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ISO 9000 and ISO 14000 standards: an international diffusion model

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Abstract

Purpose – In an economic environment characterized in recent years by globalization and the integration of economic processes, standardization in management systems has had a high growth. In this context, there has been a remarkable increase in certain standards, or norms, issued by international organizations. Among these standards, two main groups stand out, both issued by the International Organization for Standardization (ISO): one for quality management systems – the family of ISO 9000 standards – and the other for environmental management systems – the ISO 14000 standards. This paper aims to analyze the world wide diffusion process of these two standards, using data provided by the ISO itself.

Design/methodology/approach – The methodology proposed is developed in four separate phases. The first two analyze the diffusion model over time with a model based on the logistic curve proposed by Franceschini *et al.* The next two phases analyze whether the diffusion process has proceeded in a relatively homogeneous way in the different sectors of activity. In order to do that, the use of indices of concentration and instability has been carried out.

Findings – The conclusion is that the diffusion of both standards is very similar – in general and in terms of the different sectors. This result coincides with certain hypotheses formulated in the theoretical literature.

Originality/value – This is the first paper where it can be demonstrated that, world-wide, both the ISO 14000 and the ISO 9000 standards have followed very similar patterns of diffusion in their expansion.

Keywords ISO 9000 series, Diffusion, Quality management, Standardization, Management techniques

Paper type Research paper

1. Introduction

In recent years, there has been major growth in standards issued by organizations involved in standardization in the field of economic activities. This surge in

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standardization has been due, to a great extent, to the marked process of globalization and economic integration experienced in western economies throughout the two last decades (Mendel, 2001).

Standardization may be defined, generically, as an activity aimed at organizing applications and operations, which repeatedly take place in areas of industry, technology, science and the economy. Standardization was first conceived, at the beginning of the twentieth century, as a means to limit the uneconomical diversity of components, parts and supplies in order to favor their interchangeability, which in turn would facilitate mass production and the repair and maintenance of products and services (Dale, 2002). At present, there is a large number of international and national standards whose aim is to order and to systematize, among other things, the implementation of business management systems in relation to a wide variety of functions and operations, such as quality improvement (ISO 9000, QS 9000, EAQF, VDA, etc.), environmental impact (ISO 14000 and EMAS), occupational safety (OHSAS 18001), corporate social responsibility (SA 8000, AA 1000 or the ISO CSR or UNE 165010 projects), Research, Development and Innovation (RDI) activities (the experimental standard UNE 166000 EX) and activities related to management of human resources (the Investors in People standard). All of these standards have very similar methodologies, which include creation, structure and implementation processes, plus verification by a third party. By far the most successful, in terms of diffusion, are two groups of standards issued by the International Organization for Standardization (ISO): the ISO 9000 series of standards, related to the implementation of quality assurance systems, and the ISO 14000 series, related to the implementation of environmental management systems.

The paper examines how the diffusion of management standards takes place. Specifically, we analyze the diffusion of the ISO 9000 and the ISO 14000 standards and the parallels between the two processes. We investigate whether it occurs in an analogous way in individual countries and in different sectors of economic activity, and we propose an empirical diffusion model. This model is initially based on a previous research (Franceschini *et al.*, 2004) on ISO 9000 certifications.

Consequently, this paper has two objectives. First, it will examine whether the diffusion of the ISO 9000 and the ISO 14000 standards occurs in an analogous way over time. Secondly, it will analyze whether the diffusion phenomenon is parallel through different sectors of economic activity.

2. The diffusion of ISO 9000 and ISO 14000: review of the literature

2.1 The diffusion of ISO 9000 and ISO 14000

It is widely accepted that the ISO 9000 series of standards are the most popular reference model for setting up quality assurance systems in organizations. These standards, based on the BS 5750 series developed in 1979 by the British Standards Institution (BSI) in the United Kingdom, were first established in 1987, but their world wide success was a result of the revision carried out in 1994. The results of the most recent revision (2000) remain to be seen.

The ISO 9000 standard does not attempt to measure the quality of the products or services of companies, i.e. they make no reference to achieving a certain objective or result. They are, instead, standards, which establish the need to systematize and to formalize company tasks with the objective of producing products, or services that

meet customer demands. In other words, they are a management tool based on the systematization and formalization of tasks in order to obtain uniformity in the product and to conform to the specifications established by the customer (Anderson *et al.*, 1999).

On the other hand, the ISO 14000 standard, published in 1996, establishes a reference model for implementing environmental management systems in companies. These systems can be defined as the part of a company's global management which encompasses the organizational structure, the planning activities, the responsibilities, practices, procedures, processes and resources required to elaborate, apply, review and maintain the environmental policy of the company. The structure and philosophy of ISO 14000 is very similar to ISO 9000. It is not designed to measure the environmental impact of the companies that implement it, but rather to be a set of standards that establish how to systematize and formalize the procedures related to the processes of environmental impact in the company. In fact, during the elaboration of the ISO 14000 standard, the committee that created it, the ISO's technical committee 207 (ISO/TC207), quickly realized that for the standard to be widely accepted it had to be compatible with ISO 9000. That is why, as Poksinska *et al.* (2003) demonstrate, the implementation of ISO 9000 clearly facilitated the subsequent implementation of ISO 14000.

The ISO 14000 standard is not a standard of objectives or results, but of procedures. In addition, as Corbett and Kirsch (1999) state, ISO 14000 focuses on many aspects other than the environmental ones, and, therefore, should not be thought of as designed solely for a certain type of company with a high environmental impact, but as a standard that can be applied to most organizations.

Although there are major similarities between both standards, each series has its own particular elements to distinguish it from the other. It is noteworthy, for example, that the ISO 14000 standard does include, although rather weakly and ambiguously, a reference to meeting certain environmental objectives, since it establishes that companies will have to commit themselves to meeting the basic standards and environmental regulations of their respective countries. In addition, ISO 14000 takes into consideration other stakeholders that ISO 9000 does not.

There is currently a great deal of academic controversy about the integration of management systems (Beechner and Koch, 1997; Karapetrovic and Willborn, 1998, among others). In this case it mainly concerns systems of environmental management and quality, since the integration of each is often confused with the simple fusion of the documentation of both systems. There is no doubt that the similarities between both standards – in terms of the design, the language, the structure and the methodology of certification – facilitates this integration, but such integration must be carried out not only to cut costs, but also to improve efficiency (Karapetrovic and Willborn, 1998).

In terms of the diffusion of the two standards, it is well known that they have been very successful, particularly the ISO 9000 standard. The latest data provided by ISO (ISO, 2003) indicates that in December of 2002 there were already 561,747 certifications in 159 countries with ISO 9000-certified companies around the world. When the ISO 14000 standard was published, there were already 127,349 ISO 9000 certifications. Like ISO 9000, ISO 14000 has also spread throughout the world, although, so far, not with as much success. The latest available data, also from December of 2002 (ISO, 2003), indicates that there were 49,462 certifications in a total of 118 countries.

Having said that, just how has this diffusion come about? Do they follow analogous models? If both standards follow parallel paths, could they be extrapolated to other,

subsequent standards? These are the main issues raised in this work, since in the literature only the diffusion of the ISO 9000 standard has received much attention.

