A multi-level analysis of the diffusion of standards compliance in Latin America

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Abstract

This study contributes to the debate on the role of openness to international markets for the diffusion of compliance with international standards in developing countries. Relying upon aggregated data for 1995-2005, as well as upon firm-level and secondary data from the Chilean salmon farming industry, the determinants of ISO 9000 and ISO 14001 diffusion at country, industry, and firm level, in Latin American are analysed. Our evidence suggests that openness to international markets acts at different levels. At both the country and industry level, it creates awareness and access to new knowledge therefore providing economic incentives or penalisations for evaluating certification. This effect competes and complements the deliberated efforts and policies in explaining diffusion of certification. At firm level, however, openness to international markets alone does not provide sufficient opportunities to acquire the knowledge required to comply with these standards. In this case, standards' compliance depends on firm's capability to use relational and search assets, as well as on national and industrial efforts and policies to spread standards' usage.

Keywords: international standards; certification; globalization; technological infrastructures; multi-level analysis; Latin America.

1. Introduction

International Management Standards (IMS), such as ISO 9000 and ISO 14001, emerged and widely diffused around the world during the 1990s as the process of globalization was consolidating. Increasingly, firms were required to certify with IMS to access deregulated, regional and/or international markets, and especially to become part of supply-chain production networks (Withers and Ebrahimpour, 2000; Larsen and Häversjö, 2001; King et al., 2005; Vandergeest, 2007). In this context, the competitiveness of developing countries started depending on the capabilities of firms to obtain certification because inability to conform to standards might prevent them from accessing foreign markets and delay entry into global markets and production for global supply-chains (UNIDO, 2005; Maertens and Swinnen, 2009). Despite its importance and its relevance in the new trade agreement agenda, how conformance with IMS can be fostered in developing countries remains a relatively underexplored issue in the innovation literature.

The existing literature on the topic provides unclear evidence on whether conformance can be achieved only through the opening up to international markets or through a mix of domestic deliberate efforts for promoting the diffusion of IMS. As a consequence conclusions on the determinants of IMS diffusion are contradictory. Some authors argue that adequate levels of production quality and safety can be achieved in developing countries simply by creating incentives for indigenous firms to conform to international standards, as well as by governmental policies promoting openness to international capital, knowledge and markets (Christmann and Taylor, 2001; Graham and Woods, 2006; Yeung and Mok, 2005). Other authors instead stress that in developing countries, the diffusion of IMS compliance requires technical and organisational knowledge, and consequently the provision of sufficient local technical and social infrastructure (Hatanaka et al., 2005; Jaffee and Masakure, 2005).

Despite this major theoretical and policy ongoing debate, most of the empirical literature on IMS focuses either on the motivations and impact of IMS certification on firms' performance (often using survey data) or on the importance of IMS standards for improving local competitiveness and for

governing the interactions within global value chains (often using industry case studies) (eg. Seddon, 2000; Nadvi, 2004, 2008; Hoang, et al., 2006). Given the theoretical, methodological and empirical set up of these studies, compliance with IMS is seldom related directly to firms' management strategies (such as local search for policy support, engagement in collaboration for capability development, recruitment of skilled labour, etc.), and/or to the development of supporting infrastructures at both industrial and national levels (such as economic and industrial structures, experience in setting regulations and standards, and in developing new technological infrastructure). Consequently, various stakeholders, including firms, industrial associations and policy-makers in developing countries, lack relevant information since recommendations for governmental policies tend to focus on how to tackle market failures that prevent firms from complying with IMS, assuming that if these policies are effectively implemented IMS would automatically diffuse throughout the economies (eg. Schuurmann, 1998).

Hence, whether and how specifically the openness to international markets can encourage IMS diffusion in developing countries, and which are the required deliberated efforts by different national actors that enable firms to adopt IMS are still open issues. Our study is an attempt to undertake this challenge by examining the diffusion of IMS compliance in developing countries. We conceptualise IMS compliance as the result of a diffusion process (Geroski, 2000) which entails knowledge acquisition and capability development at three levels: firm, industry and country (Padilla-Perez, 2008). The main objective of our study is not to examine the evolution of specific learning processes undertaken by firms, industry associations and policy-maker involved in the process (eg. Kim, 1998; Blackman and Sisto, 2006). Instead, by combining a case study of a specific industry with the analysis of data at both firm and country level, we aim at providing the various stakeholders with the possibility to understand the available strategies to enhance the competitiveness of local producers, as well as at contributing to the debate on the role of openness to international market for the diffusion of firms' compliance with IMS in developing countries.

Empirically, we focus on the diffusion of ISO 9000 and ISO 14001 in Latin America (LA), where certification grew at a faster rate than in the rest of the world, especially from the late 1990s (ISO,

2005). Moreover, many LA countries undertook an 'open market policy' regarding access to international trade and foreign capital in the 1990s, which has led to an increase in the exports of non-traditional natural resource-based products (ECLAC, 2002; 2004). We rely upon both country and industry aggregated data, as well as firm-level and secondary data for one of the most successful non-traditional natural resource export industries in the region, the Chilean salmon farming.

Our multi-level analysis sheds light on the potential role of standards, in developing countries, to stimulate and direct the efforts of multiple actors towards the improvement of national producers' competitiveness in international markets, as well as to provide a benchmark for these national efforts. In particular, our results suggest that openness to international markets has created awareness and access to new knowledge, and provided an incentive and penalisation framework for evaluating certification. Therefore at both country and industry level it has complemented deliberated policies aimed at fostering the diffusion of certification. At firm level, however, standards' compliance has depended to a large extent on firms' capability to use relational and search assets for supporting IMS adoption, as well as on national and industrial efforts to spread standards' usage. Thus, openness to international markets did not provide sufficient opportunities to comply with IMS.

The paper is organised as follows. Section 2 reviews the role of market internationalization and of national initiatives and efforts to develop an appropriate technological and institutional framework for IMS diffusion, as well as the potential benefits and obstacles related to the adoption of IMS. Section 3 describes data and method for the analyses at the country, industry, and firm level. Section 4 provides results at country and industry level. Section 5 presents the case study and the firm level analysis of the Chilean Salmon farming industry. Section 6 discusses the results. Section 7 considers the implications for policy and management and concludes.

2. Standardization, certification, trade and development

This section reviews the context in which IMS emerged and diffused, the importance of standards as a source of knowledge and innovation for firms, as well as the role played by access to international

markets and the deliberated efforts of different national actors to develop an appropriate technological and institutional framework for IMS diffusion.

2.1. The emergence and diffusion of IMS and the globalization of markets

The origins of the diffusion on IMS trace back to the beginning of 1980s when as competition in international trade became increasingly characterized by non-price factors, compliance with testing and measurement standards became a source of competitive advantage and a way of defining market barriers (Temple and Urga, 1997). Since then, increasing public efforts to control and signal the quality of national products and firms have been put in place in developed countries through standardization and the promotion of infrastructure for supporting the standardization process (Swann et al., 1996; Temple and Urga, 1997). In fact, ISO 9000 is based on the British standard BS5750, published in 1979, and widely promoted from 1981 in the UK and abroad, among British suppliers and affiliated companies (NAO, 1990).

Given the increasing importance of quality management systems and the co-existence of multiple national and private standards, the International Standards Organisation (ISO) published, in 1987, ISO 9000 to foster international trade. ISO 9000, the international standard for quality management, was updated in 1994 and 2000. The third-party certification of conformance with the standard was first introduced in 1994. ISO 9000 was followed by other IMS such as ISO 14001, the standards for environmental management published in 1996 and updated in 2004. Other standards, including some industry-specific ones, also emerged under a similar philosophy. Certification with these standards also diffused quickly, especially after the publication of ISO 9000:2000, which facilitated the combined certification with other standards, in particular ISO 14001 (ISO, 2005).

During the 1990s, IMS became increasingly important for coordinating international production and gaining access to international markets. In both developing and developed countries, major surveys and studies have found that most firms identified ‘fulfilling the requirements of customers’ as the main reason for adopting ISO 9000 and ISO 14001 certification (Larsen and Häversjö, 2001; Pan,

2003). Indeed, governments, large buyers, and multinationals have been requesting suppliers and contractors to certify (Ringe and Nussey, 1994; Guller et al., 2002; King et al., 2005) making compliance with these voluntary IMS a prerequisite for entry into global and, in some cases, domestic markets such as new deregulated sectors and for the provision of outsourced public services (Chu et al., 2001). Multinationals and supply-chains, as well as foreign direct investments were argued to be the most important channels for the diffusion of certification (Christmann and Taylor, 2001; Guller et al., 2002; Yeung and Mok, 2005). Indeed, within firms' groups, ISO 9000 seemed to ensure compatibility of business processes between different affiliates (Larsen and Häversjö, 2001; Blind and Hipp, 2003; Pan, 2003). Moreover, as certification requires the qualification of suppliers, many firms met this requirement by 'forcing' their suppliers to certify (Stevenson and Barnes, 2002).

Thus, certification with IMS became an almost necessary condition for market access, especially in markets with relatively few and large customers, and consequently for producers from low income countries (Pan, 2003; Hatanaka et al., 2005; King et al., 2005; Jaffee and Masakure, 2005). Despite the growing importance of IMS, little empirical evidence exists on the factors supporting the diffusion of IMS compliance in developing countries.

