n = 68$) had not. This is in line with the study of Zhu *et al.* (2012), which found that out of 377 companies investigated 45.6 per cent of them had adopted TQEM. The relatively low implementation of TQEM in the Chinese manufacturing industry corroborates the previous finding regarding its limited awareness in this country. This despite the fact that TQEM may be considered a more mature environmental management approach and China has faced critical environmental burdens since few decades ago (Zhu *et al.*, 2013). Zhu *et al.* (2012) suggest that TQEM fits well within the Chinese context in terms of supporting various general regulatory policies, such as those established by the circular economy. However, this has not reflected in its wider adoption.

In relation to other environmental management approaches, although TQEM is considered a variation of ISO 14001, and vice-versa (Curkovic *et al.*, 2005), the adoption of ISO 14001 seems to have found much more proliferation in China than TQEM. For example, Qi *et al.* (2013) comment that over 35,000 organisations in China had already implemented ISO 14001 by the end of 2009. The difference in their degree of implementation may come from the fact that ISO 14001 is an increasingly common requirement for accessing markets (Stalley, 2009) while TQEM is not. Similarly, green supply chain management, circular economy and reverse logistics all seem not only to enjoy a wider recognition and awareness than TQEM (see Section 4.2) but also a more prominent role as the emphasis paid on these environmental management approaches in the scholarly literature, within the context of China, suggests their wider implementation (e.g. Chung *et al.*, 2016; Geng *et al.*, 2010; Zhu *et al.*, 2008, 2005, 2010; Abdulrahman *et al.*, 2014). Since no other reported application, or study, of green lean exists in the academic literature within the context of China, besides that presented by Zhan *et al.* (2016), it may be assumed that TQEM has been more widely deployed than this more contemporary approach.

When compared to other quality and operations improvement approaches, Taj (2008) found that lean manufacturing is not very common in Chinese factories while Lee *et al.* (2011) commented that only very few companies in this country are involved in the implementation of Six Sigma. In the case of TQM, Yusuf *et al.* (2007) found that its implementation in China has been extensive. Although it would be too adventurous to conclude that TQEM has been more widely implemented than lean manufacturing and Six Sigma in the Chinese manufacturing sector, this evidence may suggest that this could be the case. However, a specifically designed comparative study may need to be conducted to gain a more reliable and accurate insight into this. In any way, based on the huge popularity and amount of literature and empirical studies found in the body of knowledge of lean and Six Sigma, it will not be difficult to assume and accept that quality and operations improvement approaches like these two have been more widely implemented worldwide than TQEM. Again, further research will need to be conducted to scientifically confirm this assumption.

4.3.1 Company's size and implementation of TQEM. It is commonly hypothesised in the scholarly literature that large organisations have more positive attitudes towards the implementation of quality and operation improvement approaches than small companies (McLaughlin, 2013; Taj, 2008). To explore this phenomenon within the context of TQEM, a correlation analysis was performed, the results of which are presented in Table I.

Since the correlation analysis showed a coefficient < 0.50 , i.e. 0.14308, then the results indicated that the degree of adoption of TQEM is not associated with a company's size. The lack of similar analyses on TQEM makes its comparison with previous results impossible. However, if compared to other quality and operations improvement approaches, e.g. adoption of lean or quality practices, these results support the findings of Garza-Reyes, Ates, and Kumar (2015) in relation to the adoption of lean in the Turkish automotive suppliers industry and those of Mallur *et al.* (2012) and Al-Najem *et al.* (2013) in relation to the adoption of quality practices. In these cases, these studies found that the size of a company does not affect the

Table I.
Correlation analysis –
size of the company
and degree of
TQEM adoption

	TQEM adoption	
	Yes = 1	No = 0
The size of companies	Yes = 1	No = 0
Large companies = 1	38 (1,1)	41 (1,0)
Medium and SMEs = 0	13(0,1)	27 (0,0)
<i>Size of the company and degree of TQEM adoption</i>		
H1. the degree of TQEM adoption is positively associated with the size of the company		
Correlation coefficients	0.14308	< 0.3

implementation of these quality and operation improvement approaches. The results, however, contradict the studies of Sezen *et al.* (2012) and Bakas *et al.* (2011), which found that a company's size has an effect on the implementation of lean, with small organisations struggling more with such activity. These contradictory results call for further research to determine whether the size of a company has any inference of the implementation of TQEM.

