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Safety Management System in TQM environments

ABSTRACT

Safety Management Systems continue to be a prevalent research topic nowadays, which has gone from being an incipient construct to an essential factor in new currents of business management. Organizations have perceived the importance of organizing their techniques and resources under a Safety Management System with models similar to other certification systems such as the ISO 9000 family of standards. This research is aimed at knowing the conditions that accelerate the adoption of a Safety Management System, either under the principles, beliefs and values of Total Quality Management or as a consequence of the implementation and application of essential safety management techniques, namely, risk assessment processes, assumption of safety responsibilities and safety training. It has been proven that companies operating in Total Quality Management environments are more likely to adopt a Safety Management System than those which apply key safety management practices in isolation. Results show the potential of Total Quality Management to promote a Safety Management System by itself, even in the absence of proven core practices. The results are robust and suggest maintaining principles of the quality paradigm when pursuing more ambitious models based on total management such as Total Safety Management.

Keywords: Total Quality Management, Safety Management System, Total Safety Management, Risk assessment process, Safety responsibilities, Safety training.

Paper type: Research paper.

1. Introduction

Unsafe working conditions directly affect workers' health. In addition to labor accidents and diseases, the occurrence of occupational risks lowers satisfaction, worker motivation and firm performance, which may alter its market position (Bottani et al., 2009; Fernández-Muñiz et al., 2009). Competitive firms must combat occupational risks and organize resources for their prevention.

A Safety Management System (SMS) is a management model that groups functions, responsibilities, practices, procedures and processes for risk prevention. Real and effective application of an SMS allows compliance with an extensive legal framework including guarantees of effective protection for workers and continuous improvement of health and safety conditions (Granerud and Rocha, 2011). In addition, an SMS is a means to optimize performance and economic indicators of a company (Fernández-Muñiz et al., 2009). The utility of SMSs have increased as a management tool in companies (Bottani et al., 2009; Mohammadfam et al., 2016b) and promoted great academic interest in investigating their fundamental characteristics (Fernández-Muñiz et al., 2007; Bonafede et al., 2016; Gallagher et al., 2003, Mohammadfam et al., 2016b) and their interaction with other management systems (İnan et al., 2017; Jørgensen et al., 2006; Kafel and Casadesus, 2016; Moumen and El Aoufir, 2017; Vinodkumar and Bhasi, 2011). However, the literature does not specify beliefs, values or practices that promote the adoption of an SMS.

The implementation and maintenance of an SMS is a process conditioned by legal requirements, expectations and interests of the parties, and requirements of other management systems of the company that compete with the SMS to obtain resources. In addition, an SMS is characterized by the socio-technical dimension of its objectives (Grote and Künzler, 2000; Rasmussen, 1997). On the one hand, it has a social character (workers' rights, staff satisfaction, quality of labor relations) and, on the other, a technical one (modification of processes to integrate safety, investments in adequate equipment and acquisition of safe technologies) (Lowe, 2008). A socio-technical vision implies that an SMS must be developed in a work environment that values social relationships and that perceives risk prevention measures as an opportunity for improvement in order to accelerate its real and effective application.

An organizational culture capable of operating in the social domain of labor relations and integrating technical security to improve processes would favor the implementation and maintenance of an SMS. In this sense, the principles of Total Quality Management (TQM) seem to be in line with the bases that an SMS needs for effective implementation. Employee

satisfaction and continuous improvement are an integral part of the cultural change promoted by TQM (Hackman and Wageman, 1995; Sitkin et al., 1994). Continuous process improvement, employee satisfaction and motivation are intrinsic features of TQM that make this philosophy an appropriate platform to promote the adoption of an SMS.

Frequently, SMS studies are oriented towards techniques, plans, procedures and key processes of an SMS but they do not strengthen the beliefs, values and commitments that drive their adoption. “It may be equally necessary for organizations to nurture the cognitive and emotional commitment of workers” (Wachter and Yorio, 2014, p 129). The objective of our research is to determine the capacity of a TQM environment to promote the adoption of an SMS and analyze convergence of the TQM philosophy with essential SMS practices in order to favor its implementation.

This study focuses on 5,147 Spanish companies, consulted in 2009 as part of the Spanish National Survey of Safety and Health Enterprises Management (ENGE for its acronym in Spanish), by the Spanish National Institute of Occupational Safety and Hygiene (INSHT for its acronym in Spanish, 2009). The study focuses on Spain because of the importance of SMS in Spanish workplace risk prevention policy (Fernández-Muñiz et al., 2014, Morillas et al., 2013, Mullen et al., 2017, Sesé et al., 2002).

The analysis of the relationships between TQM and SMS in Spain is especially important for two reasons. The first is that tensions between social and technical aspects have been visible during the period of crisis in the Spanish economy. “In Spain, the worker representatives perceived the economic crisis to have had two main effects: companies prioritised their concerns about production and costs over dealing with demands from representatives for occupational safety and health improvements; and companies were generally less willing to accede to such demands” (EU-OSHA, 2016, p. 12).