2.2. Benefits and obstacles to IMS adoption

Consistently with the mechanistic/control aspects of the Total Quality Management approach (Prajogo and Sohal, 2003; 2004), IMS only set general guidelines which the adopting firms need to interpret and use to build up their own quality or environmental management system (Bénézech et al., 2001). Compliance with IMS involves then a review of design and production methods, and the development and documentation of control management systems that respects the general IMS guidelines (Bénézech et al., 2001; Benner and Tushman, 2002). Given the nature of IMS, the debate is open on the potential benefits and obstacles that firms adopting IMS can experience.

On the one hand, the existing literature provides mixed evidence on the financial and innovation

benefits from certification, especially related to product innovation and improvement (Terziovski et al., 1997; Lima et al., 2000; Prajogo and Saohal, 2003; Casadesús and Karapetrovic, 2005). In particular, Seddon (2000) argues that certification increases the need for documentation and control, creating an extra 'burden' that may offset any marginal benefits that IMS implementation might have on firms. On the other hand, IMS compliance is systematically found to be associated with internal organisational and process improvements, such as product conformity and reliability, reduction of non-conformities and waste, process efficiency and customer satisfaction awareness (Curkovic and Pagell, 1999; Withers and Ebrahimpour, 2000; Delmas, 2001;2002; Pan, 2003; King et al., 2005; Terlaak and King, 2006).

Within the knowledge codification literature that investigates the influence of codified organisational structures on firms' performance, some studies focused specifically on the relationship between innovation and certification. Knowledge crystallisation and organisational rigidities should be expected in firms that rely heavily upon documented processes (Cowan et al., 2000). Consequently, some authors question the effectiveness of IMS for efficiency and innovation (Seddon, 2000). However, potentials for organisational learning are limited when the organisational structures of firms are not well understood and defined (Ancori et al., 2000). Blind and Hipp (2003) show that the likelihood of ISO 9000 certification decreases in the presence of internal rigidities thus constraining innovation. Therefore, the knowledge codification literature tends to be consensual in arguing that despite not supporting the production of radically new knowledge, codification of organisational procedures may facilitate incremental innovations (Ancori et al., 2000; Cowan et al., 2000) and increase innovation 'exploitation' over 'exploration' (Benner and Tushman, 2002).

Therefore, several authors reject the argument that firms need to choose between quality and innovation (Bénézech et al., 2001; Prajogo and Sohal, 2003; 2004; Hoang et al., 2006). In particular, given the dissatisfaction with existing organisational, technological and managerial practices in developing countries, the relationship between certification and technological capability building, innovation, or productivity enhancement is often believed to be stronger (Lima et al., 2000; Christmann and Taylor, 2001; Delmas, 2002; Yeung and Mok, 2005).

Furthermore, some studies examined the factors that influence the benefits achieved from certification. These studies tend to argue that benefits from certification depend on the capabilities of managers and consultants to adapt standards' requirements, especially making sure that the control system and practices implemented do not obstruct but instead leverage upon the existing 'organic' learning practices (Ringe and Nussey, 1994; Terziovski et al., 1997; Delmas, 2001; Prajogo and Sohal, 2004; Hoang et al., 2006). Limited benefits and eventually some disadvantages are found associated with firms' viewing certification as an external burden to be applied in a 'piecemeal fashion' to operational processes rather than as a 'holistic' management tool to be used as a learning device (also to be applied to the corporate strategy) (Curkovic and Pagell, 1999; Larsen and Häversjö, 2001). Indeed, at the light of the literature on the economics of knowledge codification, which has extensively documented on the role of external codified knowledge as potential source of learning, the benefits from using IMS depend on the capabilities of users to interpret and to apply it in a way that leverages internal competencies, efficiency and innovation (Foray and Steinmueller, 2003). Certification, especially in developing countries, may require several deliberated efforts to develop a favourable technological and institutional infrastructure that supports adoption of IMS at firm level, as well as to reap benefits from adoption. This aspect is discussed in the next section.

2.3. Diffusion of IMS compliance and the role of national deliberated efforts to support IMS adoption

IMS are, to a certain extent, codified versions of management knowledge which could in principle be easily acquired by firms. However, as it happens with the development of technological capabilities, which cannot be automatically improved through the import of advanced capital goods, compliance with IMS, especially in developing countries, may require a process of knowledge acquisition and learning that takes place both within and outside the firm, that involves several actors, and that occurs through several means (Bell and Pavitt, 1993; Kim, 1998). In developing countries, the diffusion of compliance with IMS may be constrained by the lack of technological resources and access to

efficient technologies, as well as of skills to interpret and convert standards into non-abstract general guidelines (Benezech et al., 2001). To implement the system changes that IMS require, firms need financial and technical support to acquire equipment, train their employees and top-management, and secure expert consultant advice (Withers and Ebrahimpour, 2000; Jaffee and Masakure, 2005).

Therefore, while time, cost and top-management involvement are found to be the main obstacles to certification in developed countries (Curkovic and Pagell, 1999; Withers and Ebrahimpour, 2000), lack of technological infrastructures and experiences, financial resources and capabilities, as well as inappropriate national regulations and institutions are argued to constrain certification in developing countries (Aden and Kyu-Hong, 1999; Rivera, 2004; Potoski and Prakash, 2005; Cañada and Vásquez, 2005; Blackman and Sisto, 2006). On the one hand, availability of technological and basic infrastructure, such as testing and measuring facilities, training courses, information and advice services are considered crucial for the diffusion of certification with IMS, along with the development of industrial and technical expert organisations (Tassey, 1996; Blackman and Sisto, 2006). On the other hand, several authors argue that a 'market driven' model, in which firms in developing countries are led to comply with standards on quality, environment and sanitation by multinationals and developed countries' regulation, is a solution for the lack of national regulatory capability (Christmann and Taylor, 2001; Yeung and Mok, 2005; Graham and Woods, 2006).

It must be however noted that, in developed countries in the 1980s and early 1990s, governmental and industrial associations put great effort into supporting national firms to develop quality management systems through awareness campaigns, financial subsidies, development of technological infrastructure, and adequate business support services. Moreover, in some developed countries, national standards preceded the adoption of IMS (NAO, 1990; M.Qualité, 1992; Ringe and Nussey, 1994).

Evidence from successful experiences in developing countries also suggests that institutional development, such as effective and credible governmental legislation, investment and monitoring, might be required to encourage the upgrade of national firms' capabilities, certification and access to

foreign markets (Aden and Kyu-Hong, 1999; Reardon and Farina, 2002; Vandergeest, 2007). In particular, investments in the development of national certification programs, in the use of international and national public standards, as well as in the creation of industrial coordination organisations may allow the gradual improvement of national firms' capabilities for compliance with IMS standards. These efforts may also allow the communication of the institutional change to foreign buyers, and the improvement of national product reputation (Cañada and Vásquez, 2005; Hatanaka et al., 2005; Roy and Thorat, 2008). Still, the introduction of national, regional or industrial regulation or disclosure certification programmes to force firms to comply without simultaneous investment in technological infrastructures and monitory actions may fail to encourage firms' investment in capability building (Aden and Kyu-Hong, 1999; Rivera, 2004; Blackman and Sisto, 2006).

It has to be noted also, that many of the investigations carried out in developing countries rely upon case-studies of the role of standards' compliance (often of private international standards) on the internationalization of local production and on the participation in global value chains, and provide mixed findings on the importance of openness to international markets on the diffusion of compliance with IMS. In the existing literature, the adoption process by the firm, which is required to certify, is seldom related directly to firms' management strategies (such as local search for policy support, engagement in collaboration for capability development, recruitment of skilled labour), and to the development of infrastructures at both industrial and national level. Hence, this meso-level evidence alone provides rather limited perspectives for management and for policy-making in developing countries (Padilla-Perez, 2008).

In order to clarify the general trends of IMS compliance in developing countries, more comprehensive —multi-level—evidence on the required efforts is needed to allow several stakeholders, including firms, industrial associations and policy-makers the possibility to understand the available strategies to enhance the competitiveness of local producers. Beside the role played by market based incentives, it is important to identify the efforts that firms, industrial/local associations, and policy-makers need to put to foster the diffusion of compliance with IMS.

This study contributes to the ongoing debate on the role of international market mechanisms for the diffusion of compliance with IMS by examining IMS compliance at different levels of analysis: firms, industry, and country. By providing an integrated multi-level view of diffusion of IMS compliance, our analysis aims at shedding light on the efforts that different actors should put in place to enhance competitiveness of local producers in the context of an open economy. Based on our literature review, we expect that openness to international markets leads to a revision of existing economic incentives and consequently plays a particularly important role for the diffusion of compliance with IMS at both country and industry level by allowing access to new markets and technologies. Commitments for compliance with IMS are instead crucial at all levels of decision-making (i.e. firm, industry, and country). At the firm level, openness to international markets entails access to market and technology information, as well as to a new framework of incentives and penalisations. However, without national and industrial supports and deliberate managerial efforts, compliance with IMS should be expected to be a rare event, in developing countries.

3. Data and method

3.1. Data

Our analysis combines both aggregated data, as well as firm level data on standards adoption complemented with qualitative historical evidence on institutional development in a specific industry: the Chilean salmon industry.

