Difficulty in implementing continuous improvement. Rasch Measurement analysis.

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Abstract

Purpose. The aim of this paper aims is to define a general and common construct in order to measure the level of difficulty companies experience when they implement continuous improvement (CI). Additionally, a rank of barriers is obtained together with a rank of companies.

Design/Methodology/Approach. In order to achieve our objective, first, a literature review is carried out to specify the domain of the construct; secondly, a sample of items is selected; thirdly a survey is carried out in companies that have already implemented CI initiatives, the results being thus limited to this population; fourthly, measures are purified by analysing the reliability and validity of the measurements, and finally results are obtained. The Rasch Measurement Theory will be used to provide a new perspective on a mature research topic.

Findings. It can be concluded that a new valid construct has been defined together with a rank of CI barriers, a lack of time being the main barrier. A rank of companies is also obtained which is a first step in the development of future research studies.

Practical implications. Managers are provided with a better understanding of the barriers that can obstruct CI implementation. Thus, the rank of CI barriers guides managers through the most common and important obstacles so that they will be able to plan better CI strategies. In addition, the rank of companies allows each company to undertake a benchmarking exercise.

Originality/value. This work proposes a new way of analysing the difficulty in implementing continuous improvement as a continuum, rather than as independent barriers. From a theoretical point of view, it defines a new construct, and offers a rank of CI barriers together with a rank of companies based on their level of difficulty when implementing CI initiatives. This is something new, as previous

studies were mainly focus on the items side. From a practical point of view, this study offers the surveyed companies the opportunity to see how they are positioned with respect to the other companies. Moreover, this rank of companies is the foundation on which to develop further studies with a practical orientation in the future.

1. Introduction

Over the last few decades, due to the new conditions that prevail in the business environment, companies have had to innovate in order to be competitive and survive (de Jager, Minnie *et al.*, 2004; Quesada-Pineda and Madrigal, 2013). Companies have a wide range of improvement approaches at their disposal to do this (Kettinger and Grover, 1995) and continuous improvement is one of them.

Continuous improvement (CI) is a phenomenon of vital importance for companies in the current environment (de Jager et al., 2004; Hamel, 2000; Singh and Singh, 2012). As will be seen in the following sections, there are many definitions of CI. According to Deming (1982), CI means to improve constantly and continuously the system of production and service. Therefore, it may be defined as a philosophy, a way of understanding the company and how it should evolve and be improved.

The origins of CI derive from the combination or three major phenomena: changes in the business environment, the emergence of new management systems and the importance of quality management itself (Sanchez and Blanco, 2014). Nowadays, CI has become a key issue in the business environment as a facilitator towards business excellence (de Leede and Looise, 1999; Yunis et al., 2013).

The key role that CI has played for companies has also been reflected in the academic world. Thus, the CI concept has been widely studied from different perspectives over the last few decades (drivers, barriers, enablers, implementation methodologies, evolutionary models).

Specifically, there are a considerable number of papers that analyse CI barriers through independent case studies; that is, they analyse the experience of a small group of companies (generally fewer than 10). Despite this high number of studies, a common and solid theory is yet to be developed. Therefore, the aim of this paper is to define a general and common construct in order to measure the level of difficulty companies have experienced when implementing CI. This involves analysing barriers as a

whole, not independently[1]. Previous studies have shown that companies are not affected by a unique barrier but by a combination of them; therefore, this approach seems to be more appropriate (Raj and Attri 2010).

The development of appropriate measures involves specifying the domain of the construct and generating a sample of items which capture the domain as specified (Churchil, 1979). This is not a simple process; in fact, the development of measurement scales to measure unobservable constructs is one of the most problematic and controversial aspects in Social Science research (Oreja, 2005).

The level of difficulty is, in fact, an unobservable construct that cannot be directly measured so it is necessary to define a selection of items that indirectly measures it. Having said that, this study aims at defining a unifying construct named "difficulty in implementing CI initiatives" in order to develop a robust theory in this field and have a clearer understanding of CI implementation issues. The study will be based in Cantabria, a region in the north of Spain. According to Sanchez (2014), the percentage of companies that implement CI initiatives in this region is quite low and there are no studies that analyse this matter. Therefore, we consider that analysing the experience of those companies that have implemented CI initiatives could improve our understanding of this phenomenon.

In order to achieve our objective (defining a unifying construct), first, a literature review is carried out to specify the domain of the construct; secondly, a sample of items is selected; thirdly a survey is carried out; fourthly, measures are purified by analysing the reliability and validity of the measurements, and finally results are obtained.

In order to achieve this objective, the Rasch Measurement Theory (RMT) will be used. This methodology has a wide range of applications, one of its key strengths being the joint measurement of persons (companies in this case) and items (CI barriers). Not only does RMT allow a construct to be defined and validated, but it also ranks the items which integrate it. Therefore, in this case, RMT will help us to define the construct "difficulty in implementing CI initiatives" as well as ranking the final selection of barriers which will integrate it. Additionally, since RMT is based on joint measurement, we

[1] The Rasch Measurement Theory, which is the methodology used in this paper, allows the researcher to analyse the validity of a construct as a whole as well as the validity of each individual item as part of the construct.

will also obtain a rank of companies showing which companies experienced a higher or lower level of difficulty when they implemented CI initiatives.

Overall, the main contribution of this paper is the definition of a unifying construct in order to measure the "difficulty in implementing CI initiatives". Additionally, the use of RMT will provide a new perspective on a mature research topic. In fact, the current work is one of the first that uses these measurement methods in the quality management field.

From a practical point of view, identifying the key CI barriers could help those companies that are about to start with the implementation process, since only by understanding these factors will companies be able to create an appropriate environment to encourage CI. This knowledge would help companies to reduce mistakes and specially to reduce the implementation time.

Once the goal has been defined, the rest of the paper is structured as follows. In section 2, the theoretical framework is outlined. In section 3, RMT principles are presented. In section 4, the empirical research is described. The results are included in section 5 and discussed in section 6; finally, conclusions, limitations and future research lines are presented in section 7.

2. Literature review

2.1. CI concept

As mentioned in the introduction section, the origins of CI derive from the combination of three major phenomena: changes in the business environment, the emergence of new management systems and the importance of quality management itself (Sanchez and Blanco, 2014).

Regarding the changes in the business environment, over the last few decades business environment conditions have changed completely. By way of example, some of the changes have been: a shift from local to global markets, leading to an increase in competition; a change in the basis of competition from cost to quality; the appearance of a great number of technological advances, the Internet being the most important one; more demanding and better informed customers; the emergence of time as a key competitive variable; and the greater awareness of ethical and environmental issues.