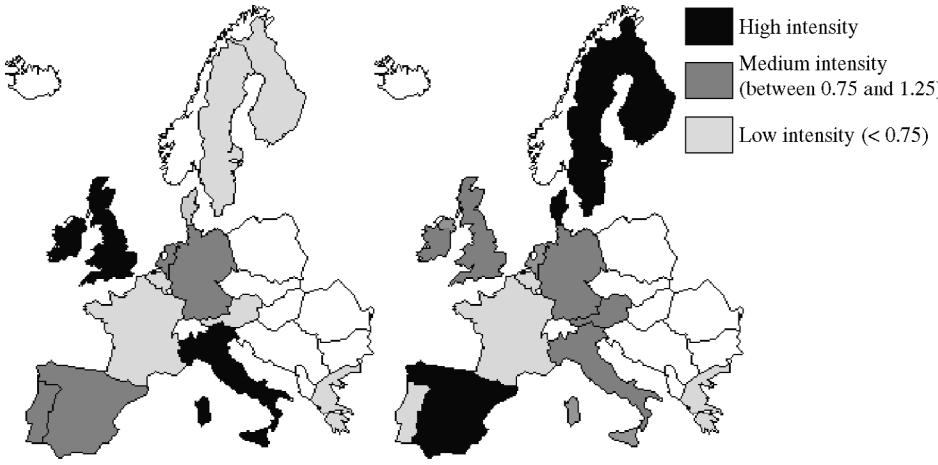
In its early stages, ISO 9000 began to spread around the world from European Union countries, specifically from the United Kingdom, where these standards originated. In 1996, more than 62 percent of certificates in the world were found in the EU (of which more than 50 percent had been issued in the United Kingdom and the number of certificates issued in Austria and the Netherlands was also very high compared to other EU countries). This may have been due, to a large extent, to the fact that various administrations and European institutions very actively supported the use of ISO 9000 in working towards harmonization in the European Union (Peach, 2002). The ISO 14000 standard, on the other hand, did not spread in the same way because the factors that stimulated and promoted its propagation were different, as has been analyzed in the literature (Corbett and Kirsch, 2001; Nakamura *et al.*, 2001; Pan, 2003; Poksinska *et al.*, 2003). An analysis of the density of ISO 9000 and ISO 14000 certificates in European Union countries during 2002 is presented in Table I, an index of our own design that measures the relationship between the percentage of certificates in each country with respect to the European total and each country's percentage contribution to the European GDP[1].

The results obtained are shown graphically in Figure 1, which clearly shows how little a relationship there is between the two. It is clear, for example, that the Nordic countries have a low intensity of ISO 9000 certifications and, yet, have among the highest intensities of ISO 14000 certifications. In short, just as Corbett and Kirsch (2001) have pointed out, there are countries that lead the way in movements such as these and in Europe the Nordic countries (which are historically the most environmentally proactive) have assumed this role and head the ranking in certifications of this type. In contrast, ISO 14000 certification is noticeably less important in the United Kingdom, despite it being the historical world leader in ISO 9000 certifications.

Country	Gross domestic product (GDP)	ISO 9000 certificates	Intensity in ISO 9000	ISO 14000 certificates	Intensity in ISO 14000
Austria	207,038	4,000	0.71	429	0.89
Belgium	247,469	4,670	0.69	264	0.46
Denmark	173,889	2,163	0.46	711	1.76
Finland	131,145	1,870	0.52	750	2.46
France	1,416,877	20,919	0.54	1,467	0.44
Germany	2,030,000	41,629	0.75	3,700	0.78
Greece	123,122	2,325	0.69	89	0.31
Ireland	102,910	3,700	1.32	289	1.21
Italy	1,164,767	48,109	1.51	2,153	0.79
Luxembourg	20,815	108	0.19	17	0.35
Netherlands	402,599	12,745	1.16	1,073	1.14
Portugal	115,042	2,474	0.79	137	0.51
Spain	609,319	17,749	1.07	3,228	2.28
Sweden	260,120	4,652	0.65	2,730	4.5
UK	1,559,392	66,760	1.57	2,917	0.8

Source: Elaborated form ISO surveys and EUROSTAT information

Table I.
Intensity in ISO 9000 and ISO 14000 certificates in the Europe Union (2002)



Source: Elaborated from ISO surveys and EUROSTAT information.

Figure 1.
Intensity of ISO 9000 certification (left) and of ISO 14000 (right) in 2002

At first it might have been thought that those countries with the most ISO 9000 certificates would also lead the way in terms of ISO 14000 certification, due to the often-cited similarities in structure and implementation procedures of the two standards. However, when the diffusion of each standard for each country is analyzed, the empirical evidence does not corroborate this. In fact, the impact of each standard in individual countries is highly divergent.

2.2 Previous research

The ISO 9000 phenomenon has raised a great deal of interest among researchers and has been widely studied. Internationally, there is a large number of empirical works on ISO 9000 implementation (Brown and Van der Wiele, 1995; Withers and Ebrahimpour, 1996; Vloeberghs and Bellens, 1996; Terziovski *et al.*, 1997; Romano, 2000, among others).

Analysis of ISO 14000 implementation is not as common in the literature, although various studies at the international level have been carried out (Van der Welt, 1997; Nakamura *et al.*, 2001, among others). The results of these investigations are very diverse, although it is generally possible to say they all highlight the great importance of external factors, such as the motivating factors behind implementing ISO 14000, while the main benefits detected have much more to do with bettering relations with the various stakeholders involved and improving organizational control, rather than improving quality-related indicators and reducing the environmental impact of products and services.

There are some recently published studies, which by taking advantage of the analogies existing between the standards, have compared their diffusion. There is, for example, an interesting study by Pan (2003) analyzing the motivation for and the benefits of ISO 9000 and ISO 14000 certification in four countries in the Far East: Japan, Taiwan, Korea and Hong Kong. After studying eight aspects common to both cases, Pan is the first author to detect a strong link between the motivations involved in implementing ISO 9000 and ISO 14000 and the benefits of certification.

With very similar objectives, the study by Poksinska *et al.* (2003) in Sweden draws similar conclusions. They find, for example, a great deal of similarity in the benefits

obtained by applying each standard. This is explained by the fact that the improvements in organizational efficiency and control brought about by ISO 14000 are more important benefits for the organization than any actual improvements in environmental performance.

Literature referring to the diffusion of these standards is very scarce. This is not the case with studies of the diffusion of various other management tools and systems, which is a subject that has received great interest on the part of academics from various fields (the summary by Roger (1995) is very interesting in this respect). In particular, there have been many investigations into the diffusion of technological innovations which could also be applied in some form to administrative innovations, as indicated by Teece (1980), who established that analytical models of the diffusion of technological innovations are not limited to tangible products. It can be deduced from these studies that, broadly speaking, the cumulative adoption of innovations over time follows an S-shaped or sigmoid curve, reflecting the fact that few members of a social system actually adopt an innovation during the first stages, but as time goes on the rate of adoption of the innovation rises until the process approaches its saturation point, whereupon the growth rate begins to fall. Stoneman (1995) points out that this model is usually a good explanation of the phenomena of diffusion in the field of new technologies. This is the evidence found in the literature that led to the idea of applying a similar model to the present case.