At country and industry level, we use data from the ISO surveys on the total number of ISO 9000 and ISO 14001 certificates issued by country and by industry in Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela. We limit the analysis to this group of LA countries, because Mexico contrary to all the other countries is part of North American Free Trade Agreement (NAFTA). Other smaller LA countries did not obtain any certificate until late

1990s or early 2000s. Thus, we use the whole existing certification series in LA of ISO 9000 (from 1995), and of ISO 14001 (from 1997) until 2005. Moreover, we use data from the World Development Indicators on Gross Domestic Product (GDP), labour force, exports, net inflows of Foreign Direct Investment (FDI), payments of royalties and licenses, share of high technology exports from total exports, share of services on GDP, and share of agriculture on GDP.

At firm level, we gain a more comprehensive view of the process of certification within firms, by using data from a semi-structured survey of 62 firms, conducted between March and May 2004. Our sample was drawn from the population of Chilean firms active in the salmon industry, which listed 175 firms. Due to time and cost limitations, we decided to focus on the firms located in the Chilean Region 10, where more than 80% of Chilean salmon exports (90% of national production) are produced. After excluding from the list firms for which there were no contacts, 87 firms were left (from the original 95). Again for time and cost limitations, we randomly sampled 62 firms, including both large and small firms, whose production totalled almost 80% of total Chilean salmon exports. This representative sample includes salmon producers – salmon egg producers, alvine producers (freshwater phase), salmon growers (saltwater phase), fishmeat processors (cutting, smoking, packing) and traders (exporters) – as well as two suppliers, fish net producers and feed producers.[1]

3.2. Method

3.2.1. Country and industry level analysis

At country and industry level, we proceed empirically in two steps. First, we analyse the importance of production and export structure for compliance with IMS. We use Revealed Advantage Ratios (RARs) to compare the industrial diffusion pattern of ISO 9000 and ISO 14001 certificates in LA

[1] Integration of tasks in the sample varies from single tasking to multiple tasks, with over 50% of the firms conducting more than 3 functions (egg production, salmon growing and processing).

with the world average (Balassa, 1965; Patel and Pavitt, 1994).[2] Second, using regression methods, we explore the role of the internationalization pattern of a country, as well as its technological and production structure, and its level of economic, infrastructural and institutional development for the diffusion of certificates. In the regression exercise our dependent variable is the number of ISO 9000 certificates issued between 1995 and 2005 and the number of ISO 14001 certificates issued between 1997 and 2005 in each LA country. To capture the role of internationalization for the diffusion of firms' certification, for each country we include the following independent variables: the relative intensity of exports, FDI and payments of royalties and licenses on GDP, as well as the growth rates of FDI intensity and of payments of royalties. FDI serves as a proxy for the transfer of production to LA and consequently the degree of participation in global production markets. Payments of royalties and licenses measure the intensity of franchising /licensing activities and the use of international knowledge in LA. Exports capture the degree of importance of foreign customers and their requirements of new environmental and quality models for national production.

To account for country specific characteristics, we include in the analysis the relative size of services in GDP, the relative size of agriculture in GDP, the growth rate of the service sector, and GDP purchasing power parity per capita. The diffusion of ISO 9000 and ISO 14001 impinges upon the presence of adequate infrastructures and institutions that support firms' compliance, and hence the level of economic development of countries (Aden and Kyu-Hong, 1999; Guller et al., 2002). In addition, their diffusion is often related to the outsourcing and deregulation of industries and to the private delivery of public services, and consequently to developments in the services sector (Chu et al., 2001). Additionally, to account for the national technological capabilities we include the share of technology-intensive exports in total exports. Due to the growing importance of resource-intensive

[2] RAR provides clear information on whether the intensity of certification in one sector is larger or smaller than the average world intensity. Values higher than one reveal higher than average intensity of certification. Values lower than one reveal lower than average intensity. The RAR for the use of practice *i* in the sector *j* is a variation of the Balassa (1965) revealed comparative advantage ratio and of the Patel and Pavitt (1994) revealed technological advantage ratio, and is computed as follows: $$RAR = \frac{\sum_{i}^{m} P_{ij}}{\sum_{k}^{n} F_{kj}} \Bigg/ \frac{\sum_{i}^{m} P_{i}}{\sum_{k}^{n} F_{k}}$$

sectors in LA export and industrial structure, it is uncertain the sign of the coefficient of this variable (ECLAC,2002; ISO,2005). Finally, to control for differences in countries' size, we include the logarithm of the national labour force.

Using these variables, we compute Negative Binomial regressions of the number of certificates on the two-year lagged values of the independent variables, as the process of certification was found to take longer than one year (Curkovic and Pagell, 1999). We use a Negative Binomial model rather than a Poisson model because the dependent count variables are over dispersed (i.e. the probability of adoption in a fixed interval of time is variable and hence incompatible with the Poisson distribution) (Long, 1997; Long and Freese, 2003). To gain a better understanding of the level as well as of diffusion of certificates, we first pooled all the data and include country and year dummies. Then we run panel model regressions, using both fixed and random effects. In the panel regressions, we include a variable 'year' to take into consideration that the market 'penalty' for not having certification increased over time.[3] Finally, we explore whether there were changes in the factors affecting diffusion of certificates after 2000, when the ISO 9000:2000 was published. For this purpose, we rerun the pooled and the panel analyses for each of the periods without a constant and then test the similarity of coefficients.

3.2.2. Firm level analysis

Finally, we delve further into the factors that supported firm's compliance with IMS certification – in particular on the role of openness to international markets, as well as of conscious efforts undertaken by firms' management and by public and industrial policies, including the setting up of national standards – by investigating the diffusion of compliance with IMS in one of the most successful natural resource-based industries in LA, the Chilean salmon farming industry. Relying on secondary qualitative sources of information, we trace the evolution of this industry, and look at the national

[3] Using the Multivariate augmented Dickey-Fuller test, we found that panels of ISO 9000 and ISO 14001 lagged two years are stationary (Sarno and Taylor, 1998).

and industrial efforts to support its competitiveness through standardization and diffusion of IMS in the last 20 years. Then, using data from a semi-structured survey, we analyse the motivations and the levels of compliance with different relevant standards in the salmon industry in Chile. In particular, we analyse the relative explanatory power for the level of compliance with IMS of a set of independent categorical and dummy variables related to openness to international markets and capital, as well as to the characteristics of firms, and industrial and national efforts to support firms' compliance.[4] For each standard, the dependent variable takes the value 1 if the firm finds that the standard is not necessary, 2 if the firm is planning to get a certification, 3 if the firm is in the certification process, 4 if the firm is certified. As each of our dependent variable is an ordinal variable, reporting the level of compliance with a standard, we use Ordered Probit models (Long, 1997; Long and Freese, 2003).

To capture information on openness to international markets, we use the following explanatory variables. The independent ordinal variable *Export* captures the degree of export openness of the firm (0%=0, 1-30%=1, 31-60%=2, 61-90%=3, 91-100%=4). *N_for_mkt* contains information on the number of market destinations for export (non-exporting=0, only one market=1, more than one market=2, more than 5 markets=3), and serves as a proxy for market diversification of firms. Firms, which rely upon several markets, are less market dependent and can take more risks, also related to non-compliance with standards. The variable *For_Own* contains information on whether the firm has or not participation of foreign capital. Additionally, we explore the impact of international management best-practices, in particular, the development and compliance with an internal written manual of procedures (*Best-Practice*). While we expect a positive impact of *Exports*, a negative impact of *N_for_mkt* on the level of compliance with IMS, the signs of *For_Own* and *Best-practices* are uncertain because domestic firms seem to be more penalised by non-certification (Rivera, 2004), and not enough evidence exist on the complementary / substitute relationship between Best practices and IMS in developing countries.

[4] Given the reduced number of observations, we use categorical rather than discrete variables to reduce the risk of spurious analysis of variance, when using them together with other dummy and ordinal variables.

To account for the national and industrial support on firms' compliance with standards, we include the following variables, whose sign we expect to be positive. The variable *Association*, which reports on whether the firm is member of the industrial Association of the Chilean Salmon Industry[5] (association member=1, non-member =0). The variable *N_Standard* reports the average level of compliance with national standards, and serves as a proxy for the importance of national standards in guiding and supporting firms to comply with the requirements of IMS.

We also took into consideration the level of firms' absorptive capabilities and their learning efforts, whose sign we expect to be positive. To measure firms' technological competencies, we created the variable *Skills* that captures information on share of professional and technical staff. It takes value 1 if the firm has more or equal to 18%, which is the median, of professionals and technicians as employees and 0 otherwise. Moreover, we included dummy variables that capture information on the collaborative behaviour of the firm. *Supplier* captures information on whether the firm engaged in collaboration with suppliers for standards compliance, and *Client* on whether the firm engaged in collaboration with clients for standards compliance (collaboration=1, non-collaboration=0).

Finally, we control for firm size and activity. *Sales*, as a proxy for firm size, includes information on 4 levels of annual sales (US$0-1.5 million =1, US$1.501-5.000=2, US$5.001-50.000=3, US$50.001-100.000=4, US$100.001 plus=5). To reflect differences in activities, we include three dummy variables that capture if a firm is active (active=1, non-active=0) in *salmon*, *net* or *feed* industry; *feed* being the reference category.