4.3.2 TQM and implementation of TQEM. Although TQEM is committed to using TQM approaches (Harrington *et al.*, 2008), and King *et al.* (2005) suggest that companies that have implemented TQM are more likely to adopt TQEM, no empirical evidence has been provided to explore such relationship. Therefore, a correlation analyses was performed (see Table II).

The correlation results indicated a correlation coefficient > 0.50 , i.e. 55,368, which suggested that the adoption of TQEM was positively associated with the implementation of TQM, a regression analysis to further explore this relationship was conducted as suggested by Hayter (2012) (see Table III).

The regression analysis indicated that 53 per cent of the companies that have adopted TQM will also adopt TQEM. Since the p -value is < 0.001 , the evidence against the null hypothesis (H_0) is strong (Hayter, 2012), thus it was rejected. Therefore, it can be concluded that companies which have adopted TQM are more likely to also adopt TQEM. This suggests that although TQM has been more widely implemented than TQEM, e.g. out of the 119 companies that participated in the study, 66 per cent ($n = 78$) had implemented TQM and only 35 per cent ($n = 41$) had adopted TQEM, the implementation of the second may also increase in the future due to the wide acceptance of TQM in China (Yusuf *et al.*, 2007).

4.3.3 Drivers, results and challenges of TQEM implementation. Figure 4 presents the main drivers which motivated the Chine manufacturing companies that participated in the study to implement TQEM, the results they obtained from such implementation and the main challenges they faced during the TQEM's deployment. Participants were given the opportunity of selecting as many answers, i.e. drivers, results and challenges, they considered played a role during and after the implementation of TQEM. This "multi-selection strategy" allowed the study to obtain a more accurate picture of the phenomenon under study (Azzara, 2010).

Choosing to implement TQEM to improve brand image (see Figure 4a), is a reasonable business driver for manufacturing companies in China as Zhu *et al.* (2010) showed that 67 per cent of Chinese and 42 per cent of the US consumers prefer to buy products/services from companies that enjoy an environmental reputation. The results obtained from the

TQM adoption	TQEM adoption (Y)	
	Yes = 1	No = 0
Yes = 1	49 (1,1)	29 (1,0)
No = 0	2 (0,1)	39 (0,0)

Table II.
Correlation analysis –
relationship between
TQM and
TQEM adoption

Relationship between TQM and TQEM adoption

H2. The degree of TQEM adoption is positively associated with the degree of TQM adoption
Correlation coefficients 0.55368 > 0.5

Regression of TQM adoption and TQEM adoption

H0. Companies who have adopted TQM are not more likely to adopt TQEM

H1. Companies who have adopted TQM are more likely to adopt TQEM

R^2	Coefficient	p -level	Evidence against null hypothesis
0.30959	0.53431	5.02718E-11	Very strong

