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"A better world with Quality!"

July 13 - 15, 2016

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FOREWORD

Welcome to the 2nd International Conference on Quality Engineering and Management!

After the successful organization of the **1st International Conference on Quality Engineering and Management** in 2014, it is our pleasure to welcome you to the conference **2nd edition** at the University of Minho, again in the historic city of Guimarães, Portugal. This event combines two areas that are not usually brought together: Quality Engineering and Quality Management. We hope that the results of our effort will translate into a successful venture, making gradually of this conference an important scientific event in the field of Quality. As was our aim, since the beginning, the conference covers different topics related to Quality Management and Quality Engineering, including Standards, Continuous Improvement, Supply Chain Quality Management, Management Systems, Six Sigma, Quality Tools, Quality Management in Higher Education, Quality Management in Services and Total Quality Management.

In this 2nd edition the balance between Quality Management papers and Quality Engineering ones is more clear, thus accomplishing one of the fundamental goals of this conference. Approximately 120 papers have been submitted and almost 85 were accepted for presentation, after review from the Conference Scientific Committee. Additionally, some of these papers were selected by the Scientific Committee to be considered for a special issue that will be published by the International Journal of Quality and Reliability Management (SCOPUS indexed journal). Papers accepted correspond to authors from all around the world, with more than 20 countries represented at this level. Therefore, a warm acknowledgment to all speakers and authors is well deserved – Thank You! The success of this second edition derives from their efforts and participation!

We would like to thank all of our four keynote speakers, who will be with us during the two days of the event: **Eric Rebentisch**, **Jiju Antony**, **Lars Sorqvist** and **Marco Reis**. We have here the chance to listen to their contributions and new research development insights, coming from some of the most influent current Quality Academicians. Many thanks also to all the excellent work carried out by the Scientific Committee during the papers selection process. We must acknowledge as well the institutional support received from the School of Engineering of the University of Minho, University of Coimbra, University of Girona, International University of Catalunya, Portuguese Association for Quality, Algoritmi Research Centre, Luso-American Foundation, American Society for Quality, Portuguese Institute for Quality, Brazilian Association of Production Engineering, Brazilian Society of Quality and Excellence in Management, Quality for Excellence Consultancy, BQualidade, Target and Cempalavras.

Again, let's take advantage of this great opportunity and make with your contributions an event with Quality, shared and built by such a top level group of participants!

Enjoy your conference! Thank you all!

University of Minho, July 14, 2016.

Paulo Sampaio (Conference Chair)

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Integrated Management Systems diffusion in South European countries

Cabecinhas, M. [2], Domingues, J. P. T. [2], Sampaio, P. [2], Bernardo, M. [1], Franceschini, F.[3], Galetto, M. [3], Gianni, M. [4], Gotzamani, K. [4], Mastrogiacomo, L. [3] and Hernandez-Vivanco, A. [1]

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ABSTRACT

Purpose – This paper dissects the diffusion of Integrated Management Systems (IMSs) encompassing the ISO 9001, ISO 14001 and OHSMS 18001 standards in the South European countries.

Design/methodology/approach – Data concerning the evolution of the amount of IMSs in Greece, Italy, Portugal and Spain were collected for the time period between 1999 and 2015. The behaviour of the evolution of the number of IMSs over the years was studied adopting both the Gompertz and the Logistic models. The results obtained with these two models were compared and analysed in order to provide a forecast for the next years.

Findings – The diffusion throughout the years of the number of IMSs follows an S- shaped behaviour. The evolution of the amount of IMSs in countries with a lower saturation level are better fitted by the Gompertz model while the Logistic model fits better when considering countries with a larger saturation level.

Research limitations/implications – For some of the analysed countries, the data related to early years are not available. In order to perform the analysis using both the Gompertz and the Logistic models, missing data have been extrapolated from the dataset provided by the annual ISO survey.

Practical implications – The obtained results provide a cross-section of the diffusion of IMSs certifications in the South European countries and enable a forecast for the trend in the next years.

Originality/value – This study aims, for the first time as we were able to find out, at the analysis of the diffusion of IMSs throughout the years.

Keywords: Certification standards, Integrated Management Systems (IMS), Diffusion model, Logistic model, Gompertz model.

Paper type: Research paper

1. INTRODUCTION

The concerns of the organizations related with new stakeholders have increased over the last few years. Hence, organizations seek to respond to various stakeholders through the adoption and implementation of different certification standards, which leads to the coexistence of several systems and the necessity of their integration, thus establishing a broad research field that has been explored extensively by management scholars.

International Organization for Standardization (ISO) publishes the ISO Survey of Certifications with data concerning to the number of certificates issued according to several management standards each year. However, data related to the number of Integrated Management Systems (IMS) are not available in this or any other relevant publication. Thus, this paper intends to report the first efforts of a work in progress that ultimately focus on the development of a forecasting model that may explain the diffusion of IMS in South European Countries. The present paper aims at answering important questions related to the diffusion of the Integrated Management Systems such as: (i) How has IMS diffusion evolved over time? (ii) How is it expected to evolve later on? So far, several authors have analyzed the individual diffusion of the most widely implemented and well known standards, i.e. the ISO 9001 and ISO 14001. This research enabled the development of forecasting models, highlighted the features that seem to promote a successful diffusion of certificates, outlined the path to sustainable certification and pointed out those countries where a saturation level apparently had been reached. Therefore, the development of similar work focusing IMS would bring some light on unexplored features disclosing the current path and the challenges yet to come. The results reported in this article have some shortcomings, since the simultaneous adoption of the ISO 9001, the ISO 14001 and the OHSMS 18001 standards is considered leaving out any information on the integration level of the respective Management Systems.