The second is that TQM was the most-used management tool during the period of study in companies of all sizes considered and in all sectors of activity of the ENGE survey. However, it is the industrial sector in which the highest percentage of companies apply TQM (74.3% of companies) and, within this sector, chemistry and metal (INSHT, 2009). Specifically, organizational innovations based on quality management were consolidated as indicative of Spanish companies during the economic crisis (Álvarez-Santos et al., forthcoming).

It should be noted that this research represents a significant advance in SMS research as it analyzes interactions between TQM and key safety management practices such as risk assessment processes, assumption of responsibilities and safety training. These interactions are a novelty in SMS research and allow robust comparisons with TQM and its ability to promote the implementation of an SMS.

The article is structured as follows: Section 2 contains the theoretical framework on SMS and TQM, which justifies the formulation of hypotheses. Section 3 describes the data and methodology used to obtain the results reflected in Section 4. Finally, Section 5 provides the most important conclusions of the research, as well as implications for managers, limitations, and future lines of research.

2. Safety Management Systems

Research on Safety Management Systems (SMSs) has revealed the multidimensional nature of the construct (Fernández-Muñiz et al., 2007; Vinodkumar and Bhasi, 2010). Safety Management System has been defined as ‘‘a combination of the planning and review, the management organizational arrangements, the consultative arrangement and the specific program elements that work together in an integrated way to improve health and safety performance’’ (Gallagher et al., 2003, p. 69).

The adoption of an SMS is a form of management that reveals the risk prevention policy of a company. The adoption of an SMS is not an end in itself, but a means to guarantee the right to effective protection of workers by improving working conditions. Currently, new SMS trends are of a proactive nature, integrated into business activities and committed to the management system policy for continuous improvement of the process system (Kontogiannis et al., 2016; Ramli et al., 2011). Nowadays, continuous improvement, the core philosophy of Total Quality Managemet (Sitkin et al., 1994), is an inherent objetive of the current evolution of SMSs (Fernández-Muñiz et al., 2007, 2009; Granerud and Rocha, 2011; Kontogiannis et al., 2016). Similarities between SMS and TQM (Vinodkumar and Bhasi, 2011) have created constructs such as Total Safety Management (García-Herrero et al., 2002) which continue to gain relevance within new SMS research trends (Kontogiannis et al., 2016).

TQM enables optimizing performance and provides a propitious environment for problem-solving in terms of effectiveness, improvement, and satisfaction of stakeholders. These qualities are especially useful for implementing an SMS while guaranteeing efficiency and continuity. The literature recognizes the existence of similarities between the structure of TQM and SMS (García-Herrero et al., 2002; Vinodkumar and Bhasi, 2011). We believe it is necessary to broaden knowledge of the convergence between TQM and safety management to know if there are elements that facilitate the adoption of an SMS in environments committed to quality. Consequently, our research question is: Do companies operating in TQM environments tend to set up an SMS? To answer this question, it is necessary to consider the practices that the

literature recognizes as key in the development of SMS and which can therefore influence the effect of TQM on an SMS.

A vital part of SMS concerns the risk assessment process, the involvement of members of the organization who assume roles and responsibilities and the training of workers (Fernández-Muñiz et al., 2009; Kontogiannis et al., 2016).

Risk assessment process is an SMS information system based on a sequence of activities that transforms the identification of dangerous situations into levels of risks defined by the probability and consequences of their occurrence (Bottani et al., 2009). Its usefulness lies in its ability to estimate and assess the risks of all jobs and to decide on the need to adopt preventive measures according to an objective criterion of priority (Aven, 2016). The risk assessment process outputs are preventive measures to improve working conditions and, therefore, a central practice of SMS information and feedback (Fernández-Muñiz et al., 2009; Nassiri et al., 2016; Papadopoulos et al., 2010).

In addition, the integration of safety in processes requires the assumption of responsibilities by functional units and safety training of personnel in order to perform their activity in accordance with the guidelines received (Segarra Cañamares et al., 2017). The design and implementation of safe working procedures and processes, periodic monitoring of working conditions to reach improvement and intervention on the causes of incidents or damage arising from work should be carried out by means of cross-functional co-operation, which is an indicator of preventive integration. For this reason, SMSs require management commitment for an effective assumption of responsibilities of the organizational structure after it has undergone safety training programs (García-Herrero et al., 2002).

Because of the diversity of practices representative of SMS it is advisable to verify its relationship with TQM and its contribution to the adoption of an SMS; i.e., how do key SMS practices combined with TQM contribute to the adoption of an SMS? The design of the sample and the measurements made allow verifying the relationship and interactions of TQM with the three essential aspects of SMS mentioned above: risk assessment processes, assumption of responsibilities, and safety training.

2.1. Total Quality Management background: convergent environment with SMS

Total Quality Management (TQM) “often is defined as the continuous improvement of processes by all employees in the organization to better meet the needs of internal and external customers” (Sitkin et al., 1994, p. 541). The TQM philosophy is a form of multidimensional and integrated management based on different principles, practices and techniques, with a desire to

improve performance as a means to meet customer specifications and expectations (Dean and Bowen, 1994; Hackman and Wageman, 1995).