For the specific case of management standards, as we have said, the literature is scarce. Recently, two works have appeared which provide a descriptive analysis of the diffusion process of the ISO 9000 standard over time. On the one hand, Saraiva and Duarte (2003) present the first research aimed at predicting how ISO 9000 certification will develop around the world in the future. From an index calculated according to the number of ISO 9000 certificates per inhabitant (using a simple regression model), they identify the leading countries and analyze how the saturation level is close to being achieved. At the same time, they forecast the development of ISO 9000 certification between 2002 and 2006. Similarly, a second investigation carried out by Franceschini *et al.* (2004) analyzes in greater detail some of the areas examined by Saraiva and Duarte (2003). Thus, using a modified logistics curve for a fixed population, they first approach the idea of ISO 9000 diffusion in six European countries, detecting what the saturation levels are for each country, i.e. the maximum number of companies in each country that will undergo certification. Although the analysis was only exploratory, it is very interesting to observe how well the model adjusts to the real data in all the analyzed countries, which makes it, without doubt, a good starting point for the present study.

Nevertheless, as far as this study is concerned, the studies carried out by Corbett on the diffusion of the ISO 9000 and ISO 14000 standards are of greater interest. Although they all deal with the mechanisms of diffusion rather than to actual diffusion over time, a first study (Corbett and Kirsch, 1999) established that the number of a country's ISO 14000 certificates is very positively related to the number of ISO 9000 certificates and, to a lesser degree, to the level of environmentalization (measured by the number of environmental treaties signed) and the level of exports of the country. In contrast, it is independent of the country's level of development. The results obtained in this investigation were later corroborated in Corbett and Kirsch (2001), not only from the analyses of the existing data they had used previously, but also from the impressions

received during visits to several ISO 14000-registered companies around the world (Corbett and Kirsch, 2000). It must be remembered, however, that this study, while interesting, is of a static nature and does not analyze the development of the two standards over time. Vastag (2003) further analyzed the resulting data, concluding that only the number of ISO 9000 certificates and the degree of environmentalization of the country are related to the total number of ISO 14000 certificates.

Subsequently, Corbett (2003) analyzed the forces that explain the diffusion of these standards, basing his study on the Bass diffusion model (Bass, 1969), and showing how it is carried out through the supply chain. His model explains that ISO 9000 certification basically began in Europe and spread from there to other countries because the European companies put pressure on their suppliers to seek certification. It also appears from this study that companies exporting goods or services to a certain region simultaneously import management practices to their company as well as to their whole area of influence (Corbett, 2003).

We believe these studies are interesting not only because of their capacity to describe and predict the actual process of diffusion of these international standards, but also because they offer certain empirical evidence as to whether or not there is an analogy between the process of diffusion of these standards and the diffusion of innovations in general. We believe there may be a link between these studies and others of a theoretical and empirical nature, already becoming traditional in the field of business management and organization and dealing in particular with the influence of fashionable practices in business management. Abrahamson (1991, 1996) are the two studies that stand out in this respect.

3. Methodology used for studying the diffusion

Three hypotheses will be contrasted to address the two objectives proposed (Table II). The two first are related to the first objective whereas the last one is related to the second.

H1a. The diffusion pattern of the ISO 9000 and ISO 14000 standards on a global scale follows a logistic curve.

H1b. The diffusion pattern of the ISO 14000 standard applied to an individual country follows a logistic curve (as does the ISO 9000).

H2. The evolution of both standards, ISO 9000 and ISO 14000, through different economic activity sectors has been similar.

The methodology proposed is developed in four separate phases. The first two analyze the diffusion model over time, the first objective of this research, in Section 4 of this paper, while the other two analyze the sectors involved, the second objective, in Section 5.

It must be remembered that the focus of this paper is not on explaining why these standards are diffused, but rather on how they diffuse, in the sense of how fast and how extensively. We are more interested in analyzing the diffusion rates and the evolution of the quantity of certificates than in the reasons for the diffusion. Although stress is placed on quantitative aspects, we will also attempt to explain the different growth rates for each norm.

Objectives	Hypothesis	Phases	Statistical techniques
The diffusion of the ISO 9000 and the ISO 14000 standards occurs in an analogous way over time	*H1a*. The diffusion pattern of the ISO 9000 and ISO 14000 standards on a global scale follows a logistic curve	1. The diffusion pattern of both (ISO 9000 and ISO 14000 standards) in a world wide scale follows the logistic curve	Logistic curve regression
	H1b. The diffusion pattern of the ISO 14000 standard applied to an individual country follows a logistic curve (as does the ISO 9000)	2. The diffusion pattern of ISO 14000 applied to an individual country follows a logistic curve	Logistic curve regression
The diffusion phenomenon is parallel through different sectors of economic activity	*H2*. The evolution of both standards, ISO 9000 and ISO 14000, through different economic activity sectors has been similar	3. The evolution of both standards, through each economic activity sector, has been similar over time	Evolution of Herfindhal index Evolution of Instability index
		4. The share of certifications of each economic activity sector is similar in both norms, comparing equivalent instants of maturity of each standard	Wilcoxon text applied in equivalent moments of maturity

Table II.
Objectives, hypothesis, phases and statistical techniques of the research

The first stage of our investigation will begin by analyzing, on a world wide scale, if the model based on the logistic curve, proposed by Franceschini *et al.* (2004), can only be adapted to explain the evolution of ISO 9000 certifications, or whether similar models can also be used to analyze the evolution of ISO 14000 certifications. Similar behavior would indicate that the diffusions of standards follow, in principle, similar parameters, although a certain temporal mismatch has already been detected.

In the second stage, we will investigate whether these models can be used solely in terms of data gathered at the world wide level, or whether they can also be adapted to each individual country involved, as Franceschini *et al.* (2004) showed for different European countries. To do this, bearing in mind the difficulty involved in analyzing all the countries involved, four countries were selected for analysis: Spain, because it is the authors' country of origin, as well as the third country in the world ranking of absolute growth during 2002, with 1,164 new ISO 14000 certifications; the United Kingdom, because it is a country with a strong tradition of ISO 9000 certification; the USA, because of recent strong growth in both standards, and its potential for very considerable growth due to its economic power; and finally, Japan, because of its spectacular growth, making it currently one of the world leaders in ISO 14000 certifications. It should be pointed out that the case of Japan is rather special since many Japanese companies, not without reason, believed at first that their own quality management practices were superior to those applied in the countries that were ISO 9000 pioneers and that certification would, therefore, be a step backwards.

Nevertheless, due to the demands of their European customers in 1990s, Japanese companies subsequently began to seek ISO 9000 certification. This led to completely different behavior with respect to ISO 14000 from the very beginning (Corbett and Kirsch, 1999).

Thirdly, it would also be interesting to find out whether the diffusion process has proceeded in a relatively homogenous way in the different sectors of activity or if, on the contrary, certification has clearly occurred more quickly in certain ones. Given that it is practically impossible to analyze all the sectors in all the countries involved, an analysis has been carried out using indices of concentration and instability. The concentration index will show whether or not a large number of certifications are grouped together in just a few sectors of economic activity, whereas the instability index will give us an idea of the capacity of each sector to maintain its relative position within the ranking.