As a result of all these changes, new management systems have been developed such as Lean Management or Total Quality Management (TQM). These new management systems place emphasis

on quality and on CI. Thus, CI is the fifth principle of Lean Management (Womack et al. 1990) and forms the basis of the TQM movement.

The TQM movement emerged in the eighties driven by worldwide experts such as Deming (1982) who proposed a 14 point plan to be applied to organisations in order to improve them; Juran (1990) who developed the quality trilogy (quality planning, quality control and quality improvement); Feigenbaum (1992) who first coined the term Total Quality Management (TQM); or Crosby (1989) known for his "zero defects" philosophy based on "doing things right the first time".

In addition, in recent years, some new models and standards intended to serve as a guide for firms to redirect their activities towards TQM have been created. The ISO 9000 is the best known standard, and the Deming Prize, the Malcolm Baldrige National Quality Award in the United States and the EFQM Excellence Award in Europe are the most well-known international awards. The Deming Prize is aimed at those companies that have achieved some quality improvements by analysing their initial situation, establishing their own aims and transforming themselves in order to achieve their objectives (not only the results are evaluated, but also the processes followed); whereas the Malcom Baldrige National Quality Award and the EFQM Excellence Award are designed to reward those companies that achieve excellence. These last two awards are based on two models that establish the evaluation criteria for the awards (the Malcom Baldrige Criteria for Performance Excellence and the EFQM Excellence Model, respectively). It should be pointed out that many companies follow the guidelines offered by the models or frameworks for self-assessment without applying to the awards.

Overall CI is an essential concept in the TQM movement as shown by the fact that CI forms the basis of TQM and is also included as a key criterion in all the above mentioned management systems, certificates and prizes.

As a result, CI has now acquired its own entity and, therefore, its concept has been widely studied, as the literature reviews carried out by Dahlgaard-Park et al. (2013) and Sanchez and Blanco (2014) showed. Due to the great number of existing definitions, and since each of them was focused on a specific nuance of the CI concept, we have tried to offer a synthetic definition which integrates the main aspects of CI and focuses on the essence of the concept. In this sense, we have defined CI as a cyclical

system, in which all of the staff participate, aimed at reducing waste and identifying new areas of improvement.

At this point, it is important to emphasise that the human factor is essential when guaranteeing the success of CI. There are several authors who, in their studies, have pointed out the fact that continuous improvement depends on the participation of all employees, not just managers. For instance, Imai (1989) defined CI as the *progressive improvement involving everyone in the company (including both workers and managers).* Equally, Bhuiyan, Baghel and Wilson (2006) highlighted that CI is a *culture of sustained improvement aimed at eliminating waste in all organizational systems and processes, and involving all organizational participants.*

Managing human resources correctly can be the difference between the success and failure of a continuous improvement initiative. Thus, as can be seen below (see Table 1), a lack of employee involvement, resistance to change, lack of training or lack of motivation are considered to be potential barriers; while in those cases where these aspects are well managed, they have been identified as facilitators (Clas Berling 2000, Khoo and Tan 2002, Beheshti and Lollar 2003, Warwood and Roberts 2004, Bhuiyan, Baghel and Wilson 2006, Middel, op de Weegh and Gieskes 2007, García-Sabater, Marín-García 2009, Marín-García, Bautista Poveda 2010, Marín-García, Bautista Poveda & García-Sabater 2012).

Despite the apparent simplicity of the concept, implementing CI is a complex process, full of difficulties (Boer et al., 2000; Middle et al., 2007). In fact, Jorgensen et al. (2003) stated that the majority of CI initiatives within Europe and USA died out within a few years.

This high failure rate may be the reason why topics related to the CI implementation process have received greater attention over the last few decades. For instance, there were several studies that focused on analysing CI enablers, barriers and/or benefits (see Albors et al., 2009; Bateman and Rich, 2003; Bateman, 2005; Beheshti and Lollar, 2003; Benner and Tushman, 2003; Fryer et al., 2007; García-Sabater and Marín-García, 2009; Jaca et al., 2010; Jun et al., 2004; Marín-García and Bautista Poveda, 2010; Marín-García et al., 2012; Middle et al., 2007; Suárez-Barraza et al., 2011; Wu and Chen, 2006; Sanchez, 2014).

Another collection of CI literature is focused on proposing implementation methodologies; that is, establishing the key stages throughout the implementation process. Without claiming to be exhaustive, some of the most widely known methodologies are: the Toyota Production System (TPS) whose basic idea is to produce the kind of units needed, at the time needed and in the quantities needed such that unnecessary intermediate and finished product inventories can be eliminated (Monden, 1983); the Lean Management philosophy, closely related to the TPS system, which could be defined as an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimising supplier, customer, and internal variability (Shah and Ward, 2007); the Six Sigma approach is described as a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimise waste and resources while increasing customer satisfaction (Harry and Schroeder, 2000); the DMAIC approach (Define, Measure, Analyse, Improve and Control), said to be a Six Sigma tool, could be defined as a quality improvement framework to meet customer needs on a project-by-project basis (Tang et al., 2007); or the PDCA cycle (Plan-Do-Check-Act) initially proposed by Shewhart (1931) but mainly developed and spread by Deming (1989).

Taking these main methodologies as a base, in the following years new methods were proposed in the literature. Most of them are mainly theoretical (Nuñez-Sarmiento et al., 2004; Prado, 2000; Wang et al., 2012): however others are empirical, that is, based and applied on a particular case study. This is the case of the methodology proposed by Bateman and Arthur (2002) which was based on a manufacturing case study, or the methodology of Suaréz-Barraza and Ramis-Pujol (2008) based and applied in the public sector, among others.

Finally, there are also some studies which are focused on analysing the level of development achieved during the CI implementation process. One of the best known evolutionary models is the one proposed by Bessant et al., (2001), later validated by Jorgensen et al. (2003).

2.2. CI barriers

A barrier could be defined as any factor that obstructs, hinders or limits the continuous improvement implementation process. It could be a negative attitude, an incorrect practice or the lack of certain resources.

In order to identify the barriers which had been proposed in previous studies, a literature review was carried out (Sanchez and Blanco, 2014). First, the Web of Science database was used and 1090 scientific articles about continuous improvement from the period 1980-2011 were analysed. The analysis combined qualitative and quantitative methods and all the articles were analysed from three different perspectives, following the structure of the work of Houy et al. (2010):

- Meta-perspective: describes the findings with regard to temporal, regional as well as other interesting aspects.
- Content-based perspective: describes aspects with regard to the content of an empirical contribution as far as the application context is concerned.
- Methodological perspective: examines the applied methodology of the empirical studies presented in the journal articles.