4. IMS in Latin America: the macro analysis

This section analyses the diffusion pattern of ISO 9000 and ISO 14001 certificates in LA countries, at both national and industrial level, focusing on the role of international markets, as well as on different national and industrial structural characteristics supporting their diffusion.

[5] APSTC- Associacion de Productores de Salmon y Trucha de Chile, which later became SalmonChile.

4.1. The pattern of diffusion of ISO 9000 and ISO 14001 in Latin America: a preliminary look

Since 2000, the growth rate of ISO 9000 and ISO 14001 certificates for the countries in our sample has been higher than the world average growth, especially for the ISO 14001. In 1996, the total number of ISO 9000 certificates in LA represented 1% of the total world certificates issued. In 2000, when the ISO 9000:2000 was published, forcing firms to build a quality system that comprises design, production, and product inspection and testing, LA certificates already represented 2.5% of the world total. Given the efforts required to conform to the new standard, in 2005, this share did not surpass 3%. The number of ISO 14001 certificates in LA represented around 2% of the world total until 2001, rising to 3% by 2004.[6]

To explore differences between LA countries and the world in industrial certification intensities, we compute the industrial share of certification in LA and in the world and then the RAR of certification. Table 1 (column 2 and 5) shows the share of ISO 9000 and ISO 14001 certificates by industry worldwide in 2005.[7] Results suggest that the highest share of ISO 9000 and ISO 14001 certificates are concentrated in construction, basic and fabricated material, electrical equipment, machinery and equipment and wholesaling, followed by other services, rubber and chemicals, food, and transport, storage and communication. Laggards are water, gas supply, publishing, shipbuilding, aerospace, wood products, publishing and nuclear fuels. A similar industrial pattern is found in LA (Table 1, column 1 and 4).

[Insert Table 1 about here]

[6] Brazil has the highest number of certificates in LA, followed by Argentina, Chile and Colombia. When considering the number of ISO 9000 certificates per number of employees (or per GDP in constant 2000 dollars), Argentina and Uruguay have a higher rate of certificates per employee in 2005 (3 certificates per 10,000 employees in 2005) followed by Chile and Colombia with 2 per 10,000 employees, and next Brazil with 1. Concerning ISO 14001 certificates, Chile has the highest intensity at 0.4 per 10,000 employees, followed by Uruguay (0.3), Argentina, Brazil (0.2) and Colombia (0.1).

[7] Data at industry level in LA is not available for 2001 or 2002; consequently, we cannot check the evolution of the RAR from 2001/2 to 2005.

The RAR data (Table 1, column 3 and 6) suggest that industries related to exploration and manufacturing of natural and energy resources (coke and petroleum, pulp and paper, mining, non-metallic mineral products, food, rubber and plastic, agriculture and fishing, concrete, leather) have a greater relative share of ISO 9000 and ISO 14001 certificates in LA than the world average. High RAR in these industries are observed in all LA countries. Pharmaceuticals, aerospace, chemicals and services related to energy supply, transport and distribution, and health and social services have considerably higher shares of certificates than the world average in some LA countries.[8] Instead, construction, and manufacturing sectors related to machinery and equipment, electrical and optical equipment, transport equipment, and wholesaling in LA fall below the world average. It is worth noting that in Chile, the share of ISO 9000 certificates in the food industry is 5.7 times higher than the world average, while the share of ISO 14001 is 14.2 times higher.

Overall, the diffusion of certificates in LA countries has occurred mainly in the same sectors as in the rest of the world. Still, the RAR figures suggest that resource-intensive sectors are more certification-intensive in LA than in the rest of the world. Furthermore, some deregulated and privatized services, as well as some domestic capital and technology intensive industries, such as aerospace, pharmaceuticals and chemicals, have fostered the diffusion of certification. Results seem consistent with the existing literature that argues that LA countries have increased their participation in external trade of resource-intensive products rather than in technology and capital-intensive global products (such as electronics, machinery or transport) (ECLAC, 2002). These results suggest that national production and export structures are important to define the level of industrial compliance with IMS. We analyse next the relative impact of economy-wide factors, such as liberalization of capital and markets, technological capabilities and economic and institutional development, which may underlie

[8] In Brazil, publishing, printing and aerospace have a higher share of national ISO 9000 certificates than the world average. The share of ISO 9000 certificates in the Chilean food industry and public administration as well as in the Argentinean other transport equipment and public administration is much greater than the world average. The share of ISO 14001 certificates is substantially higher than the world average in health and social works in Argentina and Brazil, in the pharmaceutical industry in Argentina and Colombia. The share of ISO 14001 certificates is higher than the world average in electricity and transport, storage and communication in Brazil as well as in the food industry in Chile, Colombia and Paraguay.

this industrial specialization of certification.

4.2. The impact of internationalization on the diffusion of certification: the regression analysis

Table 2 reports Negative Binomial estimates for both the number of ISO 9000 and ISO 14001 certificates in LA countries, using both pooled and panel analysis. Table 3 shows instead the pooled and panel results split by period (i.e. before and after 2000).

[Insert Table 2 about here]

[Insert Table 3 about here]

Results for ISO 9000

The pooled data analysis (Table 2, column 1) suggests that the number of ISO 9000 certificates in LA is greater in countries with higher GDP per capita, greater labour force, larger agriculture sector as well as with increasing speed of foreign proprietary knowledge and assets usage. Moreover, the higher the export and fixed-capital investment propensity of a country, and the greater the presence of FDI, the fewer the number of ISO 9000 certificates the country is expected to have.[9]

Results from the panel data analysis with random effects, which the Hausman test indicates as the most appropriate specification, are reported in Table 2 column 3.[10] These results suggest that the number of ISO 9000 certificates increased with the GDP per capita, with the relative size of agriculture and services, with the export intensity of the country, and to a lesser extent with the speed to which countries were attracting more FDI and using more foreign proprietary knowledge and assets. ISO 9000 certificates also diffused as penalties for non-certification became stronger. In other

[9] Results with enter and backward estimation methods are similar, only the share of agriculture on the GDP becomes non-significant with the backward method.

[10] Also, random-effects model produces a better fit than the pooled model.

words, rather than the degree of openness, investment and country size, it has been the economic development, the growth of services, and the speed of internationalization of markets, capitals and knowledge flows that have supported the diffusion of ISO 9000 in LA.

Results in Table 3 suggest that there was a structural change in the diffusion of ISO 9000 in LA. According to the pooled model (column 1 and 2), before 2000, the number of ISO 9000 certificates was larger in LA countries with a larger labour force, higher level of economic development, and technological capabilities, but with a smaller relative propensity to export and to attract FDI. From 2000 onwards, the number of ISO 9000 certificates was greater in countries with larger labour force, with relative larger investments in fixed capital, relative lower ability to export high-technology products and to attract FDI. Ceteris paribus, ISO 9000 certificates increase with increased efforts to attract FDI.

Panel analyses corroborated these results (column 3 and 4). Before 2000, certification diffused more in countries that had relative lower export propensity, attracted relatively less FDI, used lesser foreign knowledge but increased the rate of using it, exported relatively more high-technology products and developed their service sectors. After 2000, certification diffused more in countries that experienced an increased GDP per capita, an inversion in their industrialization processes, and a relatively small but increasing FDI presence, with low export intensity especially of high-technology exports. Thus, the diffusion of ISO 9000 certification is increasingly explained by the speed of national openness to international capital rather than by the speed of using foreign knowledge and assets or by the export of high technology-intensive products. Hence, it is supported by developments in agriculture and low-technology and resource-intensive manufacturing and exports, and consequently with stagnation of services development.

Overall, ISO 9000 diffusion in LA seems to be explained by the national institutions and infrastructures supporting economy growth, by the national productive structure or by the national efforts to acquire knowledge from external proprietary sources and to attract international capital. A structural change is observed in the diffusion of ISO 9000 in LA, after the update of the standard in

2000. Thereafter, certification seems each time less due to the raising of national firms' capabilities to acquire and use knowledge from foreign sources and assets, as well as to export and produce in technology-intensive activities. Instead, it is increasingly explained by the improvement of national attractiveness for FDI, as well as by the increased specialization in the production and export of low-technology and resource-intensive products.

Results for ISO 14001

The pooled data analysis (Table 2, column 4) suggests that the number of ISO 14001 certificates is larger in LA countries with a higher level of national income per capita, smaller labour force, relatively smaller agriculture sector, relatively lower but increasing levels of FDI, and with intense growth in the use of foreign knowledge and assets.[11]

We then consider the panel data analysis with random effects.[12] Results suggest that the number of ISO 14001 certificates increased with the level of GDP per capita, national labour force, high-technology exports, relative size of services, and to a lesser extent the rate of growth of FDI. Moreover, the presence of penalties for non-certification also supported diffusion of ISO 14001 in LA.

As pooled model suggests, smaller countries with relatively small agriculture sector, relatively low FDI presence, and increasingly tapping into foreign knowledge have a larger number of ISO 14001 certificates. Their diffusion in LA (panel model) is instead supported by the level of economic, infrastructural and institutional development, growth of services, as well as by the speed at which exports of high-technology products, and to a lesser extent attraction of FDI increase.