Finally, the fourth stage aims to check if there is any relationship between sectors certified according to one standard or the other by carrying out an analysis of non-parametric resistance. We want to contrast whether the leading sectors in implementing the ISO 9000 standard have also been pioneers in the implementation of ISO 14000. Verifying that the sectors involved are very similar would provide more arguments in favor of the similarity of diffusion of the two standards, as well as of the possible future standards.

4. Explanatory model of the diffusion

The model used to analyze the diffusion of ISO 9000 and ISO 14000 – adapted from the model used by Franceschini *et al.* (2004) – is based on the supposition that the growth of certifications of each standard is proportional to the number of existing certifications and that this growth rate is also a function of the number of certifications, both for the general economy as well as for the different economic sectors.

This model was first applied by the Belgian mathematician Verhulst in the nineteenth century (Boyee and Di Prima, 1992), in the field of Biology, to explain the growth of a species. According to this model, the growth rate is at its highest in the beginning, when there are very few individuals of the species and hardly any competition for the limited resources; it is then reduced to zero when the population reaches a certain size. This is the population size, at saturation point, that the available resources allow. This model, represented by the following expression, is developed in the Appendix.

$$N = \frac{N_0 K}{(K - N_0)\mathrm{e}^{-r_0 t} + N_0}$$

In this expression, N is the number of certifications (function of time), N_0 is the initial number of certifications, K is the maximum level that can be attained or the saturation point and r_0 is the initial growth rate.

In applying this model to the number of ISO 9000 and ISO 14000 certifications existing world wide until 2002, we get the parameterized logistic curve shown in Table III, showing how both series are well explained by the logistic model since both determination coefficients are greater than 0.99. This verifies how well these logistic curve models fit the diffusion of management standards, confirming the first hypothesis.

Table III.
Statistics of the certificates ISO 9000 and ISO 14000 regressions applying of the logistic curve

	DF	Estimate	Sum of squares	Asymptotic std. error	Mean[2]	Asymptotic 95 percent confidence interval Lower	Upper
ISO 9000 certificates world wide regression[a,b]							
Dependent variable: ISO 9000 world wide certificates							
Source							
Regression	3		1,038,195,251,858		346,065,083,953		
Residual	8		905,463,045.266		113,182,880.658		
Uncorrected Total	11		1,039,100,714,903				
(corrected total)	10		337,015,670,695				
$R^2 = 1 -$ Residual SS/Corrected SS = 0.99731							
Parameter							
N_0		43,102.8528		4,201.0725		33,415.1622	52,790.5434
K		817,539.0186		67,398.7551		662,117.2107	972,960.8266
r_0		0.3693		0.02372		0.3146	0.4240
ISO 14000 certificates world wide[a]							
Dependent variable: ISO 14000 world wide certificates							
Source							
Regression	3		4,603,582,247.41		1,534,527,415.80		
Residual	8		1,969,654.5888		393,930.9178		
Uncorrected Total	5		4,605,551,902.00				
(corrected total)	7		2,249,209,301.50				
$R^2 = 1 -$ Residual SS/Corrected SS = 0.9991							
Parameter							
N_0		1,013.1052		150.5268		626.1636	1,400.0467
K		77,416.9573		5,922.3611		62,193.0435	92,640.8711
r_0		0.6999		0.03719		0.6043	0.7955

Notes: [a] Data are of December 31 of each year; [b]Data related to years 1993 and 1994 have been interpolated

Figure 2 shows the two logistic curves including the limits that mark a confidence interval of 95 percent, as well as the moment at which 95 percent saturation is achieved. This allows us to make a preliminary estimation of the moment at which the growth will stagnate, i.e. the moment at which point the process will be very close to the asymptote of the model. The ISO 9000 saturation point is expected in 2008, whereas ISO 14000 will reach its saturation point two years earlier. Thus, the newest standard will mature first. This premature ageing of the more recently applied standard is due to its strong growth rate. While the initial growth rate of the ISO 9000 standard is 0.37, it reaches 0.70 for the newer ISO 14000. It can also be seen how the number of ISO 9000 certifications seems to stabilize at about 800,000 world wide, whereas ISO 14000 certifications do so at around 75,000 certificates.

Was this development in the number of certificates to be expected? From our point of view, the answer is yes. The studies analyzing the motivation for the implementation of these standards emphasize the relative importance of external factors over internal ones (Vloeberghs and Bellens, 1996; Withers and Ebrahimpour, 1996; Anderson *et al.*, 1999; Lee and Palmer, 1999; Casadesus *et al.*, 2001), although internal factors having to do with improvements in efficiency in the company also play an important role (Carlsson and Carlsson, 1996; Sohal and Terziovski, 2000; Martínez *et al.*, 2001; Escanciano *et al.*, 2001; Gotzamani and Tsiotras, 2002, among others). Specifically, empirical studies show that some of the most important external factors

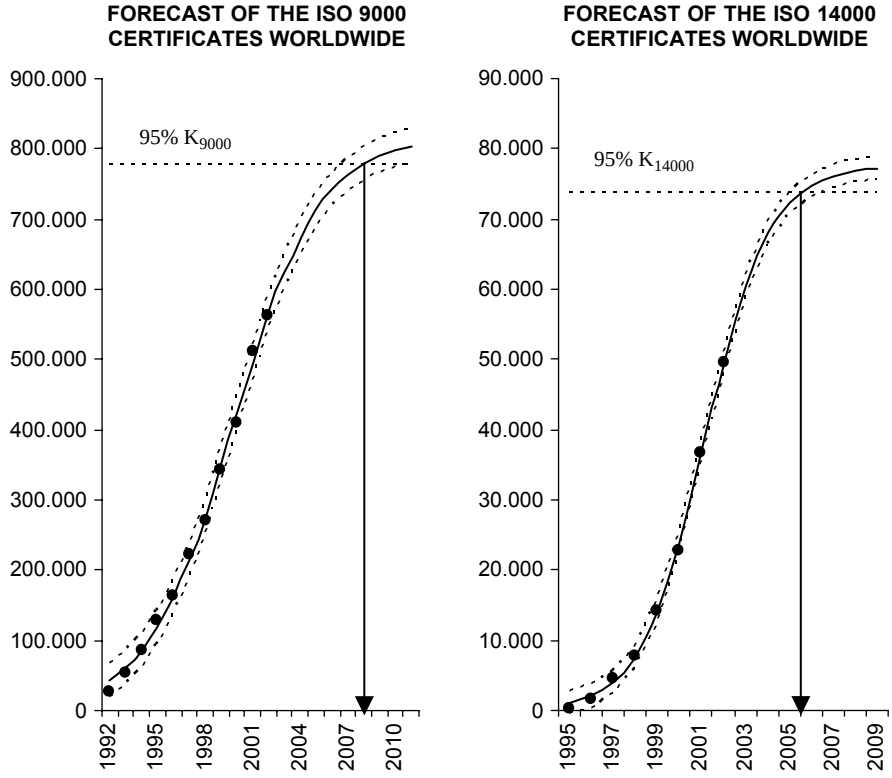


Figure 2.
World wide forecast of ISO 9000 and ISO 14000 certificates

concern customer demands, as well as the desire of companies to stand out from the crowd by having the certificate (Meegan and Taylor, 1997; Jones *et al.*, 1997; Lipovatz *et al.*, 1999; Casadesus *et al.*, 2001, among others). These factors, along with active promotion by governments and other bodies promoting the adoption of this type of innovation (business consultants, foundations, associations, etc.), have led to exponential growth in the number of certificates (Marimon *et al.*, 2002). However, at some time, fewer and fewer companies show any interest in obtaining certification because, for example, the perceived competitive advantage of having the certificate diminishes. The economic/financial analogy seems clear: the value of the certificate is inversely proportional to the number of certificates in circulation. In short, there is a clear decrease in the number of certifications and a gradual tendency towards a saturation point.