The literature review was based on three criteria**: type of document**: scientific article; **period of time**: 1980-2011; and **topic**: continuous improvement. In order to identify the articles related to this topic, two keywords were included in the search engine: "continuous improvement" and/or "kaizen". In the end, 1090 articles that included at least one of these words in their title, abstract or keywords were found.

After that, all the articles were revised to avoid duplicities and, at the same time, check that they were effectively related with the topic. One of the analyses carried out during the review consisted of classifying the papers depending on their subtopics. In addition to classifying the papers, thanks to this rigorous process, we had the opportunity to identify continuous improvement barriers while we were reading the papers, especially those related with continuous improvement implementation initiatives.

Additionally, we also consulted other relevant papers that were repeatedly included as a reference in the papers we read, even though they did not appear in the initial search.

As the paper was focused on a region of Spain, we considered it appropriate to carry out a more specific literature review focused on local or national scientific publications that, due to their scope, were not

included in the Web of Science Database. Therefore, the process was replicated based on the same criteria but using Dialnet (database for Hispanic literature) instead of Web of Science (Sanchez and Blanco 2016). Table 1 summarises the main results obtained from those reviews.

Table 1. CI barriers

BARRIERS	**AUTHORS**
Lack of time	Albors Garrigós et al., 2009; Bateman and Rich, 2003; García-Sabater and Marín-García 2009; Jun, Cai & Peterson, 2004; Middel et al., 2007; Suárez-Barraza et al., 2011
Lack of knowledge about CI	Albors Garrigós et al., 2009; Kaye and Anderson, 1999; Middel et al., 2007; Sillince et al., 1996; Suárez-Barraza and Ramis-Pujol, 2008; Walker, 1992
Lack of experience about CI	Bateman and Rich 2003; Dale, Boaden, Willcoz & McQuarter, 1997; Middel et al., 2007
Insufficient measures	Albors Garrigós et al., 2009; Middel et al., 2007; García-Sabater et al., 2012
Lack of management commitment	Bateman and Rich, 2003; Bessant, Caffyn, Gilbert, Harding & Webb, 1994; Dale et al., 1997; Jaca, Mateo Dueñas, Tanco, Vilez Diez & Santos García, 2010; Jorgensen, Boer & Gertsen, 2004; Jun et al., 2004; Suárez-Barraza et al., 2008; Suárez-Barraza et al., 2011; Corbett and Angell, 2011; Heras-Saizarbitoria et al., 2011; Mohammad Mosadeghrad, A., 2014

Lack of staff involvement	Albors Garrigós et al., 2009; Bateman and Rich, 2003; Bhuiyan et al., 2006; de Leede and Kees Looise, 1999; Jaca et al., 2010; Jun et al., 2004; Kaye and Anderson, 1999; Suárez-Barraza and Ramis-Pujol, 2008; Upton, 1996; Heras-Saizarbitoria et al., 2011; García-Sabater et al., 2012; Mohammad Mosadeghrad, A., 2014
Proposed improvements are not monitored	Bateman and Rich, 2003; Bessant et al., 1994; Jaca et al., 2010; Suárez-Barraza et al., 2011
Lack of resources	Albors Garrigós et al., 2009; Bateman and Rich, 2003; Dale et al., 1997; de Jager et al., 2004; Jaca et al., 2010; Jun et al., 2004; Sillince et al., 1996; Suárez-Barraza et al., 2011; Walker, 1992; Corbett and Angell, 2011; Heras-Saizarbitoria et al., 2011
Resistance to change (employees)	Bateman and Rich, 2003; Dale et al., 1997; de Jager et al., 2004; García-Sabater and Marín-García, 2009; Jaca et al., 2010; Jun et al., 2004; Rapp and Eklund, 2002; Suárez-Barraza et al., 2011; Upton, 1996; Heras-Saizarbitoria et al., 2011; García-Sabater et al., 2012
Resistance to change (union)	De Lange-Ros, 1999; Jaca et al., 2010; Suárez-Barraza et al., 2011
Lack of profitability of the project	Bessant et al., 1994; Jaca et al., 2010; Suárez-Barraza et al., 2011
Lack of integration between CI aims and company competitive strategy	Kaye and Anderson, 1999; Suárez-Barraza et al., 2011

Culture intolerant with mistakes	Albors Garrigós et al., 2009; Kaye and Anderson, 1999; Marsh, 2000; Schroeder and Robinson, 1991
Lack of measures or Incorrect measures	Bateman and Rich, 2003; Bessant et al., 1994; Jun et al., 2004; Kaye and Anderson, 1999; Corbett and Angell, 2011; García-Sabater et al., 2012
Lack of alignment between the competitive strategy and the operational activities	Jun et al., 2004; Suárez-Barraza et al., 2011; Tatikonda and Tatikonda, 1996; Heras-Saizarbitoria et al., 2011
Lack of training on CI topics	Albors Garrigós et al., 2009; Bateman and Rich, 2003; Bessant et al., 1994; de Jager et al., 2004; Jun et al., 2004; Marsh, 2000; Heras-Saizarbitoria et al., 2011; García-Sabater et al., 2012; Mohammad Mosadeghrad, A., 2014
Lack of information or incorrect analysis of the information	Albors Garrigós et al., 2009; Bateman and Rich, 2003; Dale et al., 1997; de Jager et al., 2004
Ambiguity (it is not understood why the change is needed)	Albors Garrigós et al., 2009; Bateman and Rich, 2003; Middel et al., 2007; Suárez-Barraza et al., 2008; Upton, 1996;
Lack of a formal process to solve problems	Bateman and Rich, 2003; Bessant et al., 1994; Dale et al., 1997 ; Corbett and Angell, 2011; Mohammad Mosadeghrad, A., 2014
Inappropriate structure	Bateman and Rich, 2003; Bessant et al., 1994; Mohammad Mosadeghrad, A., 2014
Lack of motivation	Suárez-Barraza et al., 2011; Corbett and Angell, 2011; Heras-Saizarbitoria et al., 2011; García-

	Sabater et al., 2012; Mohammad Mosadeghrad, A., 2014
Internal power struggles	Suárez-Barraza and Ramis-Pujol, 2008
High average age of managers and/or employees	García-Sabater and Marín-García, 2009
Interdepartmental barriers	Jun et al., 2004; Suárez-Barraza et al., 2008; García-Sabater et al., 2012

Source: Authors

After identifying the barriers, a construct named "difficulty in implementing CI initiatives", which would be made up of a selection of these, was defined. The selection and validation of the construct (from a content perspective) was performed by a panel of experts, a technique that has been traditionally used in the management field (see, for instance Martínez et al., (2013)).