Besides this introduction, the remainder of the paper is structured as follows: Sect. 2 reports the analysis of the existing scientific literature about IMSs and the diffusion of certifications according to international standards for Management Systems; Sect. 3 describes the methodology of research adopted in the present work and Sect. 4 shows the obtained results, presents a discussion about the main findings of the research and proposes some elements for the future work.

2. LITERATURE REVIEW

2.1. Integrated Management Systems

Nowadays, the implementation of multiple Management Systems (MSs) is increasing, improving

effectiveness, efficiency and stakeholder assurance. Many organizations are implementing multiple MSs (Bernardo et al., 2011).

The recurring themes of the literature developed so far focusing IMSs are related with the limitations of non IMSs (Almeida et al., 2014; Domingues et al., 2014; Domingues, et al., 2012), identification of critical success factors (Almeida et al., 2014; Oliveira, 2013), guidelines and strategies for integration of MSs (Oliveira, 2013; Rebelo et al., 2014a), design of IMSs (Garengo and Biazzo, 2013; Manzanera et al., 2014; Rebelo et al., 2014b; Zeng et al., 2007), factors that influence the level of integration (Bernardo et al., 2011; Bernardo et al., 2012) and suggested integration levels or degrees (Jørgensen et al., 2006; Jørgensen, 2008; Sampaio et al., 2012), relationships between different MSs (Domingues et al., 2011a; Domingues et al., 2011b; Karanikas, 2014), and difficulties and benefits of implementing IMSs (Bernardo et al., 2015; Sampaio et al., 2012; Simon te al., 2012; Zeng et al., 2011).

More recent studies presented the development of a model to analyze the relationship between integration of MSs and innovation management performance or integration performance (Bernardo, 2014), relationship between adoption of MSs and business performance (Vílchez and Darnall, 2014), lessons learned from abandonment cases (Gianni and Gotzamani, 2015b), the role of the workflow-based electronic document management in an organizational integrated context (Pho and Tambo, 2014), how to design an IMS for building a socially responsible organization that contributes to sustainable development (Mežinska et al., 2015), and the relationships between IMSs and information MSs (Gianni and Gotzamani, 2015a).

2.2. Management systems diffusion

The growth and diffusion process was studied by several authors, focusing the patterns in terms of future trends or distribution functions in many areas, such as Biology, Innovation, Economy, etc (Carrillo and González, 2002; Meade and Islam, 2006).The study of the diffusion phenomenon of MSs is not new. Several authors have already

studied the diffusion of the ISO 9001, ISO 14001, ISO/TS 16949 and SA 8000 standards. Some relevant studies are presented in Table 1.

Table 1 – Selected articles about the diffusion of MSs certification.

Paper	***Authors***	***Standard***	***Year***
A new forecasting model for diffusion of ISO 9000 standard certifications in European countries	Fiorenzo Franceschini, Maurizio Galetto, Giovanni Gianni.	ISO 9001	2004
ISO 9000 and ISO 14000 standards: an international diffusion model	Frederic Marimon Viadiu, Martí Casadesùs Fa, Inaki Heras Saizarbitoria.	ISO 9001 ISO 14001	2006
Global Diffusion of ISO 9000 Certification Through Supply Chains	Charles J. Corbett .	ISO 9001	2006
A Spatiotemporal Analysis of the Global Diffusion of ISO 9000 and ISO 14000 Certification	Paulo Albuquerque, Bart J. Bronnenberg, Charles J. Corbett.	ISO 9001 ISO 14001	2007
ISO 14001 diffusion after the success of the ISO 9001 model	Martí Casadesús, Frederic Marimon, Iñaki Heras.	ISO 9001 ISO 14001	2008

The Diffusion of ISO9000 Certification in China: A Trend Analysis Based on Grey Verhulst Model	Yongqing Chen, Erli Liu.	ISO 9001	2009
ISO 9000 and ISO 14000 standards: A projection model for the decline phase	Frederic Marimon, Iñaki Heras, Martí Casadesús.	ISO 9001 ISO 14001	2009
Diffusion of ISO 14001 environmental management systems in China: rethinking on stakeholders' roles	G.Y. Qi, S.X. Zeng, C.M. Tam, H.T. Yin, J.F. Wu, Z.H. Dai.	ISO 14001	2011
ISO 9001 certification forecasting models	Paulo Sampaio, Pedro Saraiva, António Guimarães Rodrigues.	ISO 9001	2011
An institutional perspective on the diffusion of international management system standards: The case of the environmental management standard ISO 14001	M. A. Delmas, M. J. Montes-Sancho.	ISO 14001	2011
ISO/TS 16949: analysis of the diffusion and current trends	F. Franceschini, M. Galetto, D. A. Maisano, L. Mastrogiacomo,	ISO/TS 16949	2011
Diffusion of quality standards in the hospitality sector	María del Mar Alonso-Almeida, Frederic Marimon, Merce Bernardo,	ISO 9001 "Q" Standard	2013
Diffusion of ISO 14001 environmental management system: Global, regional and country-level analyses	W. M. To, P. K. C. Lee.	ISO 14001	2014
ISO 9001 certification in the American Continent: a statistical analysis and modelling	Eduardo Gomes Salgado, Luiz Alberto Beijo, Paulo Sampaio, Carlos Henrique Pereira Mello, Pedro Saraiva.	ISO 9001	2015
Social Accountability 8000 standard certification: analysis of worldwide diffusion	Josep Llach, Frederic Marimon, María del Mar Alonso-Almeida,	SA 8000	2015

Some scholars observed the path of the diffusion certification process and they had described this path with an S-shape, similarly to the behavior of the bio-population growth curve in limited resource habitat or to a diffusion process of technologies (Chen and Liu, 2009; Franceschini et al., 2004) .