Table III.
Regression analysis –
relationship between
TQM and
TQEM adoption

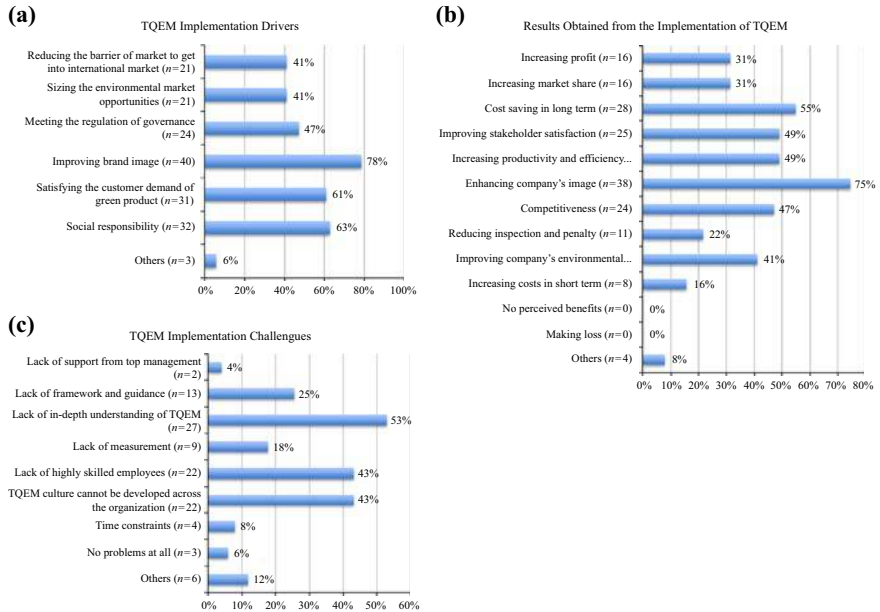


Figure 4.
(a) Drivers, (b) results and (c) challenges of TQEM implementation

implementation of TQEM indicate that Chinese manufacturers are actually benefiting from a better company's image (see Figure 4b). In the case of the second most important driver (i.e. social responsibility) (see Figure 4a), since environmental problems have seriously affected people's daily life in China, it is not surprising to see that manufacturing companies want to contribute to address this issue through the implementation of TQEM. In relation to the cost savings achieved by the implementation of TQEM (see Figure 4b), this is in line with the views of Khadour (2010), Curkovic *et al.* (2008) and Harrington *et al.* (2008), who comment that one of the objectives of TQEM is to improve internal operation efficiency and reduce costs while simultaneously achieving environmental excellence.

On the other hand, lack of in-depth understanding was found to be the main barrier faced by the companies when implementing TQEM (see Figure 4c). This is a common barrier in the implementation of quality and operations improvement approaches as shown by Garza-Reyes *et al.* (2012) and Antony and Desai (2009). A reason for this barrier may be the fact that like lean (Pingyu and Yu, 2010), TQEM has not yet gone beyond the environment of some research institutes, universities and international corporations. This is also in line with the second most important barrier related to the lack of highly skilled employees, which is normally a critical success factor to implement any improvement approach (Antony and Desai, 2009). Like TQM, TQEM is based on the participation of everyone within an organisation (Zhu *et al.*, 2013; Curkovic *et al.*, 2005). The results indicate (see Figure 4c), that Chinese manufacturing companies are struggling to develop a TQEM culture that goes across the entire organisation. This is contradictory to the now well-recognised need among Chinese companies for them to address the environmental challenges that the country is facing (Zhu *et al.*, 2008; Zhu *et al.*, 2005).

4.4 Impeding factors in TQEM implementation

Respondents from the 68 organisations that had not implemented TQEM were asked to identify the main impeding factor that they considered had stopped their organisations from adopting TQEM. The results are presented in Figure 5.