Eight experts were contacted. They were 3 academics and 5 practitioners. Among the academics, there were Professors and Senior Researchers of the Business and Management field who, all together, accumulated a total of 47 papers related to CI (29 of which were published in high impact journals (JCR from ISI-WoS)). The practitioners, meanwhile, were higher managers, quality managers or Lean Institute consultants with more than 10 years of experience in implementing CI initiatives in different service and manufacturing sectors. The inclusion of academics and practitioners was aimed at obtaining a good balance between theory and practise.

First, in-depth interviews were carried out with the experts. They had to evaluate whether the items included in the construct were appropriate. All the changes they proposed were included in the construct and, after that, the new construct was shown to all of them again. This process was repeated until they all agreed with the content of the construct.

Table 2 includes a summary of the decisions taken by the experts during the process. Their decisions were aimed at avoiding duplicities, ensuring the understanding of the different items and excluding those

items that were obsolete or could not be considered relevant in terms of CI initiatives. Thus, apart from the exclusion of some items, their proposals were basically aimed at unifying two or three items that could be considered the same by companies or changing slightly the wording of the proposed items so that they were clearer for companies.

Table 2. Summary of experts' decisions

INITIAL BARRIERS FROM REVIEW	SELECTED BARRIERS BY EXPERTS
Lack of time	Lack of time
Lack of knowledge about CI	Lack of knowledge or experience about CI
Lack of training on CI topics	
Lack of experience about CI	
Insufficient measures	Lack of a suitable management system
Lack of measures or Incorrect measures	
Lack of management commitment	Lack of management commitment
Lack of staff involvement	Lack of employees motivation
Lack of motivation	
Proposed improvements are not monitored	Proposed improvements are not monitored
Lack of resources	Lack of resources
Resistance to change (employees)	Resistance to change (employees, unions)
Resistance to change (union)	
Lack of profitability of the project	The project is not profitable
Lack of integration between CI aims and company competitive strategy	Lack of integration between CI aims and company competitive strategy
Lack of alignment between the competitive strategy and the operational activities	
Culture intolerant with mistakes	Not learning from mistakes
Lack of information or incorrect analysis of the information	Lack of information or ambiguity with CI objectives
Ambiguity (it is not understood why the change is needed)	
Lack of a formal process to solve problems	Lack of a formal process to solve problems
Inappropriate structure	Excluded
Internal power struggles	Excluded
High average age of managers and/or employees	Excluded

Interdepartmental barriers	Excluded

Source: Authors

Finally, based on the opinion and knowledge of the experts, the construct "difficulty in implementing CI initiatives" was integrated by the 13 items listed in Table 3. Companies had to evaluate whether they had been important barriers for them or not, and to what extent, enabling us to rank them. In order to value the items, a five-point Likert scale was used (1 – it was not a barrier- to 5- it was an important barrier).

Table 3. Survey – CI barriers

		1	2	3	4	5
MC4.1	Lack of time					
MC4.2	Lack of knowledge or experience about CI					
MC4.3	Lack of information or ambiguity with CI objectives					
MC4.4	Lack of a suitable measurement system					
MC4.5	Lack of management commitment					
MC4.6	Lack of employees motivation					
MC4.7	Proposed improvements are not monitored					
MC4.8	Lack of resources					
MC4.9	Resistance to change (employees, unions)					
MC4.10	The project is not profitable					
MC4.11	Lack of integration between CI aims and company competitive strategy					
MC4.12	Not learning from mistakes					
MC4.13	Lack of a formal process to solve problems					

Source: authors

3. Rasch Measurement Theory

In the Social Sciences field and, specifically, in the Business and Management area, there are many realities that cannot be directly measured. Thus, measurement is usually done indirectly by measuring a group of items that, in theory, integrate the construct or reality that we are interested in. In those cases, it is very common to use Likert scales to value those items. The scores obtained from Likert scales cannot be considered measurements since they are ordinal scores and, in order to consider them a measurement they should have an additive structure, a characteristic that only interval variables have. RMT, initially developed by George Rasch (1960), solves this problem by transforming ordinal variables into interval variables.

RMT is based on three principles:

- Unidimensionality (a construct is unidimensional when all the items are referred to the same construct or latent variable so they can be located in the same lineal construct with the subjects);
- Invariance (the results are independent of the samples of subjects and items used); and
- Additivity.

When it comes to transforming the ordinal variables into interval variables, the Theory is based on the following statement: "*persons who are more able/more developed have a greater likelihood of correctly answering all the items in the observation schedule. And, easier items are more likely to be answered/reached correctly by all persons*" (Bond and Fox, 2007).

Then, the mathematical model is derived from the logistic function that relates the increasing probability of response to all items with the persons' ability (Gonzalez Montesinos, 2008).

From this statement, a new concept is defined: distance. This is the difference between the ability of the person (β) and the difficulty of the item (δ). Three situations may arise depending on the result of this difference:

- If $\beta-\delta>0$: the probability of the subject answering the item correctly is over 50%
- If $\beta-\delta<0$: the probability of the subject answering the item correctly is below 50%

- If $\beta-\delta=0$: the probability of the subject answering the item correctly equals 50%

The mathematical expression of the model is derived from this idea and it can be consulted in any of the handbooks about the methodology (see Bond and Fox, 2007; Alagumalai et al., 2005; von Davier and Carstensen, 2007).

Overall, RMT could be considered, in essence, a more robust and appropriate methodology for working with Likert scales as it considers variables as what they are: ordinal variables. Therefore, it does not apply statistical analysis to ordinal variables that are strictly limited to descriptive analysis, although in practice the use of other analyses is commonly accepted. Several studies have already analysed whether the application of these methodologies which consider ordinal variables as continuous variables are correct. For instance, Rhemtulla (2012) concluded that at least five categories are needed to use methodologies based on continuous variables in order not to have significant differences in the obtained results. At the same time, Salzberger and Sinkovics (2006) compared the use of the RMT and factor analysis, highlighting the goodness of the first one over the second one.

Additionally, two characteristics of this methodology must be highlighted: statistical sufficiency and the ability to analyse outliers. Regarding the first quality, statistical sufficiency, this could be understood as the ability to obtain reliable results from small samples. As regards the ability to analyse outliers, RMT allows the researcher to deeply analyse the "strange" cases. This is not possible with other techniques which remove those cases that have a significantly different behaviour from the sample because they can skew results. RMT, however, identifies those cases so that the researcher can analyse them more thoroughly. We cannot forget that in our field the "strange" case could be the leader company, so that analysing its behaviour in detail could add a lot of value to the research.

Among its many applications, we would like to highlight the following: analysis of the global validity and reliability of measurements; individual validity and reliability of items and persons; unidimensionality analysis; category response analysis of the questionnaire; ranking of the items and/or persons; SWOT analysis, among others. It is, therefore, a very rich methodology with a great potential in the discipline.