TQM considers that performance is located in the processes and proposes treating the organization as an interconnected system of processes. Process management is a fundamental organizational innovation of TQM that allows the identification, improvement and control of key organizational processes (Ahire and Dreyfus, 2000, Flynn et al., 1995, Hackman and Wageman 1995, Sitkin et al., 1994). Improvements are incorporated into processes by capitalizing on the information and knowledge available within the company. But TQM philosophy is not so much a set of values, principles or philosophical ideals, as it is management by fact. The process of continuous improvement of processes is based on performance indicators obtained through organizational measurement techniques that reflect the operation of the processes and, therefore, of the company. “These tools are used to facilitate the recognition of causes of variance in production and administrative processes, and they are prerequisites for taking the actions necessary to reduce variance or errors in order to more effectively meet customer needs” (Sitkin et al., 1994, p. 41). For TQM, improving processes is improving company results, rationalizing resources and intensifying commitment. The application of the principles related to this philosophy encourages observation and control of processes (Bititci and Muir, 1997, Kaynak, 2003, Mosadeghrad, 2006) so that the best practices are standardized and become organizational routines (Hackman and Wageman, 1995; Powell, 1995).

In a TQM work environment, workers' expectations about working conditions, the identification of occupational risk and the consequences of their materialization/occurrence provide useful information for process improvement. Damage caused at work has direct and indirect negative effects on workers' satisfaction and motivation, the company image and productivity (Fernández-Muñiz et al., 2009). Occupational accidents, occupational diseases and incidents are factors that cause variability, alter the normal operation of processes, decrease customer satisfaction and expectations, or worsen the organization's position in the environment/its surroundings. Safety management problems prevent full implementation of TQM improvement strategy.

The relationship between TQM and SMS has promoted research which indicates the possibility of integrating quality and safety systems (García-Herrero et al., 2002, Mohammadfam et al., 2016a, Santos et al., 2013). The possibility of integration is based on the existence of common objectives of improvement, since the solution of security problems is in line with the reduction of variability which TQM pursues. “Traditionally, safety management has focused on correcting safety problems and on taking remedial actions to bring the system back to normal operation” (Kontogiannis et al., 2016, p. 3). There is, therefore, a common dimension between SMS and

TQM: while SMS acts on unsafe conditions capable of altering performance indicators of a process, TQM establishes criteria to control the operation of the organization's processes, and guarantee outputs that satisfy expectations of internal and external customers.

Based on the above, our hypothesis is as follows:

H1. Businesses operating in TQM environments tend to develop an SMS.

2.2. SMS practices

Risk Assessment Process

Workers have the right to effective protection. Risk factors are very diverse and must be adequately addressed, following an order of priority, and by means of a process that provides confidence in its outcome. Risk assessment process is an SMS practice based on workplace data related to work teams, environmental and industrial relations, in order to identify existing risks, evaluate them and take preventive measures according to the order of priority (Fernández-Muñiz et al., 2009). The analysis and assessment of risks is a core safety-management practice (Badri et al., 2012). Risk identification and assessment are major factors that affect successful implementation of occupational health and safety management systems (Mohammadfam et al., 2016b; Papadopoulos et al., 2010; Ramli et al., 2011).

Risk assessment is a complex process, with numerous variables, that must be controlled (Fernández-Muñiz et al., 2009; Papadopoulos et al., 2010). Its application requires the incorporation and control of factors related to working conditions, technologies, equipment, health status of workers, as well as relationships with other companies, suppliers, and social relations among workers (Dastous et al., 2008; Papadopoulos et al., 2010).

The utility of the risk assessment process does not go unnoticed in a TQM environment. Risk factors, unsafe working conditions and work-related injuries alter the performance of activities and the functioning of company processes (Aven, 2016; Fernández-Muñiz et al., 2009). Occupational accidents, occupational diseases, and incidents negatively affect activity and economic indicators of the company (Fernández-Muñiz et al., 2009). Therefore, if process management turns the company's workers into internal clients of its key processes (Hackman and Wageman, 1995; Sitkin et al., 1994), the consequences of unsafe working conditions will have a negative effect on the indicators of performance, satisfaction and motivation. When working conditions meet workers' expectations, direct and indirect benefits are generated in terms of productivity, reduced absenteeism and quality of the work environment. On the

contrary, unhealthy working conditions have consequences and result in alterations in the normal functioning of processes (Bottani et al., 2009; Granerud and Rocha, 2011).

Risk assessment processes also provide useful information for TQM improvement techniques. The reduction of process variability is one of TQM's dogmas (Hackman and Wageman, 1995). In this sense, "risk assessment and feedback mechanisms, as well as suggestions acquired through workplace assessment reports, regularly result in improvements" (Granerud and Rocha, 2011, p. 1035). Opportunities for improvement and causes of risk assessment process variability are not foreign to TQM and, therefore, promote the adoption of an SMS when the company shows a high commitment to the quality function.

The foregoing suggests the following hypothesis:

H2. TQM favors the adoption of an SMS when the company runs risk assessment processes.

Assumption of responsibilities

Safety culture includes the company's perception, commitments, values and beliefs concerning risk prevention. "A major problem with most existing models of safety culture is that they are not integrated into general models of organization and of organizational culture" (Grote and Künzler, 2000, p. 132). When a preventive culture is integrated into the general context of business management, there is a genuine integration of prevention and an effective assumption of safety responsibilities.