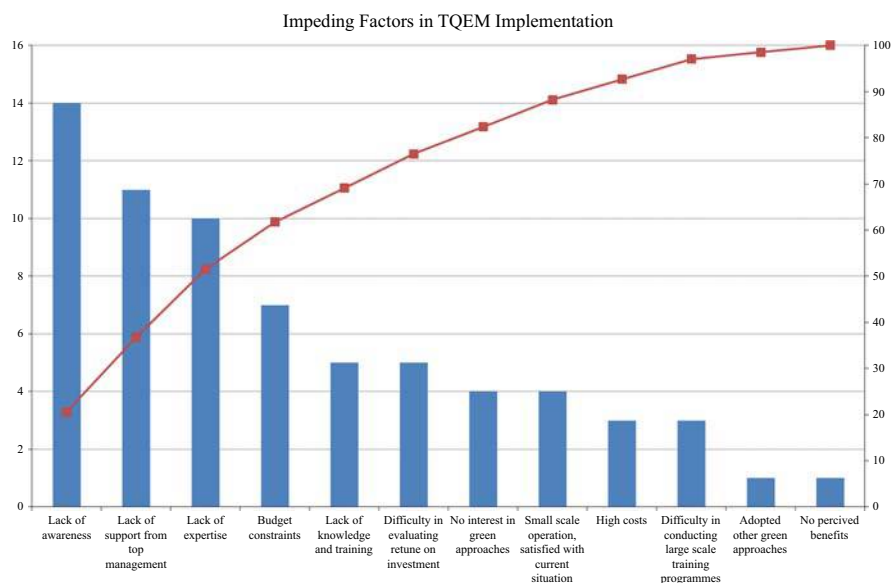


Figure 5.
Main impeding factors to TQEM implementation

The results of the study corroborate, once more, the relatively low popularity and acceptance of TQEM in the Chinese manufacturing sector as the respondents suggested “lack of awareness” as the main impeding factors for not implementing TQEM. Possible reasons for this have been discussed in previous sections. In response to the critical environmental issues faced by the country, the Chinese Government has stepped in by enacting acts on environmental protection and laws, and support state-owned medium-sized and large enterprises with technological overhaul for reducing sources of hazards and pollution (Zeng *et al.*, 2010). Similarly, it has also strongly promoted the implementation of ISO 14001 (Zeng *et al.*, 2005). A similar promotion of TQEM in the Chinese manufacturing sector may be convenient to support all the environmental strategies and actions already rolled out by the Chinese Government. As suggested by Zhu *et al.* (2012) and Curkovic *et al.* (2005), TQEM can support policies and strategies, such as circular economy and ISO 14001, geared towards jointly improving economic and environmental performance (Yuan *et al.*, 2006).

Despite the recognised consciousness of the Chinese Government (Zhu *et al.*, 2012; Zeng *et al.*, 2010), manufacturing industry (Tseng *et al.*, 2009) and society in general regarding the critical environmental challenges faced by China, this seems not to have filtered down appropriately to a company’s level as “lack of support from top management” was found to be the second highest barrier (see Figure 5). Top management support has been widely recognised in the academic literature as a cornerstone factor for the successful implementation of any quality and operations improvement approach (Talib *et al.*, 2011; Zu *et al.*, 2008). Thus, if Chinese manufacturers are to successfully implement TQEM, or any other environmental management approach, support, commitment and leadership from companies’ executives must be provided. To gain their commitment, the Chinese Government can formulate appropriate strategies based on economic incentives or create laws to force them to actively participate in the implementation of green programmes such as TQEM. Additionally, the government can provide “awareness training” to executives, which would help in developing a sense of urgency and ownership regarding their role, and that of their companies, in improving the environmental conditions of China.

“Lack of expertise” and “lack of knowledge and training” were also found to be important impeding barriers to the implementation of TQEM. Expertise, knowledge and training are also considered critical success factors for the successful implementation of any quality and operations improvement approach (Talib *et al.*, 2011). Developing learning and training within Chinese manufacturing companies will contribute in creating a well-trained workforce which will eventually play a critical role in successfully implementing any environmental management approach, including TQEM.

Al Khidir and Zailani (2009) and Min and Galle (2001) have identified high cost as one of the major challenges to the implementation of green supply chain practices. The results of the study show that this is also the case for the implementation of TQEM. Like any other green and quality and operation improvement approaches, the implementation of TQEM will require commitment and investment not only in terms of effort and time but also in terms of resources, including that of capital. This, and the fact that most environmental management approaches do not deliver immediate financial benefits (Nidumolu *et al.*, 2009) make this a critical barrier to the implementation of TQEM. However, once effectively implemented, TQEM will not only help organisations in improving their environmental performance but also their financial performance through the reduction of operational costs and savings (Khadour, 2010; Curkovic *et al.*, 2008; Harrington *et al.*, 2008). This should serve as an incentive for the Chinese Government to help organisations, especially small and medium size enterprises, to mitigate these initial costs through some form of government support.