Results on the structural change on diffusion of ISO 14001 before and after 2000 are shown in Table

[11] Results with enter and backward methods are quite similar. Payments of royalties and licences abroad on the GDP become positively significant, while their growth rate becomes not significant in the backward method.

[12] The random-effects model produces a better fit than the pooled model.

3. Results of the pooled model (column 5 and 6) suggest that there was a structural change in the diffusion of ISO 14001 certificates in LA. However, this result is not confirmed by the panel analysis (column 7 and 8). According to the pooled model, before 2000, ISO 14001 certificates were greater in number in LA countries with higher GDP per capita, relatively high use of foreign knowledge and technology assets and export of high-technology products, but with a relatively low intensity of export and fixed-capital investment, and slow services development. From 2000 onwards, ISO 14001 certificates were larger in LA countries with larger labour force, with faster service development, with relatively low use of foreign knowledge and low FDI presence. Hence, economic development and growth of services seem increasingly important for the diffusion of ISO 14001 after 2000, while technological capabilities and the level of use of foreign proprietary knowledge and assets are each time less important.

All in all, the diffusion of ISO 14001 in LA seems mainly explained by the national efforts to set up appropriate institutions and infrastructures supporting economic growth, to attract FDI, as well as by the national specialization in the production and export of technology-intensive products. These results reveal the importance of a more demanding customer base for the diffusion of environmental management system standards. There is not enough evidence to confirm a structural change in the diffusion of ISO 14001 in 2000, when combined certification with ISO 9000:2000 was facilitated. Still, the diffusion of ISO 14001 certification seems to be increasingly explained by the national production structure and by the level of infrastructure and economic development, especially by the development of services sector. Instead it seems each time less fostered by the national firms' capabilities to produce and export in technology-intensive activities or to acquire knowledge from external proprietary sources.

The main difference between factors affecting ISO 14001 and ISO 9000 diffusion relates to the relative size of the agriculture sector, export intensity, and technology-intensity of exports. The diffusion of ISO 14001 seems mainly dependent on the technological capabilities of countries. Instead, the production and export specialization in resource-intensive activities, and increase in the acquisition and use of knowledge from foreign proprietary sources favours the diffusion of ISO 9000.

These differences might also reflect the fact that ISO 14001 is a relatively younger standard than ISO 9000, and despite its relevance for resource-based activities, its diffusion has mainly taken off in the most technology-intensive sectors.

In sum, in LA, the diffusion of IMS certification seems dependent on the level of national economic and institutional development, the industrial structure, as well as on the speed at which national economies have been entering into the global production and trade of goods and knowledge. In the next section, we analyse in depth the relative importance of these and other factors by looking at the specific case of the Chilean salmon industry.

5. IMS in the Chilean salmon industry: the case study

According to UNIDO (2005), food industry is an outlier industry given its lower compliance level with IMS despite a high proportion of exports. In Chile, however, food is the industry with highest RAR in using ISO 9000 and ISO 14001, compared with the rest of the world. The Chilean salmon industry, in particular, exports more than 90% of its production mainly to the USA, Japan and Europe. Conformance with IMS is therefore crucial for the competitiveness of the industry. In this section, we analyse the diffusion of certification in the Chilean salmon industry and explore the role of openness to international markets and of deliberated efforts undertook by different actors that facilitate this process, using both quantitative and qualitative data.

5.1. Background information on the Chilean salmon industry

The Chilean salmon industry started commercial production in the mid 1980s for export. It experienced such strong growth that Chile became the top producer and exporter after Norway in 1992. Parallel with the upward surge of exports, several initiatives to control the quality of the national product and enhance its international competitiveness through the development and diffusion of national standards were undertaken.

The first attempt of certification for Chilean salmon was carried out by the private sector to differentiate good Chilean products from inferior ones so that image of stable quality could be established in the international market (Wurmann, 2004). In 1987, the Association of Salmon and Trout Producers of Chile (the Association from now on)[13] with the technical cooperation of the Fundacion Chile, a privately run institution with the public purpose of promoting technological transfer, created the private standard called 'quality seal' (sello de calidad). This private voluntary standard outlined the sanitary procedures for the fish processing plant for exports and its certification was monitored by the Association.

The public sector followed this private initiative. In particular, in 1985, the National Fishery Service (Servicio Nacional de Pesca: SERNAP, later SERNAPESCA) started developing the standardisation infrastructure to monitor the critical sanitation points of production and to diffuse the 'Sanitary Operation Procedure' (POS- Procedimiento Operacion de Saneamiento) based on the international standard HACCP- Hazard Analysis and Critical Control Points. Since the mid 1990s, SERNAPESCA has monitored and regulated the national developed standard, PAC- Programa Aseguramiento de Calidad (hereafter HACCP-PP) for farmed fish exports (interview with SERNAPESCA, 2004). The introduction of HACCP-PP by SERNAP in the mid 1990s replaced the privately initiated 'quality seal' (Alvial, 2006; UNCTAD, 2006). All the fish-processing plants producing for export need obligatory to comply with this process standard. In the early 2000s, SERNAPESCA has used the same procedure to develop and enforce HACCP-CC, as the national HACCP standard for fish farming centre, not compulsory for exports.

In the 2000s, as international environmental concerns increased and some Chilean salmon producers started obtaining ISO 14001 certification, several local initiatives tried to raise local firms' awareness on this new market demand. For instance, the Association and the public regulatory bodies developed

[13] The Association of Salmon and Trout Producers of Chile was established in 1986 by salmon producers. In 2001, the membership was extended to suppliers and its name changed to Association of the Salmon Industry in Chile (SalmonChile). At the time of the survey in 2004, Association's member firms produce about 80% of national production (about 70% of exports).

the protocol Acuerdo de Produccion Limpia (APL) – Cleaner Production Agreement – to ensure that firms would meet the agreed targets on environmental issues. This public disclosure program was established to promote compliance with regulation while creating space for negotiation and reduction of the cost of monitoring and being monitored. From 2004, firms that participated and complied with the targets set by the private-public voluntary APL standard were given the APL certificate (SalmonChile, 2004).

Furthermore, in 2003, the Association created SIGes (Sistema Integrada de Gestions: Integrated Management System) to facilitate and signal efforts towards the compliance with all the important standards in the salmon industry. SIGes was designed as a voluntary best-practice code and certification scheme aimed at becoming the umbrella standard for the salmon sector, incorporating concepts from several IMS such as ISO 9000, ISO 14001.[14] Consequently, the SIGes label disclosures and signals to international buyers the firms' effort to comply with standards relevant to the industry.

Overall, in the last 20 years, conscious efforts were made by both private and public sector to support firms attempting to upgrade their capabilities and competitiveness by means of standardisation, training, technological infrastructures, and monitoring. Over and above these gains, such efforts supported de-codification of IMS to the specificity of sector and local context, and re-codification of that specific knowledge to facilitate further compliance (Foray and Steinmueller, 2003). These efforts allowed firms to reduce transaction costs in searching for information or technical assistance to adopt standards, as well as to be reassured of the international credibility of these standards. Still, policy-makers of this sector are increasingly aware that Chile could no longer rely on 'copying and pasting' solutions – regulations, standards, policies – from developed countries. A specific regulatory system,

[14] SIGes includes the elements of: APL, RAMA, RESA, Code of good practice for environment, ISO 14001, ISO 9000, OHSAS 18000, Safe quality food (SQF), HACCP-PP, HACCP-CC, RCA (Environmental Qualification Resolution). SIGEs conforms to Safe Quality Food standards of the Association of Salmon Farming in Canada and the USA. It is also currently used by Wal-Mart in its procurement of salmon.

which addresses the geographical, natural and cultural conditions of the national industry, is required (Estrazer, 2004). We next analyse the impact of these national and industrial investments and policies, as well as of openness to international markets on firms' adoption of IMS.

5.2. Standards' compliance in the Chilean salmon industry: the regression analysis

We start by analysing the level of compliance with national industrial specific (HACCP-PP, HACPP-CC, APL, SIGEs), international industry specific (OHSAS 18000) standards, and IMS (ISO 9000, ISO 14001) in the Chilean salmon farming industry, as well as by looking at the motivations for Chilean salmon producers to engage in the process of certification. Table 4 shows the level of compliance with each standard recognized as important for the salmon industry in Chile.

[Insert Table 4 about here]

Results suggest that the national industry specific HACCP-PP is the most widespread standard among salmon producers, followed by ISO 9000 and HACCP-CC. Management best-practice and a mix group of standards, such as SIGes, ISO 14001 and OHSAS 18000, follows these. Table 5 reports the share of firms that identify as important or very important the proposed motivations for being certified or in process of certification.

[Insert Table 5 about here]

Independently of the standard, firms report engagement in certification mainly to increase their value added as well as to respond to the demand from customers and market pressure, but also to improve their image. Compliance with national regulations and demand from industry association are also important but score relatively lower. Thus, conformance with standards seems mainly a reactive decision of firms to increase their value added and respond to their customers' requests.

To understand the relative role of firms' efforts, international market pressure as well as of the national and industrial policy efforts towards standardization and certification on the compliance with IMS by Chilean salmon producers, Ordered Probit models are computed for the ordinal variables

level of compliance with IMS. Table 6 provides the Ordered Probit estimates on the compliance with ISO 9000 and ISO 14001.