Figure 3 shows the development of both phenomena side-by-side. The black points correspond to known historical data, while the white points are estimated from the logistic models of each series. At the beginning the growth of ISO 9000 is relatively strong (these are years in which ISO 9000 is already very popular and spreading quickly), whereas ISO 14000 is still relatively unknown. From the year 2000 and forecasted until 2006, ISO 14000 grows more quickly. The following years are represented with superimposed points, indicating that the level of maturation of both standards has been reached: their growth comes to a standstill.

As was mentioned in the methodology section, a second phase of the study consists of analyzing how these models can adapt not only to the aggregated data, but also to the data for each individual country implementing the ISO 9000, as demonstrated by Franceschini *et al.* (2004) for different European countries. To do so, the logistic model was adjusted to the ISO 14000 certifications in the four countries we decided to analyze. The resulting models are shown in Table IV, in which it can be seen how well the theoretical models fit. On the other hand, Franceschini *et al.* (2004) affirm that ISO 9000 certifications in an individual country also fit the logistic curve, so the second hypothesis is confirmed.

Figure 4 shows the data gathered in graphical form, showing how Spain will arrive at the threshold of 95 percent of its potential towards the end of 2004. However, in

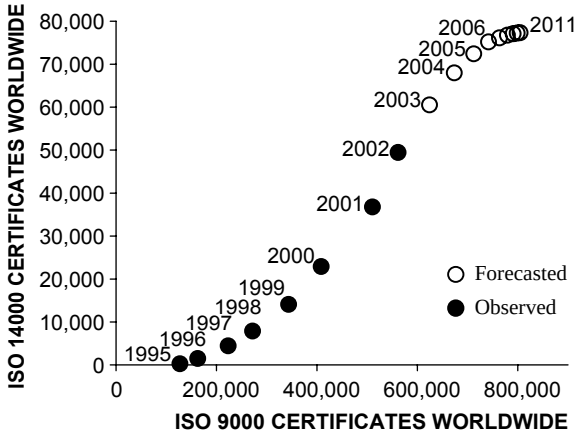


Figure 3.
Evolution of ISO 9000 and ISO 14000 world wide certificates

Table IV.
Regression results obtained by the logistic model for ISO 14000 certificates in Spain, Japan, UK and USA

Regressions of ISO 14000 taking the logistic curve.

	Spain		Japan		UK		USA	
	DF	Sum Sq	DF	Sum Sq	DF	Sum Sq	DF	Sum Sq
Regression	3	15247817.58	3	221593023.07	3	25815345.77	3	11133129.34
Residual	5	156120.42	5	59219.93	5	120429.23	5	19634.66
Uncorrected Total	8	15403938.00	8	221652243.00	8	25935775.00	8	11152764.00
(Corrected total)	7	9735593.50	7	110863187.87	7	9078053.87	7	6115626.00
R squared	0.98396		0.99947		0.98673		0.99679	

	Value	Ll	Ul	Value	Ll	Ul	Value	Ll	Ul	Value	Ll	Ul
N_0	4.79	-13.74	23.31	134.31	86.44	182.17	102.70	-17.58	222.97	40.06	5.60	74.52
K	5013.92	359.67	9668.18	13457.57	12246.57	14668.54	3169.94	2565.71	3774.16	5625.22	1394.11	9856.34
r_0	1.0813	0.3153	1.8474	0.8424	0.7563	0.9284	0.8757	0.5095	1.2418	0.6840	0.4804	0.8875

Ll: Lower limit of the 95% confidence interval
UL: Upper limit of the 95% confidence interval

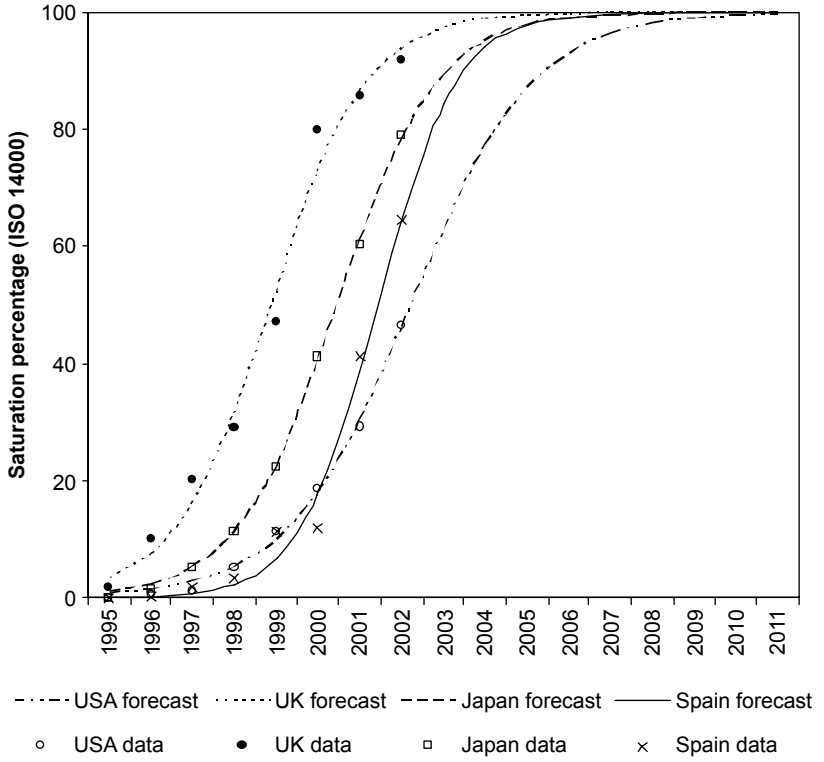


Figure 4.
ISO 14000 certificates forecast of Spain, Japan, UK and USA. The *Y*-axis represents the percentage of the saturation of each country. The historic data are plotted as points

December 2002, it had only reached 64.4 percent, so the period of maximum growth is being reached. Furthermore, the Spanish growth rate is the highest of the four countries analyzed ($r_0 = 1.08$).

On the other hand, it is clear that despite a sluggish start, certification has spread extensively in Japan and is approaching its saturation point (about 13,500 certifications – this being the country with the largest potential). At present, it has reached nearly 80 percent of this value. During 2004, it was anticipated that it will eventually reach 95 percent, due to a very high growth rate (0.842).

The United Kingdom has a growth rate similar to Japan's (0.876) and is at a more advanced stage within its logistic curve. During 2003, it already reached 95 percent saturation.