In the fifth section, where the results are included, the steps that must be followed in order to validate the construct are described, following the works of Oreja-Rodriguez (2015), Sanchez-Ruiz and Blanco (2016) and Sánchez-Ruiz et al. (2017). For those researchers who are not specialists in the methodology, the reference values are included based on the above mentioned works together with Linacre (2012b), Oreja (2005) and Febles (2008).

4. Materials and methods

Once the construct was defined, a survey was conducted. The scope of the study was focused on the Autonomous Community of Cantabria, one of the seventeen Autonomous Communities that integrate Spain.

Specifically, the target population was integrated by companies with over 20 employees that had already implemented CI (Table 4). In order to identify those companies that had already implemented CI, a short survey was conducted among all Cantabrian companies of over 20 employees (808 companies). In order to do this, all companies were contacted by phone or mail. Finally, 299 companies participated and answered whether they practised continuous improvement or not. This represented a response rate of 37% which is a slightly higher percentage than the 32% established as the average response rate in these studies (Frohlich, 2002).

Companies that decided not to participate were contacted again in order to encourage their participation; this second contact allowed us to better understand why they did not want to take part in the study. We discovered that most of the companies refused to participate because they did not practise CI initiatives so they were not interested at all in participating. This fact led us to think that most companies that did not answer the first short survey may not have implemented CI. Thus, we consider that the final obtained sample is even more representative of companies that implement CI.

Table 4. Research Technical record

Characteristics	
Geographical scope	Autonomous Community of Cantabria
First survey	Cantabrian companies with more than 20 employees: 808

Unit of analysis	Company
Period	November 2011- June 2012
Response rate over 808	37% (299 responses)
Second Survey Population	209 companies that practise CI
Response rate over 209 to second survey	52.15% (109 responses)

Source: Authors

Among those 299 companies, 209 confirmed that they implemented continuous improvement. These companies, which make up our population, were sent another more detailed survey in which different aspects of the CI implementation process were analysed, such as the barriers. Finally, 109 valid responses were obtained (52.15% response rate).

Data treatment was performed using RMT which is known to be useful when working with Likert scales (Oreja, 2005; Febles Acosta, 2008). The associated software Winsteps 3.75 (Linacre, 2012a) was used in this study.

Although several studies have already used Rasch models in business and management research (Sanfiel-Fumero et al., 2012; Oreja-Rodríguez and Yanes-Estévez, 2007; Salzberger and Sinkovics, 2006; Ewing et al., 2005; Paliwoda et al., 2009; Oreja-Rodríguez and Armas-Cruz, 2012; Oreja-Rodríguez and Yanez-Estevez, 2010; Santos-Arrebola, 2002), the current work is one of the first that uses these measurement methods in the quality management field.

5. Analysis and findings

5.1. Validity

In order to validate the construct, several analyses must be made. As RMT is not widely used in our field, in order to make the results easier to interpret for non-specialists, Table 5 summarises the analyses that must be carried out to ensure the validity and reliability of the construct defined using this methodology. Specifically, three analyses must be carried out: dimensionality analysis (Table 6), global reliability analysis (Table 7) and individual reliability analysis.

Table 5. Summary of validity checks

Analysis	Objective	Requirements	References	Suitability in this study
Dimensionality analysis	It analyses whether all items are measuring the same construct or not. That is, whether the construct could be considered unidimensional.	a) The eigenvalue of the unexplained variance of the first contrast has to be less or equal to 2. b) The percentage of unexplained variance by the first contrast has to be lower than the percentage of raw variance explained by items.	Linacre (2012b)	It could be concluded that the construct is unidimensional. See Table 6 to check requirements.
Global reliability and validity of measures	Rasch Model makes it possible to verify that the measurements obtained are reliable and valid. According to Rasch Measurement Theory, a measurement is valid when it measures what it is supposed to be measuring. And, a measurement is reliable when it has a high ability of reproducibility (that is, if another sample of persons is used, the results will be robust).	a) INFIT and OUTFIT MNSQ should be between 0.5 and 1.5. b) INFIT and OUTFIT ZSTD should be between -2.0 and 2.0. c) Reliability should be between 0.7 and 1 (optimum). d) Correlation should be 1 for	Linacre, 2012b; Oreja, 2005; Febles, 2008	It could be concluded that the measurements are globally valid and reliable. See Table 7.

		persons and -1 for items.		
Individual reliability and validity of measures	Rasch Model offers the posibility of analysing individually the reliability and validity of each surveyed person and each ítem.	a) PT-MEASURE should be positive b) INFIT and OUTFIT MNSQ should be between 0.5 and 1.5. c) INFIT and OUTFIT ZSTD should be between -2.0 and 2.0.	Linacre, 2012b; Oreja, 2005; Febles, 2008	In this case 13 companies (persons) show validity problems so they were removed from the final sample. This removal would not affect results as the invariance principle which Rasch Measurement Theory is based in, establishes. Therefore, analysis were done based on 96 responses. Regarding the items, two of them (Lack of knowledge or experience about CI, Lack of information or ambiguity with CI objectives) also had to be excluded in order to avoid distortions in results. (Due to the size of the table it has not been included but could be sent under request).

Source: Authors

Table 6 shows the dimensionality results for this case. It can be seen that the eigenvalue of the 1st constrast is two, so the first requirement is fulfilled as the eigenvalue should be equal or less than two. The second requirement is also fulfilled as the percentage of unexplained variance of the first constrast (8.1%) is lower than the raw variance explained by the items (29.3%). Therefore, it can be concluded that the defined construct is unidemensional, which means that all the items are part of it.

Table 6. Variance Components screen plot for items

	Empirical			Model
Total Raw Variance in observations	24.5	100.0%		100.0%
Raw variance explained by measures	11.5	46.9%		48.1%
Raw variance explained by persons	4.3	17.6%		18.1%
Raw variance explained by items	7.2	29.3%		30.0%
Raw unexplained variance (total)	13.0	53.1%	100.0%	51.9%
Unexplained variance 1st constrast	2.0	8.1%	15.3%	

Source: Authors

Table 7 summaries the global reliability and validity values that must be checked. Firstly, INFIT and OUTFIT MNSQ are between the acceptable values (0.5, 1.5) both for persons (0.86 and 0.84) and for items (1.05 and 1.05). Equally, the values of INFIT and OUTFIT ZSTD are between the reference range (-2, 2) both for persons (-0.5, -0.5) and for items (0.3, 0.4). Secondly, regarding the reliability, this is good for persons (0.86) and very good for items (0.97), even being near the optimum. Finally, with regard to correlation, this is acceptable for persons (0.94) and is the optimum for items (-1.00) meaning that the data is complete.