[Insert Table 6 about here]

Results suggest that the level of compliance is higher for larger firms active in net or feed industries. Moreover, adoption of IMS seems mainly dependent on the firm's organisational capabilities to use their relational network to collaborate, especially with suppliers, for acquiring knowledge and develop capabilities. Additionally, compliance with national standards enhances the level of compliance with IMS, especially of ISO 14001, revealing the importance of firms' efforts to search and benefit from support provided by industrial associations and policy makers.

In sum, compliance with IMS relies on knowledge and capabilities that can be acquired and developed through different means and processes. Firm size, its specific industry activity, cooperation with suppliers and being an active searcher of information, as well as getting support from the industrial network and public organisations are of major importance for compliance with IMS.

Cooperation with suppliers seems a crucial way in which firms can acquire knowledge, and develop new production and technological capabilities necessary to comply with general IMS. Indeed, maintenance of collaborative agreements reveals certain organisational and managerial capabilities to use external sources of knowledge. It should also be noted that from the late 1990s, the emphasis on traceability of food-related products in international markets as well as increased competition pressures, led firms to concentrate on their core activities and outsource many activities that firms withheld (Montero, 2004; Maertens and Swinnen, 2009). Therefore, as firms' dependence on suppliers for auxiliary activities has increased significantly, conformance to IMS increasingly requires collaboration with suppliers.

Still, as in all processes of technological catch-up, the effort for developing links at both firm and national level is crucial (Padilla-Perez, 2008). Indeed, our results suggest that compliance with

national quality and safety standards enhanced the level of compliance with IMS, revealing the importance of firms' involvement in using the national existing informational and technological infrastructures to improve their competencies and competitiveness. Moreover, as the earlier brief historical review suggests, the Association is a privileged channel for diffusion of information and reputation reinforcement, as well as for supporting infrastructure development. Thus, the industrial and national efforts towards standardization and codification of quality, safety and environmental best-practices, as well as towards technological infrastructure development seem crucial for the upgrade of national firms' capabilities required for conforming to IMS.

Openness to international market does not seem to provide sufficient opportunities for supporting compliance with IMS. Other studies have also recognised the importance of industrial or national efforts to interpret and transfer information available in international markets (Maertens and Swinnen, 2009).

Overall, the analysis of the Chilean Salmon industry confirms the results put forward by the country and industry analyses that highlighted how access to external markets created in firms the need to comply with IMS and increase their value added. However, it also shows that external exposure per se does not provide enough knowledge and opportunities to enable firms to fulfil IMS requirements. User-producer collaboration and adoption of national standards played a crucial role in supporting salmon farmers to upgrade capabilities and conform to IMS. The national and industrial standardization and infrastructural efforts, often based on private-public collaboration, provided the incentives and mechanisms of reputation reinforcement for standards' compliance. In particular, industrial networking and the national and industrial actors played a role: first, in raising firms' awareness about the need to comply with standards and best-practices, and second in providing them with some of the necessary supports.

6. Discussion of results

To examine the role of openness to international markets for IMS diffusion in developing countries,

we have focussed on compliance with ISO9000 and ISO14001 in LA. Using a multi-level approach, we combined aggregated data on the national and industry number of certificates in LA countries, as well as firm-level and secondary data on the specific case of the Chilean salmon industry.

Our results show that the diffusion of ISO 9000 and ISO 14001 in LA mainly depends on the national efforts to develop appropriate infrastructures, on industrial structure, as well as on the national firms' capabilities to produce, export and acquire knowledge from external sources. There is evidence of a structural change, in LA, in the diffusion of ISO 9000 certificates but not for ISO14001. In particular, after 2000, the growth of FDI, the growth of the agricultural sector and participation in trade in (so-called) low-technology products have become important determinants of ISO 9000 diffusion at the expense of the degree of usage of international knowledge and copyrights, exporting high-technology exports and developing their service sector, which were instead motivating diffusion before 2000. Thus, despite having occurred mainly in the same sectors as in the rest of the world, the diffusion of IMS certificates is wider in LA than for the world average in resource-intensive sectors. These results are in line with other studies that have referred the increased importance of resource-based industries rather than of capital-intensive products on the export and production structure of LA economies (ECLAC, 2002, 2004). Moreover, our results suggest that openness to international markets of products and capitals provides a new incentive and penalisation framework for national firms and policy-makers. Thus, at both macro and meso level, openness to international markets seems to play an equally important role as specific deliberated efforts and policies in explaining the diffusion of IMS.

Starting from these results, the paper has then focused on the case of the Chilean salmon industry as a representative case of a sector in which IMS have diffused relatively more than other sectors in LA. Results from this specific industry have shown that, firms indeed feel the need to comply with IMS when aiming at accessing international markets, mainly to increase their value added and respond to requests from customers in developed countries. However, results also show that openness to international markets alone does not provide sufficient opportunities to acquire the knowledge that enables firms to comply with IMS and fulfil the standards required by multinationals or by the

institutional and regulatory framework of developed countries. Other studies have also shown that 'external exposure' allows only low levels of technology transfer to firms and their employees in developing countries (Padilla-Perez, 2008; Roy and Thorat, 2008).

Market based mechanisms allow firms to raise their awareness on technologies, markets and best-practices information, and provide them with new incentive frameworks. Compliance with IMS instead involves deliberated efforts at micro, meso and macro level, similarly to the development of technological capabilities (Bell and Pavitt, 1993; Tassey, 1996). In particular, firms' active search for external knowledge and capability building opportunities, especially through collaboration with suppliers, as well as through engagement in compliance with national standards and use of public and industrial support, was crucial for compliance with IMS. This result reveals that compliance with IMS involves a major knowledge development process for firms in developing countries, requiring external collaboration, which is found prevalent among the most innovative and capable firms in developed countries (Tether, 2002). Moreover, the national and industrial standardization and infrastructural efforts were also essential to diffuse awareness on the need to comply with IMS and best-practices across local firms.

Thus, our analysis reveals that international competitiveness of the Chilean salmon farmers depends on a national and industry ability to mobilize resources collectively towards technological and institutional improvement, as well as on firm-level capabilities and managerial strategies to acquire external knowledge. Moreover, our multi-level analysis on the diffusion of IMS in LA suggests that openness to international markets, allowing access to new incentives and information, played a major role in the collective rather than in the individual knowledge development process. Finally, in developing countries standards may also work as a learning tool in the context of openness to international markets. They may stimulate and direct the efforts to acquire knowledge of multiple actors, and provide a benchmark for these national efforts (Foray and Steinmueller, 2003; Bodas Freitas, 2007).

7. Implications for policy and management and conclusion

To provide a more integrated view of the role of openness to the international market and of the deliberated efforts of different national actors to foster the diffusion of compliance with IMS, our study has carried out a multi-level investigation of the compliance with ISO9000 and ISO14001 in LA. Our results bear some important implications for policy, management and method.

On the policy side, concerning the role of market based incentives for the diffusion of compliance with IMS, our evidence has shown that openness to international markets may motivate certification; however deliberated efforts at firm, industry and national levels are required to support firms to acquire knowledge and develop competences that enable them to certify. Hence, despite compliance with IMS being limited by the national level of economic and industrial development and by the firm's efforts to adapt to global business practice, there is ample space for both national policies aimed at creating technological infrastructures and at opening the national economy to global markets,. In particular, national policies focusing on openness to international capital and markets, as well as tapping foreign knowledge on adoption of standards and other relevant technologies may foster the diffusion of awareness and incentives to adopt IMS (Graham and Woods, 2006; Yeung and Mok, 2005). National policies investing in the development of appropriated regulations and infrastructures, as well as supporting local industrial organisations' activities, entrepreneurship and networking, and collaborative arrangements between firms might enhance firms' capabilities and diffusion of IMS.

This study also provides evidence on how IMS diffusion depends on a variety of efforts undertook by different actors. Thus, to be effective national policies may need to be implemented through a mix of vertical programmes, designed to address both technical, professional and industrial cooperative entrepreneurial efforts, as well as of horizontal programmes, designed to provide information and technical support to individual firms' innovative and capability building efforts (NAO, 1990; Schuurmann, 1998; Teubal and Andersen, 2000; Bodas Freitas and von Tunzelmann, 2008).

Previous studies stressed that IMS need to be understood as management tools to stimulate capability

development and innovation rather than as ‘burdens’ created by international partners (Bénéezech et al., 2001). In line with these arguments, we argue that policy-makers also need to understand IMS as tools to stimulate capability building and to direct efforts of different actors towards the upgrade of the competitiveness of national producers. In particular, the development and diffusion of national standards for specific industrial/social/technological contexts may provide a series of milestones on the process of full compliance with IMS.

As IMS becomes even more widespread, efforts to leverage the opportunities linked to the adoption of IMS become increasingly important for the competitiveness of producers in developing countries, Hence, the most relevant challenges faced by national policies concern how to facilitate different types of collaboration and alignment of interests of national actors to support the development of relevant technological infrastructures, as well as to keep the pace with international standards, and foster national participation in standard negotiations in low and high technology industries.