Different forecasting models have been used in different areas with different degrees of success (Carrillo and González, 2002; Meade and Islam, 1995). More recently, the study of the evolution of the certification process wasn't an exception. It can be observed that several scholars studied the fitting of the logistic curve (Alonso-Almeida et al., 2013; F. Franceschini et al., 2011; Fiorenzo Franceschini et al., 2004; Llach et al., 2015; To & Lee, 2014; Viadiu et al., 2006), which is the most widely used growth curve in the case of management system diffusion.

3. MATERIALS AND METHODS

One of the critical assumptions in the growth curves for forecasting is whether the curve fitted is the correct one. (Martino, 1993) For that, the chosen growth curve must match with growth dynamics of the phenomenon observed. Thus, the behavior of the curve when extrapolated outside the range data will match the future behavior of the phenomenon (Martino, 1993).

There are many models used to fit S-shape behaviors, however, in this case we study only the logistic curve, already applied in the study of certification diffusion by many authors and the Gompertz model, which has been proposed in some studies in the area of biology and innovation showing a good performance when describing the path of the data analyzed (Meade and Islam, 1995; Zwietering et al., 1990). Other forecasting models have been presented in the scientific literature, for example, in studies of Carrillo and González (Carrillo and González, 2002), Meade and Towhidul (Meade and Islam, 1998) and Zwietering, Jongenburger, Rombouts and Riet (Zwietering et al., 1990).

Considering Gompertz and Logistic models, in both cases, the growth curve is divided in three phases:

- Lag phase: certification diffusion beginning, initial difficulties of the implementation;

- Exponential phase: faster growth, the initial difficulties of the implementation are overcomed;

- Stationary phase or saturation level: growth slowdown and achieve the maximum value (Buchanan et al., 1997; Franceschini et al., 2004; Martino, 1993).

None of the models applied consider an increasing or decreasing phase after the Stationary phase (Buchanan et al., 1997). Therefore, in both cases, the rate of growth is always positive, increasing until the point of inflection (the point in time where the rate of growth changes from increasing to decreasing) and then decreasing to zero when achieve the Stationary phase (Franses, 1994; Carrillo and González, 2002). It is possible observe the mathematical properties of both curves used in the study of Winsor (Winsor, 1932).

It is important to consider that:

- the model considers only the total number of certified enterprises, paying no attention to their specific dimension and to their commodity sector;
- we suppose there are not events or external interferences that can change the natural evolution of the number of QES (for example, international/national prescriptive changes, strong regulatory/legislation changes).

The Gompertz Curve is a model widely used in the scientific literature and it is described by an S-shape, asymmetric relatively to his inflection point. The value of a gives us the saturation value, the maximum number of certified companies possible to achieve, k is a mathematic parameter of

the model and t_c represents the time at the curve reaches to his inflection point (Mar-Molinero, 1980; Meade and Islam, 1995; Carrillo and González, 2002). The shape of the Gompertz curve is sketched in **Erro! A origem da referência não foi encontrada.**. There equation is presented in (1)(Carrillo and González, 2002; Winsor, 1932; Zwietering et al., 1990)

$$y(t) = a.e^{-e^{[-k(t-t_c)]}} \quad (1)$$

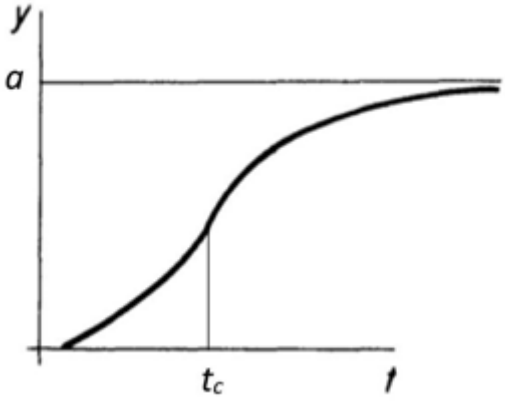

Figure 1 - Typical behavior of a Gompertz curve (Mar-Molinero, 1980)

The Simple Logistic Curve is one of the most used curves in the literature. This model differs from the Gompertz curve because it is symmetric relatively to the point of inflection, this means that happened when half of the saturation level is reached (Carrillo and González, 2002; Franses, 1994; Mar-Molinero, 1980; Meade and Islam, 1995). Like in the Gompertz curve, k is a mathematic parameter of the model and t_c represents the time at reached the inflexion point. The shape of the Logistic curve is observed in the **Erro! A origem da referência não foi encontrada.**. There equation is presented in (2) (Carrillo and González, 2002; Winsor, 1932; Zwietering et al., 1990)

$$y(t) = \frac{a}{1 + e^{[-k(t-t_c)]}} \quad (2)$$

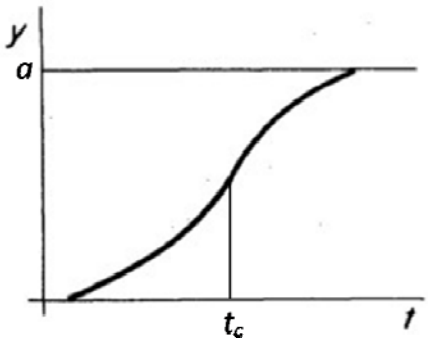

Figure 2 – Typical behavior of a Logistic curve (Mar-Molinero, 1980)