The new SMS approach incorporates practices, procedures and processes oriented towards a culture of prevention. Assuming roles and responsibilities for risk prevention are indicators of an effective preventive culture. Fernández-Muñiz et al. (2009) observed that assumption of responsibilities of all organization members and training have a positive effect on safety, competitiveness and economic-financial performance. Assumption of responsibilities incorporates the principles of a risk prevention policy into employees' values and commitments, integrating security within the general context of management. "It can be argued that employees' perceptions of management commitment give an overall picture derived from the totality of the employees' assessment of the interest of management in the safety and health of employees, as manifested in various activities and initiatives of the management towards safety" (Vinodkumar and Bhasi, 2010, p. 2091). There is, therefore, a direct relationship between leadership and the assumption of roles or responsibilities at different hierarchical levels (Clarke, 2013; Kim et al., 2016; Mullen et al., 2017). Thus, management commitment is not an end in itself but a stimulus to integrate security into the organizational structure and articulate the principles of risk prevention policy.

TQM bases have a strong orientation towards commitment, learning and improvement (Dean and Bowen, 1994; Sitkin et al., 1994). The performance that TQM promotes is based on facts, is rigorous, and may require a change of mentality. "To accomplish its purposes, TQM must alter how people actually behave at work (Hackman and Wageman, 1995, p. 325). Thus, assumption of responsibilities is an SMS technique which is consistent with the TQM movement in two ways: on the one hand, TQM solved "the problem of isolation that quality directors experienced, when quality was exclusively the responsibility of the Department of Quality or the Director of Quality (García-Herrero et al., 2002, p. 15). On the other hand, TQM values the commitment to practices oriented towards improvement, so that the assumption of security responsibilities can acquire greater intensity in a TQM environment and stimulate the adoption of an SMS.

Under this approach, the following hypothesis results:

H3. TQM favors the adoption of SMS when the company promotes the assumption of responsibilities.

Safety training

Safety training is an especially valuable technique in SMS (Dastous et al., 2008; Fernández-Muñiz et al., 2009). "A key element in every successful organization, in any successful accident prevention program and in any occupational safety and health program is effective safety training" (Vinodkumar and Bhasi, 2010, p. 2084). Training is a necessary condition so that workers at any organizational level perceive safety as an essential and inseparable part of their activity (Chau et al., 2007; Fernández-Muñiz et al., 2009; Kontogiannis et al., 2016; von Thiele Schwarz et al., 2016). The employer must ensure that each worker receives effective and adequate training, both theoretical and practical. It should always take place prior to the start of their activity, and must be updated when there are changes in functions performed, new technologies are introduced or work teams are changed. "To improve the quality of safety and health for all employees, organizations should institute a systematic, comprehensive safety and health training program for new employees, provide a mentor for these employees, and use a buddy system to help orient new employees in safety and health and quality systems" (Vredenburgh, 2002, p. 262). When safety training goes beyond a mere legal or formal obligation, it becomes a powerful technique for improvement.

"Organizations that implement TQM invest heavily in formal training for a large proportion of their employees" (Hackman and Wageman, 1995, p. 315). The advantages of adopting a safety training program converge with TQM beliefs related to the value of staff training. Training is a

tool aimed at achieving the excellence pursued by TQM, and allows communicating risk prevention policy in the form of practices and standards that contribute to guaranteeing workers' safety and health. Safety practices and norms are incorporated into the company's activity in the form of routines by means of a theoretical and practical learning process based on the continuous improvement of working conditions and staff participation. An SMS relies on training workers to make safety routine and natural.

It seems reasonable to assume that training programs contribute significantly to disseminating the benefits of security and therefore to adopting SMSs in TQM environments.

Accordingly, the hypothesis raised would be:

H4. TQM favors the adoption of an SMS when the company promotes safety training.

3. Data and methodology

3.1. Sample and Measures

In 2009 the Spanish National Institute of Occupational Safety and Hygiene (INSHT) conducted a National Survey of Safety and Health Enterprises Management (ENGE), aimed at obtaining reliable and representative information on the management of occupational risk prevention in Spanish companies. Its specific objectives are:

- To determine the resources and preventive organization that employers have at their disposal to ensure the safety and health of workers.
- To estimate companies' preventive activity based on actions developed within the framework of their management system.
- To determine a company's perception regarding occupational hazards.

The content of the survey allows identifying companies committed to TQM as well as those that have chosen to implement an SMS. In addition, the companies consulted report in the survey on the use of key security practices: risk assessment processes, assumption of safety responsibilities, and safety training.

According to survey analysts, the first step in obtaining data began was a telephone call to companies. Subsequently, documentation for this study was sent out. Two weeks later a team member visited the company to collect the questionnaire, resolve any doubts and carry out initial supervision of their consistency. All questionnaires were subjected via telephone calls to a second process of supervision by the team of experts as well as quality controls on the

goodness of information with a minimum of 30% of the interviews collected. This research is based on a total of 5,147 interviews carried out. The most up-to-date data is available at: http://encuestasnacionales.oect.es/.