Our results also provide implications for industrial associations and other similar (public/private) associations. As earlier studies stressed, these organisations can also support local firms’ capabilities through diffusion of information and reputation reinforcement, as well as through provision of business support services (Vandergeest, 2007; Roy and Thorat, 2008). Their efforts to tap international knowledge on standards adoption and to adopt it to local needs and context, as well as efforts to negotiate with foreign buyers local supplies might be of crucial importance for the capability building and competitiveness of local producers (Hatanaka et al., 2005). Our case study also provides evidence on how the repackaging processes of knowledge and information on IMS and on other quality best-practices need to be continuously updated. Hence, we stress that to be able to support compliance with IMS, these organisations may need to invest continuously in the identification of best-practices on the implementation of IMS requirements, and in the design of specialized technical support and training services (Bodas Freitas, 2007). Moreover, to leverage the learning opportunities from adoption of IMS, these associations should consider to design support for IMS compliance as part of their overall strategy to support national/local producers to upgrade their international competitiveness. In other words, associations’ support for IMS diffusion should be

coordinated with support for the diffusion of other industry relevant management and technology best-practices (Teubal and Andersen, 2000). Thus, keeping track of international knowledge developments, assessing the required institutional and technological infrastructures (including standardization efforts, and design of new support services), as well as fostering private-public collaboration in the design and development of new infrastructures and institutions may be among their biggest challenges.

On the managerial side, our results show that user-producer interaction and search for public and associative support for IMS compliance enhance firms' ability to certify, while openness to international markets only provides firms with awareness of the need to certify. These results suggest that firm's managers in developing countries may find easier to conform with standards of foreign markets if they use their relational network to build up and improve their technical and organisational capabilities, as well as if they look for national and foreign external sources of knowledge. In particular, user-producer collaboration (and eventually collaborations with public research organisations) permit firms to complement internal efforts and investments in knowledge and capability development (eg. Tether, 2002). Similarly the search and use of national technological infrastructures provided by public and industrial organisations may provide firms with access to important resources to develop competences to certify. Additionally, search for information in foreign developed countries on competitors' technologies and organisation and on customers' tastes and needs allow firms to keep updated on the evolution of their market. The major challenge faced by firms engaged in compliance with IMS relate to the design of a formal documented management system, as required by IMS guidelines, that enhances information feedback and integration, as well as team and individual learning (Withers and Ebrahimpour, 2000; Bénéezech et al., 2001; Prajogo and Sohal, 2003,2004; Hoang et al., 2006). In other words, firms are challenged to use the process of IMS compliance to create learning opportunities.

Finally our analysis bears an important methodological implication. Our research has analysed the case of IMS diffusion at different levels: firms, industry and country. This approach has allowed us to single out both the role played by openness to international markets and the role played by national

efforts and policies. If, similarly to the existing literature, we had not taken a multi-level approach our policy and managerial implications would be conflicting, as the existing evidence seems to be. Our macro results would lead us to argue fatalistically that economic development, industrial structural change, export to international markets, attract FDI, and use of proprietary foreign knowledge are required to improve domestic firms' capabilities to comply with IMS (e.g. Graham and Woods, 2006). Our industry-case study results alone could lead instead to the optimistic argument that local industrial and policy entrepreneurship in supporting the development of technological infrastructures, and national brands and standards are 'enough' to support the development of domestic firms' capabilities and the diffusion of IMS (e.g. Jaffee and Masakure, 2005). The firm-level results could instead lead to overemphasize the responsibility of firms in developing capabilities to comply with IMS through collaboration with other firms, networking with local industrial partners and by exporting (eg. Yeung and Mok, 2005). On the contrary, taking a multi-level approach all fatalistic and optimistic interpretations of compliance with IMS in developing countries can be encompassed thus providing a way to account for the perspectives of each stakeholder.

Given the nature of our study, some limitations have to be taken into account. First, there might be a bias in the results induced by the specific case used. To have the full picture of IMS diffusion in LA, it would be interesting to gather firm and industry level information about standard compliance in non-resource based industries, in particular, in low-technology and high-technology intensive activities. Second, this paper focuses only on IMS, other product and process industry-specific standards may be as important as IMS for firms to compete in global markers. It would be interesting in future works to examine compliance with industry-specific standards, especially in medium and high-technology intensive activities.

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Table 1: Industrial revealed advantages in the number of ISO 9000 and ISO 14001 certificates, in Latin America

	ISO 9000 industrial shares		LA revealed advantages	ISO 14001 industrial shares		LA revealed advantages
	LA	World		LA	World	
Nuclear fuel	0.2%	0.0%	**10.09**	0.0%	0.3%	0.14
Publishing companies	0.3%	0.1%	**2.77**	0.0%	0.1%	0.29
Gas supply	0.2%	0.1%	**1.41**	0.1%	0.4%	0.20
Shipbuilding	0.2%	0.2%	0.97	0.0%	0.1%	0.32
Aerospace	0.4%	0.2%	**2.36**	0.1%	0.2%	0.87
Recycling	0.2%	0.2%	0.64	0.5%	3.0%	0.18
Water supply	0.5%	0.2%	**1.98**	0.7%	0.7%	1.05
Manufacture of coke & petroleum products	0.4%	0.3%	**1.26**	2.9%	0.9%	3.10
Mining and quarrying	0.5%	0.4%	**1.36**	6.1%	1.0%	5.89
Leather and leather products	0.6%	0.4%	**1.71**	0.3%	0.3%	0.90
Electricity supply	0.7%	0.4%	**2.05**	4.1%	1.7%	2.45
Pharmaceuticals	1.5%	0.5%	**3.33**	0.9%	0.8%	1.08
Hotels and restaurants	0.5%	0.6%	0.88	0.7%	0.9%	0.84
Public administration	0.8%	0.7%	1.19	0.2%	1.3%	0.13
Manufacture of wood and wood products	0.4%	0.8%	0.50	0.5%	0.8%	0.62
Agriculture, Fishing and Forestry	0.6%	1.0%	0.68	3.3%	1.7%	1.98
Pulp, paper and paper products	1.2%	1.0%	**1.27**	1.2%	1.7%	0.71
Printing companies	1.0%	1.0%	1.03	0.3%	1.4%	0.26
Other social services	1.6%	1.1%	**1.39**	1.9%	4.8%	0.40
Manufacturing not elsewhere classified	0.8%	1.2%	0.65	0.9%	1.0%	0.85
Non-metallic mineral products	1.8%	1.5%	**1.22**	0.7%	1.3%	0.56
Concrete, cement, lime, plaster etc.	1.5%	1.5%	1.01	1.6%	1.0%	1.51
Financial intermediation, real estate, renting	1.8%	1.7%	1.04	0.2%	0.9%	0.24
Textiles and textile products	1.6%	1.8%	0.86	1.7%	1.4%	1.26
Other transport equipment	1.4%	2.1%	0.68	4.8%	3.3%	1.47
Information technology	2.9%	2.1%	**1.38**	0.9%	0.9%	1.01
Education	1.3%	2.1%	0.60	0.4%	0.4%	0.92
Health and social work	3.7%	2.2%	**1.70**	0.9%	0.5%	1.81
Engineering services	3.2%	3.5%	0.91	2.0%	2.6%	0.76
Chemicals, chemical products & fibres	5.7%	3.9%	**1.46**	9.1%	6.0%	1.51
Transport, storage and communication	7.1%	3.9%	**1.84**	8.9%	4.0%	2.23
Food products, beverage and tobacco	4.6%	4.2%	1.09	12.4%	4.7%	2.62
Rubber and plastic products	4.9%	4.4%	1.11	3.8%	5.8%	0.66
Other Services	10.1%	5.7%	**1.77**	3.6%	3.7%	0.98
Wholesale & retail trade; repairs	4.1%	7.2%	0.57	2.7%	6.7%	0.41
Machinery and equipment	1.8%	7.4%	0.24	2.8%	5.9%	0.48
Electrical and optical equipment	7.0%	9.4%	0.74	7.2%	11.0%	0.65
Basic metal & fabricated metal products	11.8%	11.4%	1.04	7.7%	9.6%	0.81
Construction	10.9%	13.6%	0.80	3.6%	7.1%	0.50

Source: ISO Survey 2005, elaboration of the authors

Table 2: Estimates of Negative binomial regressions for the number of ISO 9000 and ISO 14001 certificates (lagged 2 years) in Latin America