Table 7. Reliability and validity of measures

	INFIT[a]		OUTFIT[b]		RELIABILITY	CORRELATION
	MNSQ[c]	ZSTD[d]	MNSQ[c]	ZSTD[d]		
Persons	0.86	-0.5	0.84	-0.5	0.86	0.94
Items	1.05	0.3	1.05	0.4	0.97	-1.00

Source: Authors

[a]INFIT is an information-weighted fit statistic, which is more sensitive to unexpected behaviour responses to items near the person's measurement level. [b]OUTFIT is an outlier-sensitive fit statistic more sensitive to unexpected behaviour by person or items far from the person's measurement level. [c]MNSQ is the mean-square infit/outfit statistic. [d]ZSTD is the infit/outfit mean-square fit statistic t standardised to approximate a theoretical mean 0 and variance 1 distribution

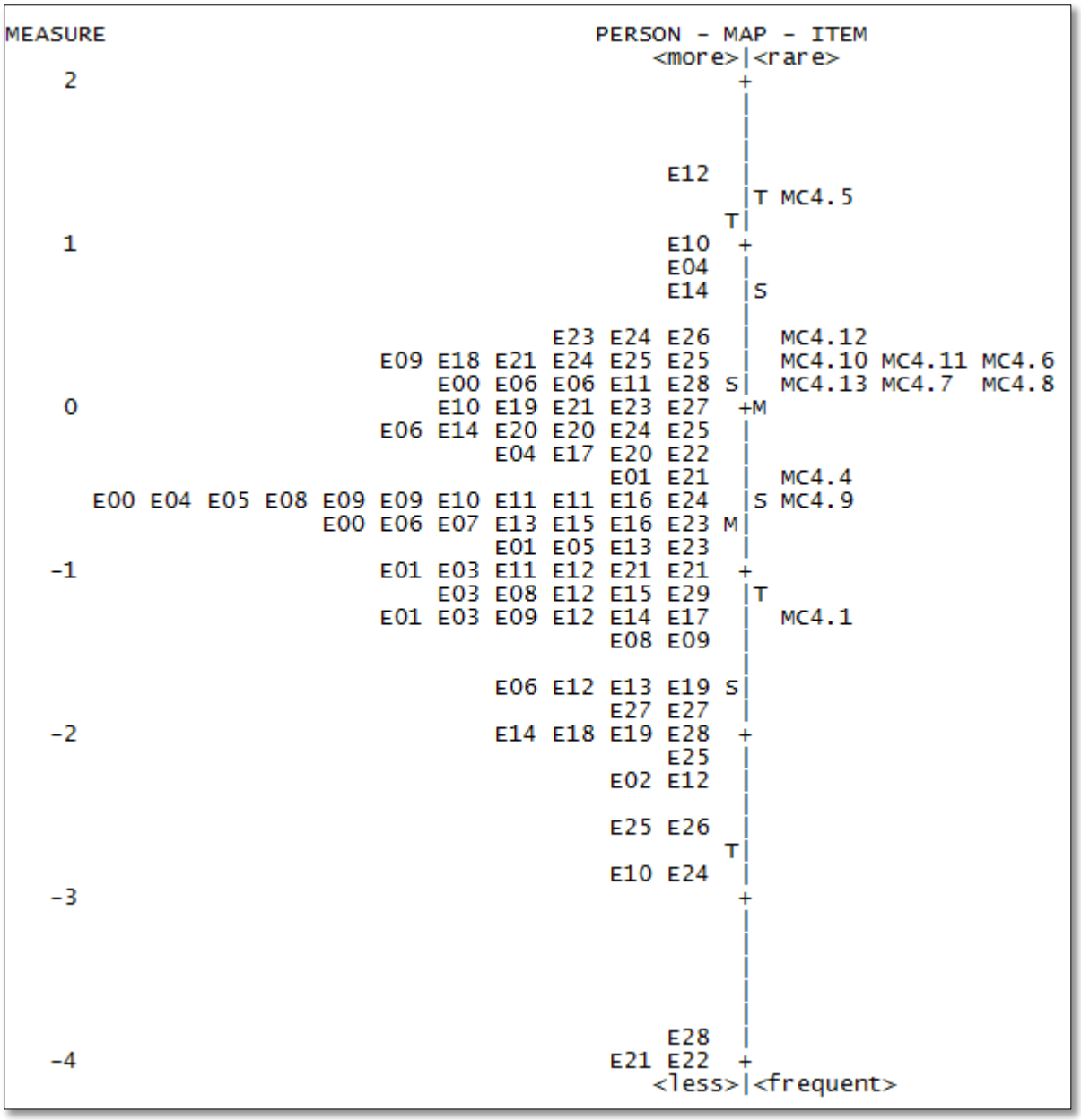
Finally, the individual reliability and validity of measures for each person and each item are checked (tables are not included due to their size). When undertaking this analysis, some problems could be identified. Thirteen companies and two items presented validity problems and, based on the invariance principle that RMT is based on, they were taken out of the sample so that the results were not distorted. As a result, the final sample is made up of 96 companies and the final construct was composed of 11 items.

At this point, it must be said that, after taking these items and companies out, dimensionality and global reliability and validity analysis were repeated in order to check that everything continued to be correct.

5.2. Rank of CI barriers

Once dimensionality, validity and reliability have been checked, the final rank of CI barriers is shown in Figure 1 where both companies and items are represented.

Figure 1. Variable Map



Source: Authors

On the left side of the vertical line (this line represents the construct "Difficulty in implementing CI initiatives") companies are represented by a code (EXX) in order to remain anonymous. Companies are positioned based on their level of difficulty when implementing CI. Thus, the company E12 is the one which, according to the results, experienced a higher level of difficulty, whereas companies E21 and E22 experience the lower level of difficulty. The "M" represents the average value for companies, "S"

represents the distance of the standard deviation and "T" represents twice the distance of the standard deviation.

At the same time, on the right side of the vertical line, items are located. In contrast with what happens with companies, the most important barrier is the one located at the bottom (MC4.1.) and the least important one is item MC4.5. The meaning of M, S and T is the same in this case.

Comparing both sides of the vertical line, we could say that, for instance, company E12 has a higher probability of being affected by item MC4.1 than company E09, as it is located above that item. Meanwhile, company E10 has a lower probability of being affected by the item MC4.5 than company E12 as company E10 is located below the item. Equally, companies E21, E22 and E28 are the ones with the lowest probability of being affected by any of the items as they are located below all the items and that is the reason why we concluded that they are the companies which experience the lowest level of difficulty. In contrast, company E12 is the one with highest probability of being affected by any of the items as it is located above all of them.

For ease of data analysis, the results from the variable map have been included in a list (Table 8) where barriers are classified from highest to lowest importance. Thus, for Cantabrian companies of over 20 employees that practise CI, the most important barrier is a lack of time while the least important one is a lack of management commitment.