The most effective approach for fitting Gompertz or Logistic curves is the non-linear least squares regression (Seber and Wild, 1989; Martino, 1993; Meade and Islam, 1995; Zwietering et al., 1990). In the present work, we used the "Non-linear curve fits" function of the software Origin® 2016.

The performance of the fit is determined by the information present in the data used for the estimation. In particular, the result is affected by the number of collected observations and by the inclusion of the inflection point in the range of variation of the data (Meade and Islam, 1998).

4. RESULTS: ANALYSIS AND DISCUSSION

For data collection about IMS of Greece, Portugal and Spain, the local certification bodies were contacted in order to provide any information available, since there is lack of IMS information directly accessible, either public or private. In the Italian case, the required data have been obtained by the on-line database of Italian accreditation body ACCREDIA. Table 2 reports the source of the data, years and what they represent. The "number of certificates" represents the valid certificates annually issued in the studied period of time. This means that decertifications are also taken into account and, thus, data are regularly updated. The "number of companies" reflects the number of certified companies (not the number of certified sites, nor the number of certificates). There is a substantial difference between the "number of certificates" and the "number of companies", in fact a single company may hold more than one certificate. However, in our specific situation, this difference is negligible and does not influence the results of this analysis.

Table 2 - Synthesis of the extend of the collected data, what they represent and their source

Country	*Years*	*Unit*	*Source*
Greece	2013-2015	n.° certificates	Greek Certification bodies
Italy	1999-2014	n.° companies	ACCREDIA
Portugal	2007-2013	n.° certificates	Portuguese Certification bodies
Spain	2008-2014	n.° certificates with standards implemented by Aenor	Aenor

In this study, data refers to IMS simultaneously certified (QES, i.e. Quality, Environment and Safety) according to ISO 9001, ISO 14001 and OSHMS 18001 standards. However, it must be highlighted that the required data for the whole time interval from 1999 to 2015 were not available for some of the analyzed countries. Hence, in order to obtain, at least, an estimate of data from 1999 until 2013 for the considered countries, the missing values for Greece, Portugal and Spain were estimated by extrapolating them from the ISO survey (ISO, 2015). In the Greek case, due to the lack of data, it was extrapolated what happened during the previous seven years (2012 until 2006) in order to had points of the exponential phase and the saturation phase. The next section describes the procedure used for the extrapolation. The initial collected data are not showed.

4.1. Estimation of the missing data in the period from 1999 to 2013 for Portugal

In other to achieve the extension of data pretended, the linear relations were studied between the number of certificates QES and the number of certificates to each standard studied. Analyzing the relations obtained (not showed), it can be observed that a linear relationship can be substantiated between the number of certificates QES and the number of certificates to the standards ISO 14001 (R-squared coefficient = 0,9613) and OHSMS 18001 (R-squared coefficient

= 0,9713). This finding was used along with the ISO survey data on ISO 14001 (no OHSAS certification international data available) to estimate the relationship of the individual certifications with the number of QES.

Observing the percentage of ISO 14001 used in QES presented in the Figure 3, it can be observed that in the years studied, there is an increasing trend between 2007 and 2012, with a last-year decrease. Analyzing the figure 3 it is also possible to verify a moderate linear relation between the % QES/ISO14001 and the year analyzed. The resulting equation (see Fig.3) was used to calculate the % QES / ISO 14001 percentage and obtain QES data since 1999 until 2007.

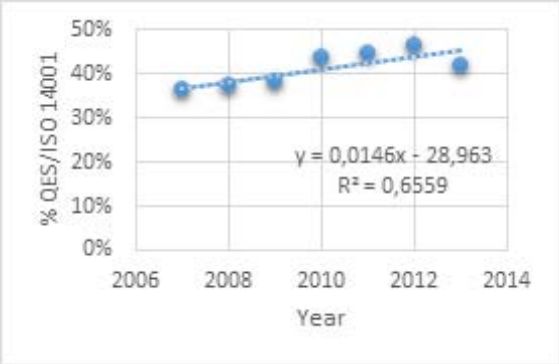

Figure 3 - Evolution of the %QES/ISO14001 from 2007 until 2013 from Portugal

The obtained QES data is presented in the Table 3. The data referring to the year 2008, it was not consider, since it was collected in August, and not in the end of the year, representing a point out of the path presented with the rest of the data collected.

4.2. Estimation of the missing data in the period from 1999 to 2014 for Spain

The starting point for the estimation of QES in Spain is the data provided by AENOR and the number of ISO certified companies (ISO, 2015).

In order to have an estimation of the QES population in Spain, the following parameters were considered for estimating the QES number.