Based on the results of the survey, four out of ten companies with 50 or more employees apply an SMS. In general terms, SMS adoption under OHSAS standards occurred in 57.71% of all companies surveyed. According to the INSHT (2009), the priorities of companies at the beginning of 2009 were clearly orientated towards increasing productivity (40.1%) compared to other objectives such as improving quality (27.8%) or the SMS (3.8%). During that time, in Spanish companies the most frequently adopted business strategy was an increase in productivity, whereas the establishment of SMS improvement objectives played a much more secondary role and ranked seventh among the nine options proposed in the survey.

However, in 2012, Spain was one of the better performers in Europe in terms of SMS (Stolk et al., 2012). Therefore, despite the priority given to productivity in the previous years, Spanish companies increased their commitment regarding the adoption of SMS. This phenomenon has not been explained in the literature and could mark a new perspective in the research on factors that promote the adoption of SMS. The hypotheses put forward suggest that TQM's popularity among companies in 2009 contributed to companies indirectly maintaining interest in applying SMS. The descriptive variables and statistics used in the research to test the hypotheses are explained below.

3.2. Variables

The dependent variable SMS is a proxy variable of Safety Management System. The SMS was set up by those companies that applied an Occupational Health and Safety Management System based on the family of standards OHSAS 18000 or any other similar standard during the period of study. On the other hand, the independent dichotomous variable TQM was developed by those companies that had a Total Quality Management program underway in 2009. In addition, the relationship between TQM and key safety management practices (Risk Assessment, Process Assumption of Responsibilities, and Safety Training) has been proven by analyzing interactions with proxy variables ***assessment***, ***responsibilities*** and ***training***. In all three cases, dichotomous variables are used which indicate the application or not of any of the three practices.

The models have been supplemented with continuous control variables commonly used in research on safety management: the log of the number of employees (Autenrieth et al., 2016; Bonafede et al., 2016) (***lognw***) and the log of the age of the company which answered the

questionnaire (Abad et al., 2013) (***logtime***); activity sector (Fernández-Muñiz et al., 2009) (***industrial*** or ***services***) is another dichotomous variable operating as a control.

Multicollinearity checks verify the absence of correlation between the independent variables. The analysis was carried out using the Variance Inflation Factor (VIF), whose result was 1.32 (median value). The correlation coefficients between the variables and the descriptive statistics used in the research model are summarized in Table 1.

Table 1. Correlation matrix and descriptive statistics

		1	2	3	4	5	6	7	8	9
1	SMS	1.00								
2	TQM	0.42***	1.00							
3	Assessment	0.15***	0.10***	1.00						
4	Responsibilities	0.20***	0.18***	0.21***	1.00					
5	Training	0.17***	0.17***	0.28***	0.33***	1.00				
6	Industrial	0.07***	0.10***	- 0.27***	0.10***	0.10***	1.00			
7	Services	0.06***	0.03*	0.16***	0.05**	0.09***-	- 0.29***	1.00		
8	Firm size	0.18***	0.22***	0.22***	0.29***	0.33***	0.11***	0.46***	1.00	
9	Firm age	0.04**	0.04**	0.12***	0.08***	0.13***	0.05**	- 0.01	0.20***	1.00
	Mean	0.58	0.66	0.78	0.51	0.76	0.18	0.28	3.83	5.09
	SD	0.49	0.47	0.41	0.50	0.42	0.39	0.45	2.29	1.09
	Min	0	0	0	0	0	0	0	0	0
	Max	1	1	1	1	1	1	1	11.29	9.16

* p < .05
** p < .01
*** p < .001

4. Results

Table 2 shows the data obtained in the logistic regressions that relate the TQM explanatory variables to the SMS variable, which is a proxy for the adoption of a Safety Management System from 4,888 observations. This sample is smaller than the initial one (5,147 companies), since the missing values of the questionnaire were discarded. The regressions were calculated using the robust option to correct possible heteroskedasticity effects.

The results show a positive and statistically significant relationship between the TQM variable and the dependent SMS variable (2.41; p <0.001). This relation allows verifying hypothesis *H1*. The statistically significant relationship between TQM and SMS is maintained even when a company directs its business strategy towards a greater commitment to environment sustainability or when it promotes research, development and innovation. Both cases are strategies which can be verified by means of the data from the survey. This verification was

carried out to test the maintenance of a significant relationship between SMS and TQM even in extended integrated models of quality, safety and environment (İnan et al., 2017; Kontogiannis et al., 2016). Convergence between TQM and SMS is maintained when available resources and efforts must be shared with the environmental management system.

The influence of TQM is also notable in the analysis of marginal effects. Marginal effects show the change in the probability of SMS adoption. When a company operates in TQM environments, the probability of SMS adoption increases in greater proportion (53 %) than with key practices *Assessment* (20 %), *Responsibilities* (14 %) or *Training* (11 %) operating in isolation.

The negative and statistically significant coefficient of the interaction between TQM and Assessment (-0.58; $p < 0.01$) verifies compliance with hypothesis *H2*. The coefficient of the interaction term estimates the difference between the effect of *TQM* (1 vs 0) when *Assessment* = 1 and the effect of *TQM* when *Assessment* = 0. The negative (-0.46) and statistically significant ($p < 0.05$) coefficient indicates that the effect of *Assessment* on the adoption of an SMS is lower when TQM = 1 than when TQM = 0. The lack of statistical significance in Model 5 does not allow verifying *H3* and *H4* globally.