Table 8. Rank of CI barriers

1	MC4.1	Lack of time
2	MC4.9	Resistance to change (employees, unions)
3	MC4.4	Lack of a suitable measurement system
4	MC4.13	Lack of a formal process to solve problems
5	MC4.8	Lack of resources
6	MC4.7	Proposed improvements are not monitored
7	MC4.11	Lack of integration between CI aims and company competitive strategy

8	MC4.10	The project is not profitable
9	MC4.6	Lack of employees motivation
10	MC4.12	Not learning from mistakes
11	MC4.5	Lack of management commitment

Source: Authors

6. Discussion

According to the results, a **lack of time** is the main barrier faced by companies when implementing CI, as other authors have already stated (Albors et al., 2009; Middle et al., 2007; Suarez-Barraza et al., 2011). CI is a constant cycle that should not be undertaken as an occasional activity and, as a result, a lot of time should be allocated to it. Sometimes companies are too worried about solving daily problems to allocate any time to implement CI initiatives. In addition, companies should be aware that time requirements vary over the course of the implementation process. For instance, at the beginning of the project, more time is needed because everything is still to be done.

Resistance to change is the second most important barrier. This barrier has been previously identified as one of the most important problems faced by companies (Jaca et al., 2010; Jun et al., 2004). Companies should work on eliminating, or at least reducing, resistance to change because staff involvement is a key element to guarantee CI sustainability (de Jager et al. 2004; Pavitt, 2002).

In order to reduce it, managers have several mechanisms available. The first one is training, which has previously been identified as a CI enabler (Bhuiyan et al., 2006; García-Sabater and Marín-García, 2009; Marín-García et al., 2012; Marsh, 2000; McLean and Antony, 2014; Mejías Sacaluga et al., 2009; Middel et al., 2007; Suárez-Barraza et al., 2011; Suárez-Barraza and Ramis-Pujol, 2008; Warwood and Roberts 2004). Through training, firstly, a common language of work is established (de Jager et al., 2004) encouraging all employees to understand, participate and benefit from CI initiatives. Employees have to understand why CI is beneficial and why it is necessary in the current business environment.

Moreover, they should be aware of their role in the whole process. Otherwise, if concepts are not clearly explained, misunderstandings may appear and CI may be perceived as a control system (Tennant et al., 2001).

Regarding resistance to change, there is an interesting debate in the literature about whether it is influenced or not by the age of the employees. According to García-Sabater and Marín-García (2009), older employees are more resistant to change. However, some of the experts we consulted proposed that resistance to change was more influenced by seniority than by age. Thus, the higher seniority the higher resistance to change, probably because the employee has been doing the same routines and the same work for a longer period of time. We consider that more research focused on analysing the effect of age and/or seniority on resistance to change is required.

It is true, however, that training is a time-consuming process and companies do not have a lot time. Fortunately, nowadays, thanks to the wide range of new technologies available, companies can offer personalised online courses to their employees so that they can follow the course at their own pace, depending on their workload and their schedule. Obviously, this should be carefully monitored, as the training provided must be of a high quality.

Besides training, companies could also reduce resistance to change by using rewards: this has already been identified as an enabler to encourage staff participation (García-Sabater and Marín-García 2009; Khoo and Tan, 2002). It should be highlighted that rewards do not have to be economic; recognition of achievements is also appropriate (Marín-García et al., 2012).

Furthermore, undertaking some pilot experiences with the collaboration of some employees may be helpful. In this way, employees would experience what CI really is, how it works and its positive effects.

The barrier **Lack of a suitable measurement system** has also been identified by Bateman and Rich (2003) and Middle et al. (2007) as one of the most important ones. In this sense, several authors concluded that having a good measurement system is a key factor in achieving CI sustainability (García-Sabater and Marín-García, 2009; McLean and Antony, 2014).

The lack of a suitable measurement system may be related to another barrier identified in this study, **proposed improvements are not monitored,** which has been also identified by Jaca et al. (2010). Logically, if companies do not design a good measurement system they will be unable to monitor their improvement initiatives. In turn, if they do not monitor their activities, they will be unable to implement a constant improvement cycle.

Lack of a formal process to solve problems is another important barrier. De Lange-Ros and Boer (2001) also identified this problem in shop-floors. In order to address this problem, García-Sabater and Marín-García (2009) proposed compiling a manual of good practises. It would not be aimed at automating the CI process, but at offering some ideas about how to proceed when a problem is identified.

Lack of resources is one of the most common barriers identified in the literature, as can be seen in Table 1. It must be noted that this may not only refer to financial resources but also to personal resources (Bateman and Rich, 2003), knowledge or time resources. A lack of personal resources is an important problem, especially for smaller companies, as they are not able to keep staff exclusively dedicated to CI initiatives (García Sabater and Marin García, 2009). A lack of knowledge could be partially avoided by consulting external experts. This is especially suitable during the first implementation stages.

Lack of integration between CI aims and company competitive strategy and **lack of profitability of the project** are two barriers that hold an intermediate position in the obtained results. During the first stage of the Deming cycle, managers have to plan how and where improvements are going to be made. Therefore, they have to be able to choose those profitable initiatives that are in accordance with the general values and objectives of the company. Otherwise, CI would not be sustained.

Lack of employees' motivation is the third least important barrier according to the results. This is a very positive outcome, as staff involvement is a key element in guaranteeing CI sustainability (Behesti and Lollar, 2003; Bhuiyan et al., 2006; García-Sabater and Marín-García, 2009; Martín-García et al., 2012; Suárez-Barraza et al., 2011; Suárez-Barraza and Ramis-Pujol, 2008; Warwood and Roberts, 2004).

This result may seem contradictory with the high relevance of resistance to change. However, we consider that this may be understood as follows: once initial resistance to change has been eliminated and employees decide to join the CI process, they are motivated and involved in the project. Therefore, the beginning is the most critical stage as, at that moment, employees may not know what CI is, nor how it works or what its benefits are.

Not learning from mistakes is the second least important barrier. This is clearly a cultural problem which basically consists of punishing mistakes instead of learning from them. The main problem derived from this barrier is that it can cause other barriers, such as a lack of employee motivation or resistance to change. This barrier is often related to a lack of time, because the process of analysing the problem and proposing potential solutions is time-consuming.