The estimated yearly proportion of ISO 9001 certified companies with an integrated QES based on the AENOR data is calculated by the following equation (3).

$$p_i^*(QMS,QES) = \frac{QES_i}{QMS_i} \quad (3)$$

Consequently, considering the same yearly proportion of QES for the population of companies that have the ISO 9001 certification, the expected number of integrated MSs, when having ISO 9001, is written as follows in (4).

$$E^*(QMS,QES) = ISO9001_i * p_i^*(QMS,QES) \quad (4)$$

By using the same procedure, only now taking ISO14001 as reference, the expected number of integrated companies, when being ISO 14001 certified is calculated by (5):

$$E^*(EMS,QES) = ISO14001_i * p_i^*(EMS,QES) \quad (5)$$

Since both expected values take different references (ISO9001 and ISO14001), the average expected values of QES are used as estimations of the number of companies that have integrated MS at each level.

From years 1999 to 2008 the same proportions of ISO 9001 and ISO 14001 certifications relatively to QES are used, since the last available data provided by AENOR date back to 2008. The acquired data is presented in Table 3.

4.3. Estimation of the missing data in the period from 2006 to 2015 for Greece

In the Greek case, the data collected range only from 2013 to 2015. A data collection process similar to Portugal's was followed.

In this case, it was observed that QES number shows a linear relationship (R-squared coefficient greater than 0.8) with the number of companies certified to the ISO9001 and the OHSMS standards than to the number of companies certified to the ISO 14001 standard.

Due to the lack of less recent IMS (QES) data for Greece, a comparison was made with the evolution of the ISO 9001 certification percentage over the years for the Italian, Greek, Portuguese and Spanish cases. In the Figures 4, 5, 6 and 7 this evolution is presented for Italy, Greece, Portugal and Spain, respectively. These results are based on the data collected and not on extrapolated or estimated data.

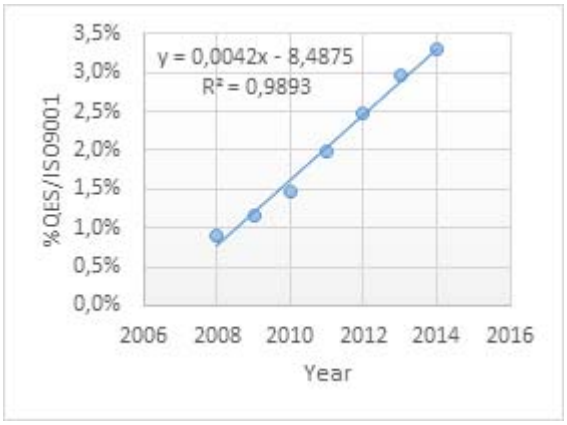

Figure 4 - Evolution of the %QES/ISO9001 from 2008 until 2014 from Italy

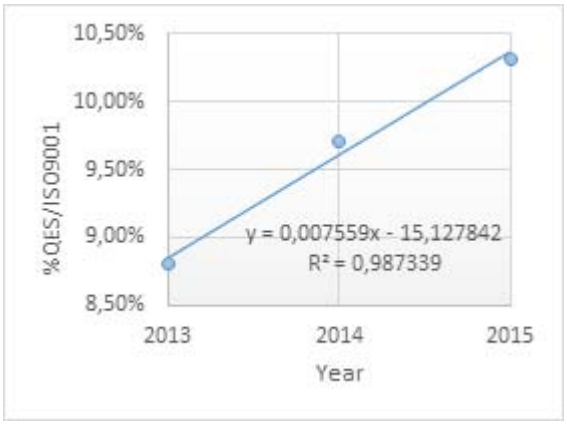

Figure 5 - Evolution of the %QES/ISO9001 from 2013 until 2015 from Greece

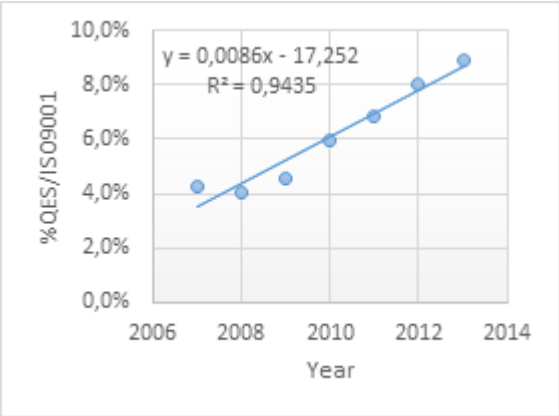

Figure 6 - Evolution of the %QES/ISO9001 from 2007 until 2013 from Portugal

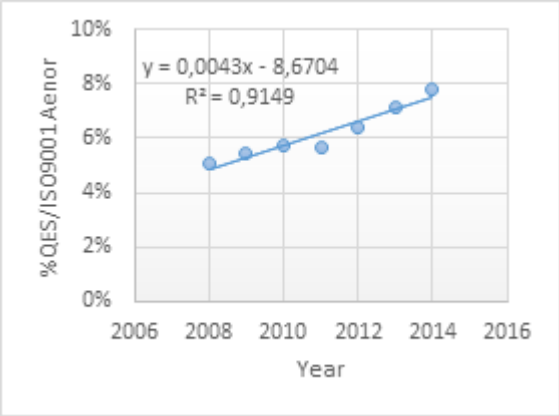

Figure 7 - Evolution of the %QES/ISO9001 from 2008 until 2014 from Spain

Comparing the different cases, it is possible conclude that the evolution of the %QES/ISO9001, in all cases, is crescent over the years, and has similar values, except for the Italian case. So, it was calculated the %QES/ISO9001 based on the data of ISO survey for the years back until 2006. Then, QES data was calculated for the time period ranging from 2006 until 2012. The data obtained is presented in Table 3.