In contrast, the progress of the standard in the USA is still in its early stages, having reached merely 46.6 percent saturation, with 5,600 certifications. With a growth rate of 0.684, it is anticipated that 95 percent saturation will be reached in 2007. In general, we have verified that not only does the model adjust very well, but that different countries are at different stages along the curve, and that the approximate saturation levels in each case are 5,000 certificates in Spain, 12,500 in Japan, 3,000 in the United Kingdom and 5,500 in the United States.

Finally, in order to get a more detailed answer, it was considered opportune to analyze whether it was possible to adjust the intensity indicators of ISO 14000 certifications to another logistic curve, following the same pattern as before. We analyzed, in particular, how the logistic curve adjusts to a variable constructed as a quotient between the number of certifications and the Gross National Product at constant prices and, in addition, to a quotient of the number of certifications with respect to the number of inhabitants as carried out by Saraiva and Duarte (2003). The adjustment obtained in both cases is also very good, but not as good as the one obtained directly from the number of certifications, which is why we have preferred to use those described previously.

5. Analysis of the diffusion of the standard among sectors of activity

Following the methodology proposed, the third phase of the investigation consists of an analysis of the diffusion of the ISO 9000 and ISO 14000 standards through the principal sectors of economic activity. To this end, we carried out a complementary analysis using commonly used indicators to find out the degree of competition that the companies maintain in a certain market, i.e. indicators of the degree of concentration and the level of instability in these sectors. The degree of concentration refers to the market share of the leading companies, whereas the level of stability analyzes the relative situation of each company, over time, in this market. Both concepts are applied to the presence of companies from each sector of economic activity among the total number of certifications. In other words, the same tools as before are applied, but bearing in mind that, in this case, the elements competing in the market for certifications are the sectors, not the companies.

First of all, we studied the level of concentration of each standard. Is it true that just a few sectors of activity represent a high percentage of the number of certifications? Or, on the contrary, can we say that all the sectors have a similar number of certifications? Greer (1992) and Cabral (1997) maintain that a useful means of analyzing the concentration is the Herfindahl index, designed originally to measure the concentration of market share held by particular suppliers in a market and defined as:

$$H = \sum_{i=1}^{n} s_i^2$$

where s_i is the quota of sector i, and n is the number of sectors. The value of H varies between $1/n$ (minimum concentration) and 1 (maximum concentration). In our case, the minimum level is 0.026 (1/39). There are other indexes to evaluate the concentration effect, but compared to them, this is one that has better consistency properties (Jacquemin, 1987).

Secondly, we analyzed the instability of the ranking of sectors for each standard. It is possible that the concentration index will remain stable over time, despite there being a continuous rotation of sectors heading the ranking for each standard. Cabral (1997) states that one of the most commonly used measures to calibrate this effect is the index of instability, defined as:

$$I = \frac{1}{2}\sum_{i=1}^{n} |s_{i2} - s_{i1}|$$

where s_{i1} and s_{i2} are the quotas of sector i during periods 1 and 2. The index ranges from zero (minimum instability) to one (maximum instability). The value $I = 0$ relates to a situation in which all the sectors keep their share, while the value $I = 1$ corresponds to a situation in which all the sectors competing in the initial period are out of the market in the second period.

Figure 5 shows the development of the Herfindahl index, applied world wide to both standards. It shows how the ISO 9000 series has remained at a stable level of concentration during recent years, while ISO 14000 has also moved towards the same level of concentration. These values are much closer to the minimum concentration value than to the upper limit. Thus, we can verify that the level of concentration for each standard is similar and low.

Figure 6 shows the development of the instability indices for both standards. It can be seen, first of all, that the tendency of both standards is towards lower levels of instability; that is to say, both are maturing with time, and the leading sectors for each standard maintain their positions with little variation. Secondly, it shows that ISO 9000 is more stable than ISO 14000. This was expected, given the time lag between the creation of each standard.

The analysis of these two indices shows that there is a high degree of similarity between the diffusion of each standard. On a world wide scale, each has a similar level of concentration, looking at how each sector of activity is represented, and both show the same tendency towards greater stability.

In addition, in order to find out whether the different sectors of activity are represented similarly in terms of the percentage of ISO 9000 and ISO 14000 certifications, the Wilcoxon statistical test was applied. This is, in fact, the fourth and

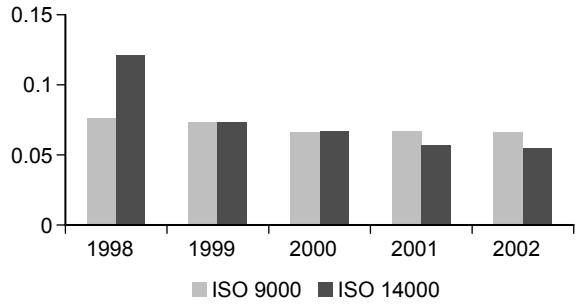


Figure 5.
Evolution of Herfindahl index of ISO 9000 and ISO 14000, applied to the world wide certificates by economic activity sector

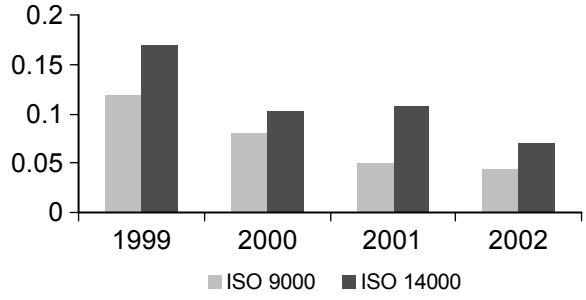


Figure 6.
Evolution of Instability index of ISO 9000 and ISO 14000, applied to the world wide certificates by economic activity sector

final phase of the investigation. To do this, the variables that express the number of ISO 9000 and ISO 14000 certifications in each of the 39 sectors world wide in 2002 were standardized. The Wilcoxon rank-sum test analyzes the 39 differences between the standardized value for the ISO 14000 series and that of the ISO 9000 series. At a significance level of 0.05, the test does not permit a rejection of the null hypothesis that the differences of the pairs of values are centered at zero. Using the analogy mentioned previously, we can, therefore, say that the degree to which each sector is represented, or its market share, is similar for each standard (Table V).

Nevertheless, when analyzing the data referring to one particular year (in this case, 2002, this being the latest year for which data are available), it could be said that, in reality, two equivalent moments of expansion in the progress of each standard need to be compared, since, as has been verified, their propagation speeds, as well as their initial starting points or births, are different. Therefore, should not the equivalent moments in the expansion of each standard be compared? World wide, for example, the ISO 9000 standard reached 33.25 percent saturation in 1998. In contrast, ISO 14000 certifications reached a similar level (29.58 percent) in 2000. At this point, the following question needs asking: when ISO 9000 certifications reach 33 percent saturation, are the quotas of diffusion for each sector similar to those of ISO 14000 at an equivalent level of saturation?

To answer this question, Figure 7 shows the world wide development of both standards, at the same scale and as a percentage of the saturation of each standard, so

	Wide world scale, year 2002 ISO 14000 - ISO 9000 (standardised values)
Z	− 0.321[a]
Sig. asympt. (bilateral)	0.748

Note: [a]Based on positive ranks

Wilcoxon signed-ranks test for the standardized variables of ISO 9000 and ISO 14000 certificates by economic activity sectors at wide world scale, during the year 2002

Table V.