Finally, the least important barrier according to the companies' opinion was ***lack of management commitment*** in contrast to other studies (Albors et al., 2009; Tatikonda and Tatikonda, 1996; Jaca et al., 2010). We consider that this difference may be due to the fact that the surveyed companies were already committed to CI initiatives, so it could be deduced that at least part of their success is due to the fact that they already have the support and commitment of their managers; and, as a result, the item appears as the least important one. However, if our target population had been made up of companies that had not implemented CI or failed in this process, this item could have been in a different position. This is just a hypothesis that can neither be confirmed nor refuted with the results of this study, as it would be necessary to repeat the survey among companies that have not implemented CI initiatives. Therefore, we suggest that further research should be carried out on this issue by replicating the survey among a wider target population, including companies that have not implemented CI. Far from being a problem, this fact only highlights the need to undertake more research analysing potential differences depending on the level of experience or the stage of implementation the company is in.

The fact that the survey was mainly answered by high and medium managers could be another reason why lack of management support is the least important barrier according to the results. It would be interesting to increase the scope of the study and conduct the survey among employees in order to check whether they have the same opinion. Additionally, other quantitative and qualitative methods such as

case studies or in-depth interviews could be used in order to identify potential differences among managers and employees.

7. Conclusions, limitations and future lines

This paper falls within the CI field. It is aimed at developing and defining a unifying construct to measure the level of difficulty in implementing CI initiatives. This approach, unlike traditional studies, considers CI barriers as a whole, as part of a superior construct. In order to do this, the RMT is used, analysing the field of CI barriers, which is quite mature, from a different and innovative perspective.

Therefore, from a theoretical point of view, the main contribution of this paper is the analysis of CI barriers with a new approach using the RMT, making it one of the first research works in the CI field to use this methodology.

The design of the construct named "Difficulty in implementing CI initiatives" was based on a rigorous literature review, a panel of experts and some validation checks that were made using the RMT. As all of the results obtained were satisfactory, it could be concluded that a new unifying construct has been obtained. This result adds value to the CI field since up to now there has not been any common starting point to work with. Therefore, each researcher usually decided subjectively which items should be analysed in their study. The main consequence of this fact is the impossibility of making comparisons and developing the theory of the field further. Henceforth, if the defined construct is used as a common starting point, results could be easily compared and theory may be further developed.

Additionally, a rank of barriers is obtained and the results are discussed. The most unexpected result is the position of the item "lack of management support" which, unlike in previous studies, appears to be the least important one. This could be due to the fact that the surveyed companies are already committed to CI, so their managers are supportive. Including companies not committed to CI in the target population of the survey might have changed this result. However, this does not invalidate this item in this case. Nonetheless, several future research lines are proposed in order to analyse this issue further.

As RMT is based on the joint measurement of persons (companies) and items (CI barriers), the position of companies regarding the level of difficulty in implementing CI has also been obtained. This is an interesting result for companies as they can develop a benchmarking exercise by locating themselves along the construct.

From a practical point of view, the following results may be highlighted. First, managers are provided with a better understanding of the barriers that can obstruct CI implementation. Additionally, the results show that each company is affected by CI barriers differently. Thus, each manager has to analyse the specific case of their company in order to increase the possibilities of success of CI implementation. Nonetheless, the rank of CI barriers guides managers through the most common and important barriers. Thanks to these results, managers will be able to plan better CI strategies.

Overall, the authors consider that this study adds value to previous research because of the following reasons. Firstly, as there is no generally accepted theory in this field, it covers an existing gap by offering a unifying construct. In order to do this, this study includes an in-depth literature review which compiles the barriers of previous studies and proposes and validates a construct. This might be considered a theoretical contribution. Additionally, the number of barriers included in the construct is higher than in other studies. As far as the authors are concerned, there are very few studies which analyse such a high number of items and, in any case, they do not obtain a final ranking of items.

Secondly, a survey is conducted among companies from different sectors, obtaining a final sample of 109 companies already committed to CI. This fact adds value to the field because of the sample size and because there are very few studies that include different sectors. Many studies usually work with small samples, usually with individual case studies.

Finally, this study uses a methodology which is not widely used in the quality management and improvement field, but which, in our opinion, has great potential. This is the reason why we encourage the use of this methodology and offer our collaboration to develop joint research studies and projects.

For instance, it is important to highlight that RMT allows us to develop a deeper study of the position of the subjects, in this case, companies that have implemented CI: firstly, by providing a ranking of

companies which shows the level of difficulty each company experiences (Figure 1). This means that implementing CI is not difficult or easy but is a continuum, which means that each company can experience a different level of difficulty. As far as the authors are concerned, there are no studies which analyse and compare the position of companies regarding their level of difficulty. Secondly, obtaining a ranking of the companies is the first step, a precondition, in developing additional studies which could offer very interesting information for companies. For instance, thanks to RMT, it is possible to carry out an individual behaviour analysis. Therefore, we could verify which barrier affected each company more strongly. Along these lines, it would be interesting to analyse the individual situation of the best positioned companies, carry out some thorough research by doing in-depth interviews with them and obtain a deeper understanding of the strategies they followed when implementing CI in order to reduce the level of difficulty. We consider this information to be very useful for other companies interested in implementing CI in the future. In any case, this study is a precondition to those additional studies.

We are aware that the study has one main limitation. Due to the geographical scope of the study, the results should be treated with caution. However, the sample is large enough for the results to be valuable.

In our view, further research is necessary to have a clearer understanding of CI implementation issues. First we think that increasing the scope of the study could help to move the CI discussion forward. As mentioned in previous sections, some results of this study differ from previous studies, so it is necessary to analyse the causes of these differences. Some potential suggestions are:

- To replicate the study among companies that have not implemented CI initiatives;
- To replicate the study among companies from other regions or countries in order to identify whether cultural differences affect the CI implementation process. If there were differences, different implementation methodologies should be proposed depending on the cultural environment of the company or, at least, traditional implementation methodologies should be approached in a different way.
- To replicate the study surveying employees, not only managers, as we did in this study, so that we can discover whether the perception about the CI implementation process varies depending on the position. In other words, it would be interesting to know if employees, whose

involvement is a key factor to success, are affected by different barriers or, by the same barriers but at a different level[2].

Moreover, by using other applications of RMT, we would like to develop additional analyses. For instance, taking this study as a starting point line, and based on the different position of the companies along the construct, in-depth interviews could be carried out among some of the companies in order to detect why they are affected differently. Thus, if the better positioned companies are interviewed, good practices could be identified, while interviewing the worst positioned companies could help us to detect what they did wrong. In both cases, the results could help other companies to plan better CI implementation strategies.

Additionally, as RMT enables us to develop an individual analysis of each company, it would be interesting to inform each company of their result and to see whether, in a certain period of time (a year for example), they are able to use this information to improve.

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[2] With the aim of responding to these lines of research, the authors are willing to collaborate with other researchers who want to replicate the study in their regions and/or countries. We would be willing to share our data to jointly respond to these issues and make progress in the field of CI.

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