However, the research delves into the significant relationship between TQM and SMS by graphically analyzing the interactions between categorical TQM variables and key SMS practices: *Assessment*, *Responsibilities* and *Training*. Categorical by categorical interactions provide a better understanding of convergence between TQM and SMS variables based on key practices of the latter. The interactions between categorical variables (also called factor variables or factors) have been designed with two factors because they are dichotomous variables that take on value 1 or 0; in which case the interaction is referred to as two by two interaction (Mitchell, 2012). The statistical significance of coefficients of categorical variables has been completed with the analysis of their interactions, which allows determining the relation of each of them to the dependent variable. The interactions have been graphically represented in order to help understand the effect of TQM and important safety management practices on the adoption of an SMS. In two by two models, steepness of the line reflects the effect of the explanatory variable on the dependent variable when interacting with another categorical variable of the model (Mitchell, 2012). This research has been aimed at verifying the effect of TQM on the adoption of an SMS when TQM interacts with the variables *Assessment* (risk assessment process), *Responsibilities* (assumption of safety responsibilities) and *Training* (safety training).

Each line in Graphs 1.a., 2.a. and 3.a. reflects the effect of TQM. The steepness of the line reflects the size of the effect of TQM. The line for Assessment=0 looks steeper than the line for

Assessment=1 (Graph 1.a.), suggesting that TQM has a greater effect when companies do not carry out risk assessment processes (-0.58; $p < 0.01$). This same approach can be maintained with respect to the categorical variables *Responsibilities* (-0.35; $p < 0.05$) (Graph 2.a) and *Training* (-0.44; $p < 0.01$) (Graph 3.a.). The slope of the lines indicates that TQM has a greater effect on the adoption of SMS when the companies do not assume responsibility for risk prevention or when they do not have a training program regarding safety and prevention of occupational risks.

Similarly, the effect of key SMS practices can be observed when a company does or does not operate in a TQM environment. In general, it can be seen that the slope of the lines corresponding to *Assessment* (Graph 1.b.), *Responsibilities* (Graph 2.b.) and *Training* (Graph 3.b.) is steeper when a company has not implemented a TQM program. This suggests a greater effect on the adoption of an SMS than when the company operates under principles of TQM. However, the probability of adopting an SMS when the company applies key practices is noticeably greater when operating in a TQM environment.

It does seem possible to deduce that some safety practices have a higher incidence on others with regard to the adoption of an SMS. The slopes of the lines are similar, although safety practices seem to contribute to the adoption of SMS more when a company is not committed to TQM (a steeper slope is observed in the graphical representation). When a company does not have a TQM program in place, safety practices contribute to the SMS adoption process. However, in TQM environments safety practices seem to give way to values promoted by TQM to organize an SMS and the probability of adoption becomes greater.

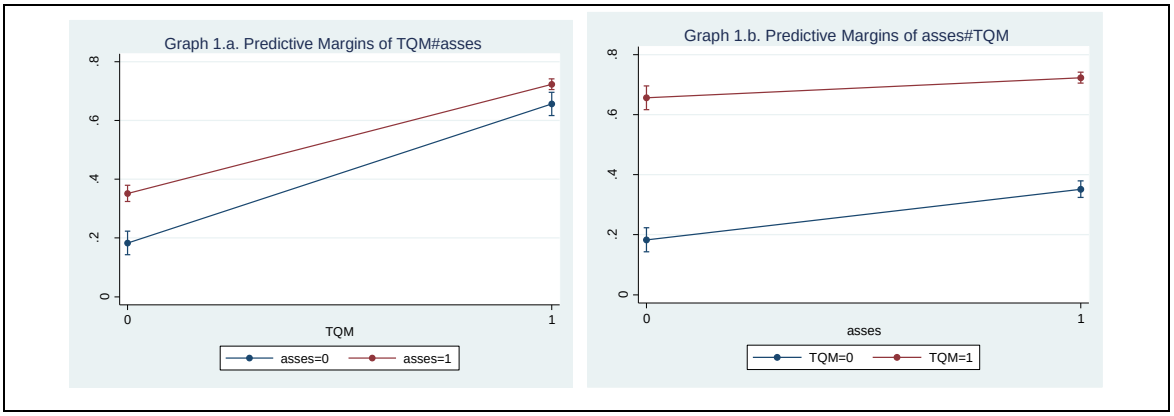
As far as control variables are concerned, there are no differences related to the size of the company or the length of time is has been in operation. Regarding the activity sector, statistical significance is higher in industry than in the service sector in all of the models, which indicates a greater tendency of the industrial sector to adopt an SMS when the company operates under the principles, techniques and total quality practices.