Table 3 - Data used for constructing the forecasting models (note that **bold data** have been estimated)

Ano	*Counter*	*Greece*	*Italy*	*Portugal*	*Spain*
1999	1	-	3	**7**	**240**
2000	2	-	8	**12**	**472**
2001	3	-	32	**25**	**519**
2002	4	-	35	**40**	**835**
2003	5	-	53	**77**	**968**
2004	6	-	67	**131**	**1252**
2005	7	-	95	**170**	**1486**
2006	8	**168**	128	**199**	**1825**
2007	9	**221**	181	281	**2105**
2008	10	**341**	265	-	2280
2009	11	**292**	372	347	2198
2010	12	**284**	528	429	2419

2011	13	**305**	782	468	2120
2012	14	**387**	1060	577	2761
2013	15	353	1425	670	2316
2014	16	358	1759	-	2163
2015	17	308	-	-	-

Furthermore, the analysis of the Italian data seems to confirm proximity between the data collected and the estimation results. In fact the % QES/ISO9001 and the % QES/ISO14001 as a regular trend in the years after 2008 (see Figures 8 and 9). In Table 4 it is possible to verify that collected and extrapolated data for Italy are very close to each other.

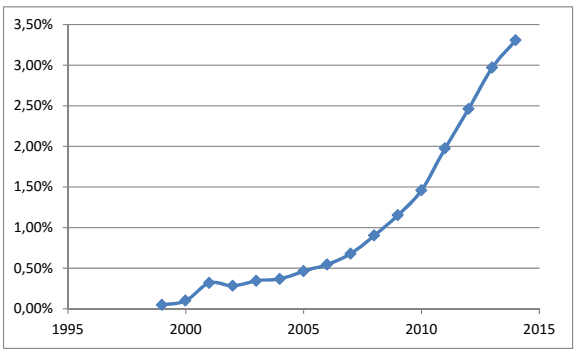

Figure 8 - Evolution of the % QES/ISO9001 from 1999 until 2014 in Italy

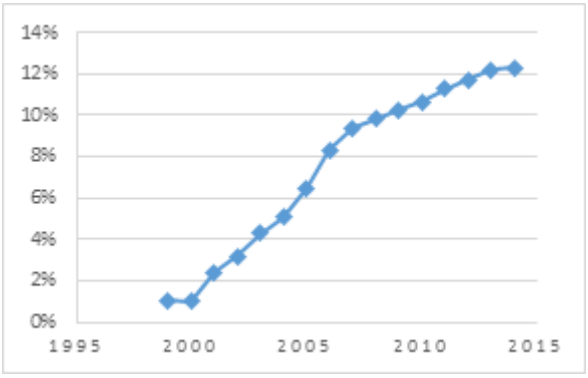

Figure 9 - Evolution of the % QES/ISO14001 from 1999 until 2014 in Italy

Table 4 – Comparison between collected and estimated data about QES certifications in Italy

Year	*Collected*	*Estimated ISO9001*	*Estimated ISO14001*
1999	3	26	1
2000	8	33	3
2001	32	41	6
2002	35	51	11
2003	53	63	15
2004	67	75	24
2005	95	84	35
2006	128	96	49

2007	181	110	143
2008	265	245	243
2009	372	406	381
2010	528	608	563
2011	782	833	789
2012	1060	1088	1050
2013	1425	1416	1397
2014	1759	1795	1766

4.4. Logistic and Gompertz model regression

The models for forecasting and analyzing the actual state of QES have been constructed considering data in Table 3 and using the second column ("Counter") as independent variable.

The parameters of each model applied to different countries are reported in Tables 5 and 6. With this data and the graphics presented in Figures from 10 to 17, it is possible to observe that the studied countries reach different levels of the growth. For example, observing the curves obtained for Greece and Spain, it is possible to conclude that these countries have already achieved the saturation level. Studying the statistic parameters of this two countries both models present a good fitting of data, and the final values of the saturation level respectively obtained with this two models do not present any significant difference. Therefore, it is possible to conclude that, applying this two models to countries that already reach the saturation level, similar results for the value of the saturation level can be obtained. Observing the Residual Sum of Squares it is also possible to conclude that, in the Greek case, the Gompertz curve describe better the growth, and in the Spanish case, the Logistic describes better the current dynamic.

Analyzing the values for Portugal and Italy, we found that both countries are positioned in the exponential phase of the curve, and very dissimilar results are obtained when applying each model. For Italy, it is quite obvious which forecasting model is the best fit based on the currently available data, because the saturation level predicted by the Gompertz curve is unrealistic, this could happen, because the construction of the model consider that the data used do not reached to the inflexion point and it is far from that, in the case of Gompertz. Furthermore, observing the Residual Sum of Squares, it is possible to confirm that the Logistic model performs much better than the Gompertz one. With more data (future data) could be possible to obtain better results.

Looking at the Portuguese data, it seems that Gompertz curve provides better statistic results than the Logistic curve. This is further confirmed by the Residual Sum of Squares. Then, it is concluded that, the Gompertz curve describes better the dynamics of QES growth until now for Portugal.