	ISO 9000			ISO 14001		
	Pooled	**Panel**		**Pooled**	**Panel**	
		Fixed-effects	**Random-effects**		**Fixed-effects**	**Random-effects**
Constant	-109.25*** (38.49)	-519.73*** (57.54)	-455.47 (52.65)	104.48** (43.02)	-966.5*** (71.44)	-865.72*** (56.56)
Ln (national labour force)	6.27*** (2.09)	-0.02 (0.31)	0.66 (0.46)	-5.72** (2.35)	0.49*** (0.23)	0.84*** (0.17)
GDP PPP	0.0004*** (0.00)	0.0003*** (0.00)	0.0004*** (0.00)	0.0002* (0.00)	0.00 (0.00)	0.0003*** (0.00)
Share exports in the GDP	-0.042*** (0.02)	0.02 (0.02)	0.05** (0.02)	0.01 (0.02)	-0.02 (0.02)	-0.01 (0.02)
Share royalties in the GDP	-1.35 (0.85)	1.61 (1.02)	0.22 (1.21)	1.74 (1.09)	1.41 (1.35)	0.76 (1.25)
Share FDI in the GDP	-0.053** (0.02)	-0.05 (0.03)	-0.02 (0.03)	-0.09*** (0.04)	-0.08* (0.04)	-0.05 (0.04)
Share services in the GDP	0.02 (0.02)	0.06*** (0.02)	0.09*** (0.02)	0.01 (0.02)	0.02* (0.01)	0.03** (0.01)
Share agriculture in the GDP	0.055** (0.03)	0.05** (0.02)	0.06** (0.03)	-0.18*** (0.03)	-0.02 (0.04)	0.00 (0.03)
Growth rate services	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)	0.02 (0.01)	0.01 (0.02)	0.02 (0.01)
Growth rate royalties	0.022*** (0.00)	0.01* (0.01)	0.01* (0.01)	0.01*** (0.00)	0.02* (0.01)	0.01 (0.01)
Growth rate of FDI	0.03 (0.03)	0.14** (0.06)	0.11* (0.06)	0.15** (0.08)	0.16* (0.09)	0.14* (0.07)
Share gross fixed capital	-0.053** (0.02)	0.05** (0.03)	0.02 (0.03)	-0.03 (0.03)	0.01 (0.03)	-0.01 (0.02)
Share high technology exports	0.00 (0.01)	-0.01 (0.02)	-0.04 (0.02)	0.00 (0.01)	0.02 (0.01)	0.02** (0.01)
Year		0.26*** (0.03)	0.22*** (0.03)		0.48*** (0.04)	0.43*** (0.03)
Country dummies	All Significant			All Significant		
Year dummies	All Significant			All Significant		
Observations	104	104	104	97	97	97
Wald chi2	5056***	632***	693***	14365***	820***	1157***
Df	31	13	13	31	13	13
Log Likelihood	-567.14	-518.82	-613.84	-275.25	-256.43	-323.35
Hausman test		6.78			16.08	

Note 1: *** p<0.01, **p<0.05, * p<0.1.

Table 3: Estimates of Negative binomial regressions for the number of ISO 9000 and ISO 14001 certificates (lagged 2 years) in Latin America, before and after 2000.

	ISO 9000				ISO 14001			
	Pooled		Panel Fixed-effects		Pooled		Panel Fixed-effects	
	Before	After	Before	After	Before	After	Before	After
Constant			-1158.8*** (142.55)	-250.16*** (93.38)			-1612.6*** (227.47)	-962.4*** (135.43)
Ln (labour force)	0.3*** (0.10)	0.6*** (0.14)	0.24 (0.44)	-1.64*** (0.36)	-0.07 (0.27)	0.49*** (0.19)	-0.18 (0.58)	-0.04 (0.65)
GDP PPP	0.0004* (0.00)	0.00 (0.00)	0.00 (0.00)	0.0004*** (0.00)	0.001** (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Share exports in the GDP	-0.072*** (0.03)	0.01 (0.03)	-0.05** (0.02)	-0.07*** (0.02)	-0.17** (0.09)	0.04 (0.03)	-0.15** (0.06)	0.00 (0.03)
Share royalties in the GDP	-0.99 (1.20)	-3.40 (2.19)	-2.63*** (0.97)	-2.31 (1.78)	7.33** (2.96)	-6.64*** (2.17)	-0.73 (2.39)	-3.97 (2.41)
Share FDI in the GDP	-0.07** (0.03)	-0.09** (0.04)	-0.06** (0.03)	-0.13*** (0.03)	-0.06 (0.08)	-0.09** (0.04)	-0.02 (0.07)	-0.08* (0.05)
Share services in the GDP	0.00 (0.02)	-0.01 (0.02)	-0.02 (0.02)	-0.09*** (0.03)	0.00 (0.06)	0.01 (0.03)	-0.02 (0.04)	0.01 (0.03)
Share agriculture in the GDP	0.04 (0.06)	-0.02 (0.05)	0.01 (0.05)	0.085* (0.04)	0.19 (0.14)	-0.07 (0.08)	0.10 (0.10)	-0.12* (0.07)
Growth rate services	-0.01 (0.02)	0.01 (0.02)	0.04*** (0.01)	-0.04*** (0.01)	-0.12*** (0.04)	0.06*** (0.02)	0.03 (0.03)	0.04 (0.03)
Growth rate royalties	0.02*** (0.00)	0.15 (0.19)	0.02*** (0.00)	0.15* (0.09)	0.01 (0.01)	0.00 (0.34)	0.03*** (0.01)	0.08 (0.28)
Growth rate of FDI	0.05 (0.04)	0.28*** (0.09)	0.01 (0.05)	0.23*** (0.05)	-0.07 (0.18)	0.17 (0.13)	-0.09 (0.15)	0.11 (0.12)
Share gross fixed capital	-0.03 (0.03)	0.14** (0.04)	-0.03 (0.02)	0.02 (0.03)	-0.14*** (0.05)	0.03 (0.04)	-0.05 (0.04)	-0.01 (0.04)
Share high technology exports	0.044*** (0.01)	-0.024*** (0.01)	0.03*** (0.01)	-0.023** (0.01)	0.04* (0.02)	0.01 (0.01)	-0.01 (0.03)	0.00 (0.02)
Year			0.58*** (0.07)	0.14*** (0.05)			0.81*** (0.12)	0.49*** (0.07)
Country dummies	Most Significant	Most Significant			Most not Significant	Most Significant		
Year dummies	All Significant	All Significant			Not Significant	All Significant		
Observations	64	40	64	40	58	39	58	39.
Wald chi2	162280***	132899***	998***	234***	172620***	192700***	343***	177***
df	25	24	13	13	25	24	13	13
Log likelihood	-298.62	-237.42	-228.57	-171.45	-133.37	-138.46	-91.76	-103.92
Log likelihood test	581.24***		38.06***		217.09***		0.01	

Note 1: *** p<0.01, **p<0.05, * p<0.1.

Table 4: The level of compliance with international and national standards by Chilean firms in the Salmon Industry

	Share of certified firms	Not necessary	Planning	In process	Certified
		All	All	All	All
ISO 9000	21.7	6	18	11	10
ISO 14001	9.1	11	18	9	4
OHSAS 18000	8.6	14	13	5	3
HACCP- PP	70.3	7	0	3	24
HACCP- CC	21.2	10	7	8	7
SIGes	8.8	12	7	11	3
APL	4.3	6	37	0	2
Best-practice	12.8	9	1	28	6

Source: survey data, 2004

Note: Firms performance can be better, worse or equal than three years ago

Table 5: Important or very important motivations for compliance with different management standards. Share of firms in process of certification or already certified.

	ISO 9000 (% of firms)	ISO 14001 (% of firms)	OHSAS 18000 (% of firms)	HACCP-PP (% of firms)	HACCP-CC (% of firms)	APL (% of firms)	SIGes (% of firms)
Required by the association	38.1	**50.0**	**50.0**	0.0	**56.3**	34.2	**57.1**
Competitors have them	38.1	**50.0**	37.5	48.3	43.8	34.2	**57.1**
Required by the consumer	47.6	**57.1**	**50.0**	**51.7**	**56.3**	36.8	50.0
Improve the image of firm	**71.4**	**92.9**	**100.0**	**89.7**	**87.5**	**63.2**	**92.9**
Required by the market	**61.9**	**71.4**	**62.5**	**89.7**	**87.5**	**57.9**	**78.6**
Required by the clients	**57.1**	**71.4**	**62.5**	**79.3**	**75.0**	**55.3**	**71.4**
To comply with national regulation	42.9	42.9	**62.5**	**65.5**	**68.8**	**50.0**	**57.1**
Increase value added	**61.9**	**78.6**	**75.0**	**79.3**	**87.5**	**57.9**	**78.6**
No. of firms with high level of compliance	21	13	8	29	16	38	14

Note 1: Source: survey data
Note 2: Only firms with high level of compliance i.e. firms that are in process of certification or already certified.

Table 6: Ordered Probit estimations of the level of compliance with ISO 9000 and ISO 14001

	ISO 9000	ISO 14001
Client	-0.41	-0.79
	0.51	0.50
Supplier	1.03**	1.03**
	0.52	0.51
Association	0.11	0.88
	0.46	0.56
N_Standard	0.62*	0.51**
	0.33	0.25
Skills	-0.46	-0.35
	0.52	0.48
Export	0.37	0.21
	0.32	0.33
N_for_mkt	-0.60	-0.25
	0.59	0.55
For_Own	-0.26	-0.08
	0.38	0.51
Sales	0.17	0.06
	0.11	0.11
Best-practice	-0.12	-0.21
	0.17	0.18
Salmon	-2.72***	-2.8***
	0.97	0.90
Net	-1.06	-1.62
	1.30	1.08
/cut1	-2.73	-2.45
/cut2	-0.88	-0.54
/cut3	0.19	1.04
Observations	44	43
Df	12	12
Wald chi2	48.14***	70.4***
Log Pseudo-likelihood	-41.19	-36.72
Pseudo R2	0.28	0.32

Note 1: *** p<0.01, **p<0.05, * p<0.1.