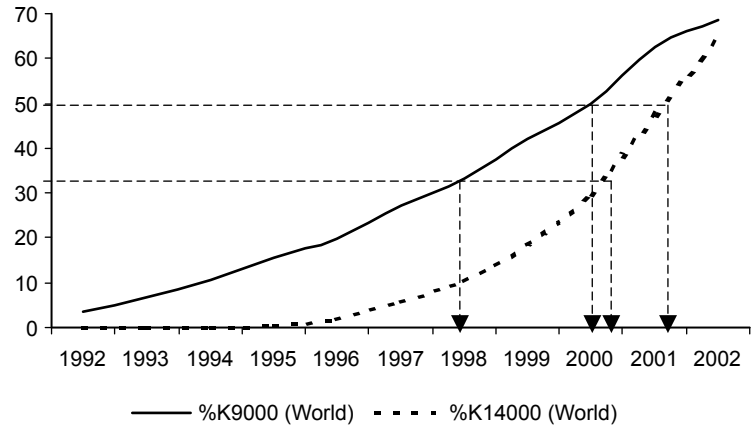


Figure 7.
World wide evolution of the ISO 9000 and ISO 14000 certificates, measured as a percentage of its saturation

that the equivalent moments in the development of each can be compared. Thus, we can see that the number of ISO 9000 certifications reached 33 percent saturation in 1998, while the ISO 14000 standard approached this level in 2000. It can also be seen that ISO 9000 certifications reached 50 percent of their maximum level in 2000, whereas ISO 14000 certifications reached 50 percent in 2001.

Subsequently, we carried out the Wilcoxon test for the standardized variables of the number of ISO 9000 and ISO 14000 certifications, both by sectors, at two specific moments:

(1) when the levels of certification of each standard were close to 33 percent of their respective saturation points; and

(2) when they reached 50 percent saturation.

In both cases, p-values are greater than 0.05, which does not allow rejection of the null hypothesis and means the market share for each sector for both standards is similar. It can, therefore, be said that the sectors holding leading positions in the ranking of ISO 9000 certifications at a given moment also occupy the leading positions in the ranking of ISO 14000 certifications at an equivalent moment and, in addition, they have similar quotas.

At this point, it is seen that the analysis carried out previously is highly pertinent. In fact, even when the situations for both standards are compared in one particular year (2002 in this case), the comparison is valid because, at that time, both standards had very similar levels of saturation: ISO 9000 at 69 percent and ISO 14000 at 64 percent.

This analysis was also carried out for the four countries that were studied in more detail although, in these cases, other moments of equivalent level of progress need defining in order to find various years with similar levels of development. To give an example, ISO 9000 certifications reached 22.99 percent saturation in Japan in 1999. By coincidence, ISO 14000 certifications reached a similar level (22.40 percent) in the same year. In this case, therefore, the progress of each variable in 1999 should be compared. As a result of such analysis, it can be concluded that the diffusion of the two set of standards has taken place through the same sectors in the countries analyzed, although with different rates of propagation.

As has been said, both standards are currently at similar stages of development, which allows us, when studying the last two years, to carry out a Wilcoxon comparative analysis, using data for each set of standards corresponding to the same year. Table VI shows the results for each of the four countries for the last two years. The market share of each sector for each standard is similar. Specifically, although the statistics are not as robust as those shown in Table V (which analyzes the situation world wide), they are sufficiently reliable to say that the quotas reached by each standard are similar, when compared directly to the situation during the same year.

After analysis of the evolution of Herfindahl and instability indexes, and the Wilcoxon tests on the rankings of both standards comparing equivalent maturity moments, we conclude that the third and last hypothesis formulated is accepted as well: the evolution of both standards, throughout the economic activity sectors, has been similar.

Finally, to reinforce this analysis, Figure 8 shows the development of the rankings of the five leading sectors for each standard, world wide. It shows that there are four sectors that coincide in the two lists.

		Spain ISO 14000-ISO 9000 (standardised values)	Japan ISO 14000-ISO 9000 (standardised values)	UK ISO 14000-ISO 9000 (standardised values)	USA ISO 14000-ISO 9000 (standardised values)
2001	*Z*	−0.966[b]	−0.803[b]	−1.944	−1.224[a]
	Sig. asympt. (bilateral)	0.334	0.422	0.052	0.221
2002	*Z*	−1.047[b]	−0.884[b]	−1.210[b]	−1.257[b]
	Sig. asympt. (bilateral)	0.295	0.376	0.226	0.209

Notes: [a]Based on negative ranks; [b]based on positive ranks

Table VI.
Wilcoxon signed-ranks test for the standardized variables of ISO 9000 and ISO 14000 certificates by economic activity sector in Spain, Japan, UK and USA, during the years 2001 and 2002

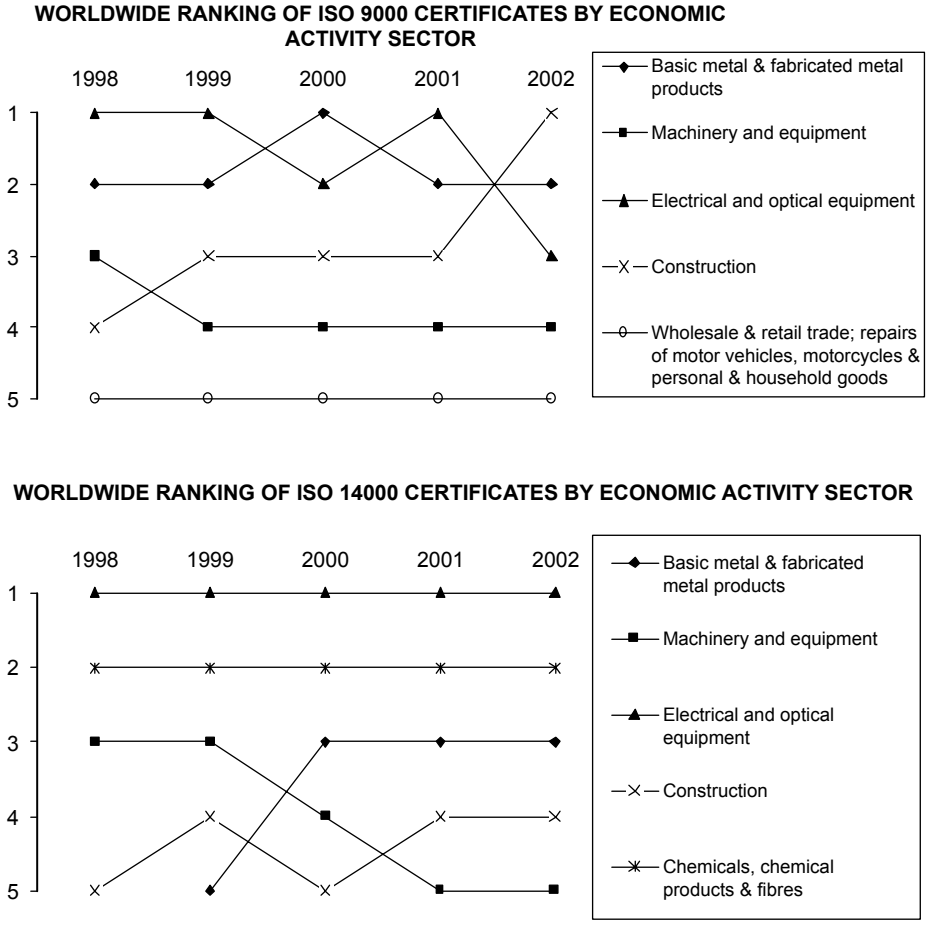


Figure 8.
Evolution of the top places in the world wide ISO 9000 and ISO 14000 certificates rankings by activity economic sector

The construction sector, for instance, climbed from the fourth position in the ISO 9000 ranking in 1998 to first place in 2002. This sector has shown a high degree of interest in their quality systems. It also shows a good position in the ISO 1400 ranking. On the other hand, the chemical sector, quite sensitive to environmental aspects and maintaining itself in second place in the ranking of ISO 14000 throughout the years studied, is nevertheless out of the first positions in the ISO 9000 ranking. It could be concluded that environmental concern is a strategic issue in the competitiveness of the chemical sector.