If comparing Portugal and Italy, the selected models respectively predict that Italy will achieve the saturation model approximately in 2025, while Portugal is still in the growing phase, this was an expected result, since Portugal is having a slower growth if compared to Italy.

Observing the actual results, it seems that Gompertz curve describes better the dynamics the countries with lower saturation level, and the Logistic curve describes better the diffusion of the countries with larger saturation level.

These results will be improved when more information will be added throughout the years, since, as mentioned in the literature review, the performance of the model is determined by the

provided information, i.e. by the number of data and their positioning along the curve shape (Meade and Islam, 1998).

Table 5 - Parameters and statistics for the Gompertz fitting of Greece, Italy, Portugal and Spain

	Gompertz			
Country	Greece	Italy	Portugal	Spain
a	338,888	62748,162	1945,016	2524,022
xc	7,529	34,010	15,878	4,401
k	0,730	0,070	0,105	0,302
Degrees of Freedom	7	13	11	13
Residual Sum of Squares	10430,931	7547,328	4605,993	425533,31
R-Square	0,660	0,998	0,993	0,956

Table 6 - Parameters and statistics for the Logistic fitting of Greece, Italy, Portugal and Spain

	Logistics			
Country	Greece	Italy	Portugal	Spain
a	336,275	3709,132	996,990	2421,936
xc	8,016	16,213	12,908	5,646
k	0,927	0,413	0,296	0,475
Degrees of Freedom	7	13	11	13
Residual Sum of Squares	10547,777	2866,908	7368,164	339517,019
R-Square	0,656	0,999	0,988	0,965

Gompertz Curve

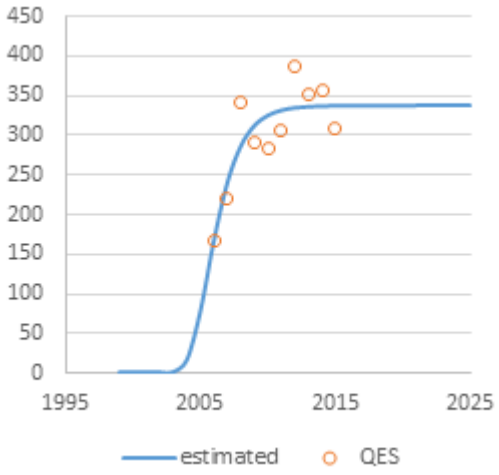

Figure 10 - Gompertz curve (Greece).

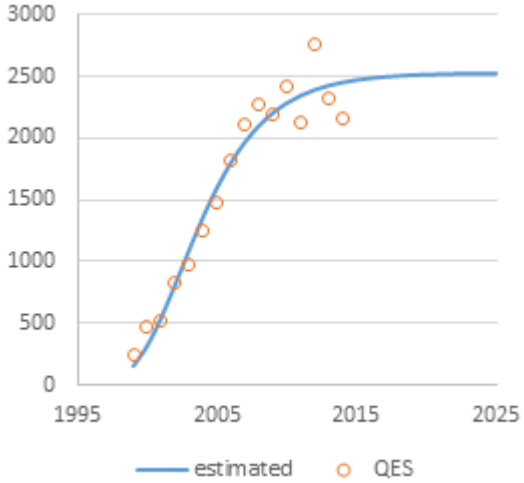

Figure 11 - Gompertz curve (Spain).

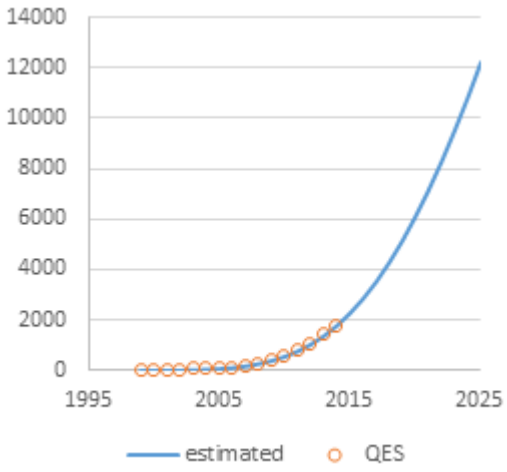

Figure 12 - Gompertz curve (Italy).

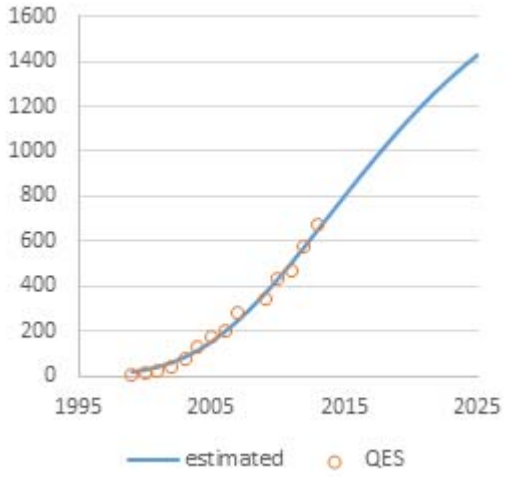

Figure 13 - Gompertz curve (Portugal).