Finally, although the respondents were given the opportunity of mentioning any other barrier, besides those provided to them as part of the fixed-alternative questions, none of them cited the lack of a clear implementation framework, such as in the case of the UK's construction sector (Khadour, 2010), as an impeding factor for the implementation of TQEM.

5. Concluding remarks, limitations and future research directions

Much of the dramatic growth of China over the last decade has been fuelled by a strong manufacturing base that has served the country, and indeed the world, as an engine of economic and social development. This growth, however, has been accompanied by equally dramatic environmental problems such as environmental degradation, climate change and natural resources scarcity. To address these concerns, substantial academic research has been devoted to study the application of environmental management approaches such as ISO 14001, cleaner production, green supply chain management, circular economy, reverse logistics and green lean by Chinese manufacturing organisations. However, very limited research has been conducted regarding the application of TQEM. Therefore, this paper is among the very first studies which have investigated the degree of adoption of TQEM by Chinese manufacturers. In this way, the present paper fills a research gap, as previously established in Sections 1 and 2, and extends our knowledge in the field of environmental management systems by:

- exploring the degree of awareness of TQEM among Chinese manufacturing organisations, including its relationship with a company's size and source;
- investigating the degree of adoption of TQEM among Chinese manufacturing organisations and establishing its relationship with a company's size and the implementation of TQM;
- exploring the drivers which motivated Chinese manufacturers to adopt TQEM, the results they have obtained from such adoption, and the challenges they faced during its deployment; and
- helping us to understand the main impeding factors that have stopped Chinese manufacturers from more widely adopting TQEM.

Besides these theoretical contributions, the paper also contributes to the practice of environmental management systems as these contributions are beneficial for managers who aim at effectively adopting TQEM to simultaneously improve the environmental, operational and financial performance of their organisations. Although the present study was particularly focussed on the manufacturing sector of China, other industrial sectors such as logistics and transport, healthcare, services, among others, which also have the need of addressing the negative impact of their operations, are also likely to benefit from this study due to the wide applicability of TQEM. Like the manufacturing industry in China, all these sectors are receiving increasing pressures from various stakeholders to operate more sustainably.

Generally, the paper provides some interesting insights into the implementation standing of an environmental management approach, i.e. TQEM, in China. This may motivate organisations not currently embarked on the “green wagon” to contemplate the benefits that the implementation of TQEM, or any other environmental management approach, may bring to their operations and business.

In terms of limitations and future research directions, this paper has been mainly confined to an exploratory study which provides light into the application of TQEM. Future research can consider and adopt the findings derived from this research to develop an implementation framework which facilitates the adoption of TQEM. Although this was not an impeding factor to adopt TQEM in the Chinese manufacturing sector, according to the results of this study, it was a relevant factor in the UK’s construction sector as suggested by Khadour (2010). Another compounding constraint of this research is the fact that it was only limited to the manufacturing sector of China. Thus, further research is required to provide added insights into the application of TQEM in other industrial sectors and countries. A study of this type will provide further evidence on the role of industry characteristics towards the adoption of TQEM and its contribution to the environmental, operational and business performance of organisations. As this study was particularly focussed on industrialists, future studies can also include academic and research experts in order to also obtain a theoretical-based view on the implementation of TQEM. A combination of both pragmatic and theoretical views will certainly provide a more powerful combination source to not only understand the implementation nature of TQEM but also other environmental management approaches. Finally, also coupling future research with qualitative methods such as interviews can contribute in uncovering more specific details regarding the adoption of TQEM. As these future research directions have been defined based on the limitations of the present study, it has not only brought further light into the environmental management system field but it has also opened new areas for research within this area.

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