In fact, the absence of significant changes demonstrates once more a high degree of stability for both standards, as demonstrated in this section. The diffusion of the two standards shows a certain similarity and this similarity is stable at the world wide level.

It should be pointed out that in a study by Franceschini *et al.* (2004) there is a preliminary analysis of the development of ISO 9000 certifications according to different sectors in Italy, in which different rates of implementation in the different

sectors were detected. Thus, although certain stability was found in the pioneering sectors, the growth rate of certifications between sectors was highly uneven, leading to a forecast of short-term changes, exactly the opposite of what we found in our investigation.

6. Conclusions

Pan (2003) and Poksinska *et al.* (2003) had already demonstrated that many of the reasons why companies seek certification and the benefits obtained from certification are the same for both the ISO 9000 and the ISO 14000, despite it being evident that the objectives of each series of standards are completely different. However, in terms of diffusion, it was unknown until now whether or not the two standards followed the same parameters.

It should be pointed out that the available data were incomplete, especially for ISO 14000, which is one of the limitations of the study. Nevertheless, we believe that the methodology presented can be generalized across a broad variety of contexts.

In this paper, it has been demonstrated that, world wide, the expansion of both the ISO 14000 and ISO 9000 standards have followed very similar patterns of diffusion. The ISO 9000 standard, much more popular and older, is at 68.7 percent of its saturation point and will presumably reach it towards 2007. The ISO 14000 standard, which began to be implemented some years later, is spreading at a much greater speed, although with the same pattern of growth: the pattern established by the logistic curve. For this reason, it has currently reached nearly the same relative level as ISO 9000 and is forecasted, according to the model proposed here, to reach 95 percent saturation in 2006.

According to the model proposed, both standards have currently reached an important moment in their maturity: about two-thirds of their limit. Also, when we analyze the presence of these standards in the different economic sectors, more signs of their maturity are to be seen. On one hand, both are developing towards smaller indices of concentration and, on the other, there are fewer and fewer fluctuations in the sectors' positions in the rankings of certifications (the rates of instability for both standards tend towards smaller values). From the analysis of individual countries, we also observed that in the United States there is still a long way to go before the ISO 14000 standard begins to fully mature, with an index of saturation currently at only 50 percent.

Furthermore, we can conclude from this study that both standards spread in similar ways among the economic sectors: those sectors that were leaders or pioneers in the introduction of the ISO 9000 standard, have played similar galvanizing roles in the case of the ISO 14000 standard. We can, therefore, confirm the hypothesis established by some authors, according to whom the unprecedented surge in the progress of the ISO 9000 standard has been an important factor in explaining the surge in the ISO 14000 standard (Mendel, 2001), a hypothesis already partly confirmed by a study of a more general nature by Corbett and Kirsch (2001).

Regarding the limitations of this type of analysis of prediction based on mathematical models, it should be said that they are studies based solely on endogenous factors of growth and that, therefore, they have important limitations, such as not taking into consideration the development of exogenous factors to the actual process of growth of the standards, which may include, for example, a radical division or change in tendencies at a particular moment during its progress.

Among other external factors that could be mentioned are new government policies actively promoting implementation and certification in a particular country via grants and incentives, the issuing of a new version of some of the standards (as has been the case with ISO 9000), or successful entry into the market of another standard or substitute model.

Another important event that could not have been analyzed is the impact of the new release of the ISO 9000 standard, ISO 9001:2000, published at the end of the year 2000. We need more time to calibrate this effect.

Nevertheless, we believe that the results of this investigation may be relevant to those institutions and organizations involved with this type of certification: accreditation organizations, certifying bodies as well as the business consultants specializing in the implementation of these systems.

On the other hand, we also consider these empirical conclusions to be of interest from a strictly academic point of view, particularly for the line of research analyzing the diffusion and adoption of ideas, models, systems and tools of business management. We have demonstrated that these management tools spread following a logistic or S-shaped curve and that, in addition, they follow very similar parameters in all the cases analyzed. The question arises, however, as to why? Does this evidence confirm the theory of management fashions? Can this model be applied generally to the process of diffusion of other management standards, or to other types of organizational and management innovations? Can the diffusion of management innovations be compared to product diffusion in line with the well-known service life cycle? And why do certain members of a social system adopt innovations before others? In short, in our view, the empirical statements gathered in this paper will lead to new questions and hypotheses that should provide further study of interest in the future.

Note

1. The formula used to calculate the densities of the ISO 9000 standard for a country in a geographic zone is:

$$\text{Intensity}_{\text{country}}^{\text{ISO 9000}} = \frac{\text{Certificates ISO 9000}_{\text{country}}/\text{GDP}_{\text{country}}}{\text{Certificates ISO 9000}_{\text{zone}}/\text{GDP}_{\text{zone}}}$$

   There are analogous formulas for ISO 14000 densities.
   There is no doubt that it would be even more interesting to calculate this density, not in relation to the GDP but, for example, in relation to the number of industrial plants or companies in each country. However, such data are too difficult to obtain and so the GDP was chosen as the indicator.

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Appendix. Logistic curve

The logistic model describes the development of a population which grows with a net growth rate r (Boyee and Di Prima, 1992). It was introduced by Pierre Verhulst (1938) to describe phenomena related to the growth of the biomass of species:

$$\frac{dN}{dt} = rN \tag{1}$$

From the initial size (N_0), the population grows at a rate r, which also depends on the size of the population, according to the following expression:

$$r = r_0\left(1 - \frac{N}{K}\right) \tag{2}$$

The population experiences a maximum growth rate (r_0) when the size of the population is close to zero. K is the saturation size. When the population reaches this size, it stops growing. In this way, growth can be expressed as:

$$\frac{dN}{dt} = r_0\left(1 - \frac{N}{K}\right)N = r_0N - \frac{r_0}{K}N^2 \tag{3}$$

This is a Bernoulli differential equation, whose solution is:

$$N = \frac{N_0K}{(K - N_0)e^{-r_0t} + N_0} \tag{4}$$

The phenomenon related to the growth of the biomass of species requires the condition $N_0 \neq 0$. Obviously, when the norms were published the number of certifications was zero. However, we believe that it is not wrong to apply this model in our case, because we analyze the evolution of certifications from the 31 December of the year in which the norm was published, so the initial number was not zero, although it was very low.

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