Logistic Curve

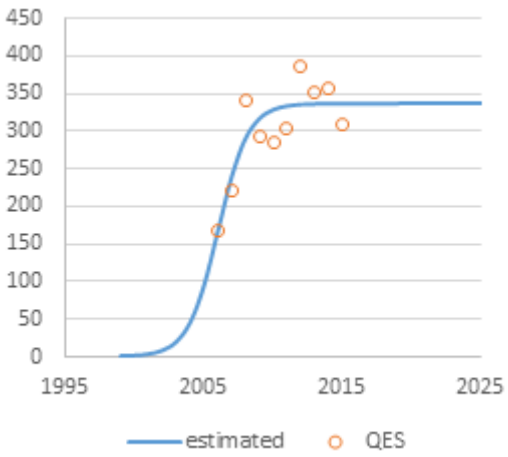

Figure 14 - Logistic curve (Greece).

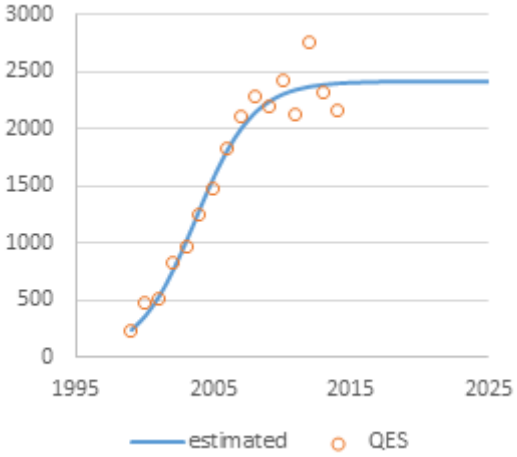

Figure 15 - Logistic curve (Spain).

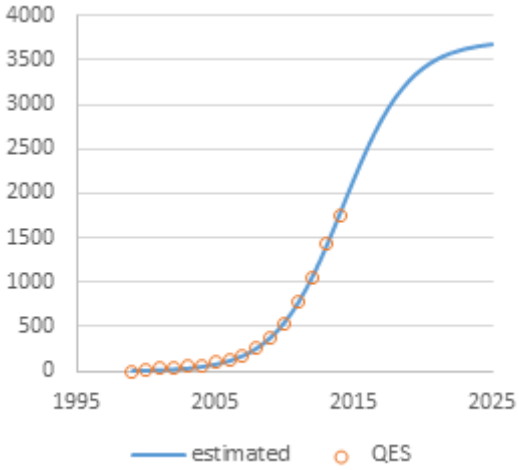

Figure 16 - Logistic curve (Italy).

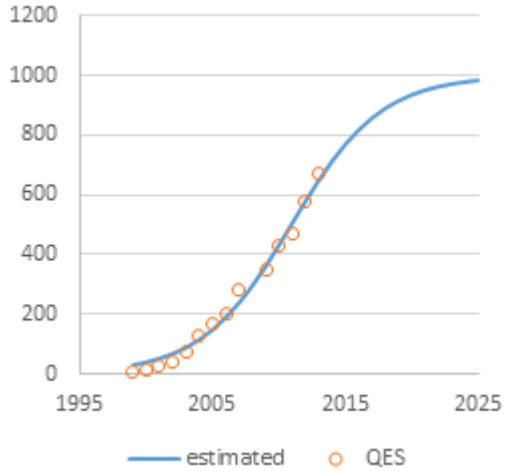

Figure 17 - Logistic curve (Portugal).

5. CONCLUSIONS

Basing on the gathered information, it is possible to conclude that, despite the geographic proximity between the countries that participated in this research (all of them being South European) cross-country results show significant dissimilarities, with regard to QES evolution.

However, there is a similar growing trend in the percentage of ISO9001 used in the QES across the participating countries. In the case of Greece and Spain, this happens, due to their decrease of ISO9001 certification rates in the last years. In the case of Portugal and Italy, the implementation of ISO9001 has increased, and the %QES/ISO9001 has increased, as well, which means that, in the last few years, domestic companies decided to integrate more.

In relation to the considered forecasting models, Gompertz and Logistic, it was found that Greece and Spain have already reached the QES saturation level and the results of both models are similar in respect with the saturation level, yet Gompertz model describes better QES evolution in Greece, whereas Logistic describes better the Spanish case.

When both models are applied to the countries found in the exponential phase, i.e. Portugal and Italy, the results are very different. In order to define which one is the best fit model in this case, more research is needed to study the trends of the countries and the factors that affect the trend of diffusion within these countries, with respect to QES.

In general, it was concluded that a single model does not fit all the paths described for the countries studied, as in the countries that already achieved the saturation level, i.e. Greece and Spain that had all the necessary information for the construction of these models in their data yet leading to different conclusions (Gompertz better for Greece, Logistic better for Spain).

The lack of information relatively to the IMS are the main limitation of the present study. The only country where data extension was available was Italy since IMS data since 1999 until 2013 were provided. Data from Greece only refers to years since 2013 until 2015. In the case of Portugal, it was needed to extrapolate data from 1999 until 2007. In the Spanish case, data for the years since 2008 until 2014 were estimated based on the AENOR and ISO survey data, and it was needed to extrapolate data for the years before. These estimations and extrapolations introduced some uncertainty in the results.

Future research on Integrated Management Systems would further highlight whether the trend of the concurrent implementation of more than one standard is increasing, which will be the impact of the actualization of the standards in the present trends. Another interesting research topic is the impact of the OHSMS 18001 turning into an ISO standard on QES evolution. Furthermore, the study of IMS diffusion across more countries may lead to more robust conclusions, shedding light on possible causes for the different state and dynamics of growth.

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