TABLE 2 Logistic regression. TQM-SMS and interactions[a]

VARIABLES	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Marg. change
Theoretical							
Hypothesis 1 TQM		1.74*** (0.07)	2.20*** (0.16)	1.91*** (0.10)	2.06*** (0.14)	2.41*** (0.18)	0.53*** (0.03)
Hypothesis 2 TQM x Assessment			- 0.58** (0.17)			- 0.46* (0.18)	- 0.11* (0.04)
Hypothesis 3 TQM x Responsibilities				- 0.35* (0.14)		- 0.22 (0.15)	- 0.05 (0.03)
Hypothesis 4 TQM x Training					- 0.44** (0.16)	- 0.26 (0.17)	- 0.06 (0.03)
Main effects							
Assessment	0.51*** (0.82)	0.51*** (0.87)	0.90*** (0.15)	0.50*** (0.09)	0.51*** (0.09)	0.83*** (0.16)	0.20*** (0.03)
Responsibilities	0.52*** (0.64)	0.43*** (0.70)	0.42*** (0.07)	0.67*** (0.12)	0.43*** (0.07)	0.57*** (0.12)	0.14*** (0.03)
Training	0.36*** (0.78)	0.28*** (0.83)	0.28** (0.08)	0.28** (0.08)	0.55*** (0.13)	0.45** (0.14)	0.11** (0.03)
Firm controls							
Industrial	0.40*** (0.09)	0.32** (0.10)	0.32** (0.10)	0.32** (0.10)	0.31** (0.10)	0.31** (0.10)	0.08** (0.02)
Services	0.99 (0.08)	0.23* (0.09)	0.23* (0.09)	0.22* (0.09)	0.23* (0.09)	0.22* (0.09)	0.05* (0.02)
Firm size[b]	0.09*** (0.02)	0.02 (0.18)	0.02 (0.02)	0.02 (0.02)	0.18 (0.18)	0.02 (0.02)	0.005 (0.004)
Firm age[c]	- 0.02 (0.03)	- 0.01 (0.03)	- 0.01 (0.03)	- 0.01 (0.03)	- 0.01 (0.03)	- 0.01 (0.03)	- 0.003 (0.007)
Constant	- 0.92*** (0.15)	- 1.17*** (0.16)	- 2.11*** (0.19)	- 1.88*** (0.17)	- 1.99*** (0.18)	- 2.23*** (0.20)	0.11** (0.007)
Wald chi-square	358.74	903.11	875.48	887.03	881.45	855.74	
Number of observations	4,888	4,888	4,888	4,888	4,888	4,888	

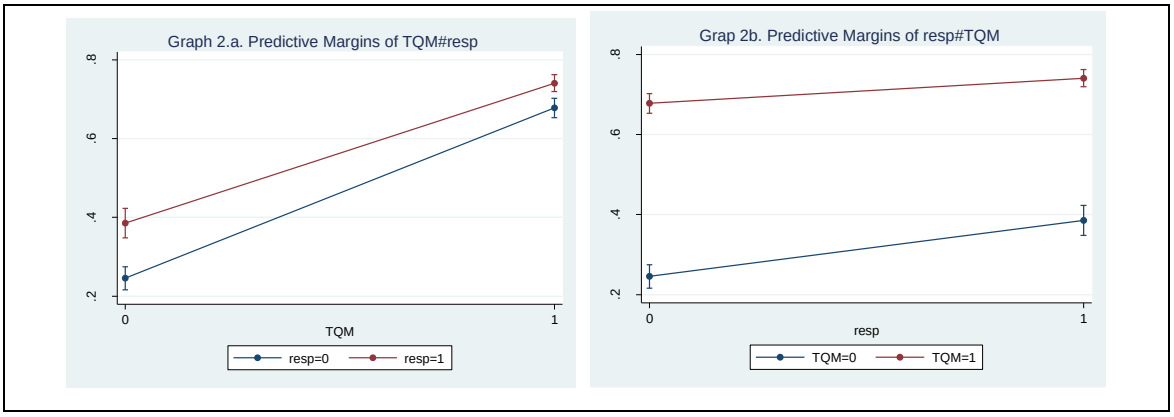
[a] Standard errors are in parentheses.
[b] Natural logarithm
[c] In months (natural logarithm)
* p < .05
** p < .01
*** p < .001

Graph 1. Interactions: TQM and Assessment



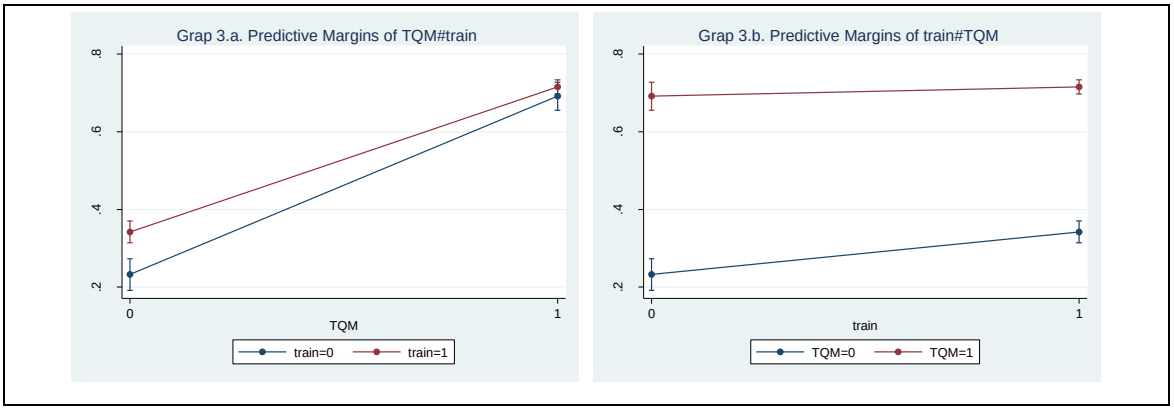
Source: the authors of this article

Graph 2. Interactions: TQM and Responsibilities



Source: the authors of this article

Graph 3. Interactions: TQM and Training



Source: the authors of this article

5. Conclusions, implications for managers, limitations and future lines of research

The results of this research show a positive and significant relationship between TQM and SMS: companies operating in TQM environments tend to develop Safety Management Systems. TQM raises an underlying concern about the consequences of occupational risks. Thus, it has been proven that a holistic treatment of TQM contains values, beliefs and principles that can promote the adoption of Safety Management Systems. TQM's capacity exceeds the initiative that could be provided by the key risk assessment practices, assumption of responsibilities and training operating in isolation. We suggest, therefore, that TQM provides companies with continuous improvement criteria applicable in the adoption of an SMS even if the company does not apply key practices.

The consequences of unsafe working conditions do not go unnoticed in light of TQM's desire to reduce variability. It was verified that TQM is capable of providing by itself potential for the implementation of an SMS in the absence of key safety management practices, namely risk assessment processes, assumption of responsibilities and training. In addition, interactions have shown that in the presence of key SMS practices, the possibility of adopting an SMS is noticeably higher when the company operates in TQM environments. Excellence in quality management forces the company to remain alert and interested in knowing, eliminating, reducing and controlling causes that interrupt and jeopardize expected performance. Model 1 of the empirical analysis shows statistical significance throughout the three practices of SMS that were contrasted. The empirical analysis of the interactions shows a greater significance of the variable risk assessment process and, therefore, could contribute more to the adoption of an SMS in TQM environments than safety training and assumption of responsibilities. Training and assumption of responsibilities are key factors for SMS. However, risk assessment processes converge better with TQM to promote SMS adoption. Assumption of responsibilities and safety training are constructs difficult to measure in terms of their effectiveness and impact on management.

The survey uses dichotomous variables referring to the obligation to include prevention in all decisions taken and the carrying out of training activities. No other items are considered regarding the degree of adoption, efficacy or means of control. We suggest TQM converges better with risk assessment because it is a documented process whose operation and revision are regulated by legal and technical standards.

The design of the sample allowed testing the hypotheses in companies that had a TQM program underway during the period under study, so the empirical analysis was carried out under a holistic treatment of the construct. The TQM movement has inspired a safety approach based on

the principles of TQM called Total Safety Management (TSM), which currently remains in force (García-Herrero et al., 2002; Kontogiannis et al., 2016). A total safety approach promotes a culture of continuous safety improvement based on the preventive principle and TQM techniques. The results of the research suggest that the TSM approach is more based on the TQM philosophy than the isolated application of key Safety Management System practices. This observation is essential for the implementation of TSM models. We believe that companies can fail to operate under TSM models if they are based solely on the isolated application of key SMS practices. The preventive excellence of TQS requires that prevention techniques be applied with rigor, control and a desire for continuous improvement of TQM in a framework of management by fact.

Implications for managers

The TQM philosophy is in line with the objectives of employee accident reduction, satisfaction and motivation. Companies can take advantage of TQM's interest in controlling the causes of process variability to enhance the SMS by creating a secure environment and satisfactory working conditions.

We have verified the strong relationship between TQM and Safety Management. For this reason, the adoption of a Safety Management model could be more successful in those companies familiar with quality systems. Risk assessment process converges with TQM in order for the company to adopt an SMS. If the company manages risk assessment processes in a TQM environment, it could accelerate the adoption of an SMS.

Companies can go further in terms of excellence and work under a Total Safety Management (TSM) model. To do this they must apply and maintain the principles and philosophy of TQM. We suggest that adopting a TSM system in a TQM environment allows us to rationalize resources and efforts to achieve the security paradigm.

Limitations and future lines of investigation

The most important limitation of our research is the existence of a single National Survey of Safety and Health Enterprises Management (ENGE) for the year 2009. We are confident that this research will promote new editions of the survey, given the Importance of Occupational Safety and Health Management in scientific literature. The existence of a single edition of ENGE does not allow verifying the evolution of the constructs nor the relation between them. At present the literature recognizes the possibility of customization of the management models

to meet the needs of the company, both in research related to TQM (Wu et al., 2011; Zhang et al., 2014) and to SMS (Gallagher et al. Al., 2003). In this sense, an update of ENGE would allow carrying out new investigations to establish empirical bases concerned with the indicated ends.

On the other hand, ENGE only allows carrying out a holistic study of TQM. This clear limitation constitutes at the same time a new line of research. The multidimensional character of TQM makes it advisable to continue analyzing the tendency of its techniques on SMSs and TSMs. Testing the individual synergistic effect of TQM practices on SMSs would allow companies pursuing security excellence to more effectively and efficiently adopt TSM models.

In addition, the content of the survey does not allow the analysis of the entirety of key SMS practices recognized in the literature. The use of practices employed in the analysis has been justified, but the scope of the survey limits research to the techniques described.

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