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Global Diffusion of ISO 9000 Certification Through Supply Chains

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The ISO 9000 series of quality management systems standards is widely diffused, with more than 560,000 sites certified in 152 countries as of December 2003. Anecdotal evidence suggests that global supply chains contributed to this diffusion, in the following sense. Firms in Europe were the first to seek ISO 9000 certification in large numbers. They then required their suppliers, including those abroad, to do likewise. Once the standard had thus entered other countries, it spread beyond those firms immediately exporting to Europe to be adopted by many other firms in those same countries. This paper empirically examines the validity of this view of the role of supply chains in global diffusion of ISO 9000. To do so, we decompose the statement "supply chains contributed to the global diffusion of ISO 9000" into a series of four requirements that must be met for the original statement to be supported. We then use firm-level data from a global survey of more than 5,000 firms in nine countries to test the hypotheses that correspond to these requirements. Our findings are consistent with the view that part of the global diffusion of ISO 9000 did move upstream in global supply chains. In short, this means that firms that export goods or services to a particular country may simultaneously be importing that country's management practices. We conclude by suggesting how these findings might form the basis for future research on the environmental management systems standard ISO 14000.

Key words: ISO 9000; ISO 14000; quality management; supply chains; diffusion; global; empirical; survey
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1. Introduction

Do management practices diffuse through global supply chains? That is the question underlying this research. There are many mechanisms by which management practices might spread: through industry associations, government interventions, consulting firms, management education, etc. Some of these mechanisms operate primarily within countries, others could contribute to practices spreading across countries. Our interest here is in whether management practices diffuse across countries as a result of global supply chains. In other words, when firms export goods or services to a country, do they also import some management practices from that country?

We study this question in the context of ISO 9000, the widely diffused quality management systems standard. ISO 9000 was introduced in 1986 and had been adopted by over 560,000 sites in 152 countries by December 2003 (ISO 2004). Anecdotal evidence suggests that this worldwide spread occurred in part through supply chains. According to that view, large numbers of firms in Europe were early to adopt ISO 9000; they then imposed the standard on their suppliers, including suppliers abroad. These foreign suppliers essentially imported the standard into their own countries, after which it spread to other firms in the same countries.

This paper empirically examines this view of global diffusion of ISO 9000. To do so, we decompose the statement "supply chains contributed to the global diffusion of ISO 9000" into a series of four requirements that must be met for the original statement to be supported. This gives a self-contained theoretical framework for studying diffusion in supply chains; we relate this to the well-known Bass (1969) model of diffusion—which combines a constant innovation rate with a contagion effect—in Appendix A. Applying this theoretical framework to the case of ISO 9000, the four requirements translate into specific hypotheses. We combine global country-level certification data with firm-level data collected in a survey of more than 5,000 firms in nine countries to test these

hypotheses. Overall, our data are largely consistent with the view that ISO 9000 was initially adopted by large numbers of firms in Europe, then imported by supplier firms in other countries that exported to Europe. (Other regions that were early to adopt did not drive adoption elsewhere.) Those supplier firms, in turn, triggered traditional single-market diffusion mechanisms, hence contributing to certification by yet other firms within their country. This is consistent with the Dekimpe et al. (2000) view that, in studying diffusion, both breadth (across countries) and depth (within countries) must be considered simultaneously. We conclude that supply chain pressures related to export flows did contribute to global diffusion of ISO 9000. We should emphasize that a range of other factors, including those mentioned in the opening paragraph, also contribute to global diffusion. Our goal is not to rule out any other factors, but only to determine whether supply chains contributed to this global diffusion.

In §2, we review selected literature on ISO 9000 and related standards, and on diffusion theory. Section 3 presents our theoretical framework. Section 4 describes the data, and §5 discusses the methodology and results. Section 6 summarizes our findings and the limitations of this study.

A good concise introduction to ISO 9000 is available at www.iso.org. It states, among others, "ISO 9001:2000 specifies requirements for a quality management system for any organization that needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements and aims to enhance customer satisfaction,"[1] where ISO 9001:2000 is the revised version of the standard, introduced in 2000, integrating the earlier ISO 9001, 9002, and 9003 standards, which were first introduced in 1986. Certification to ISO 9000 means that a third-party auditor has verified that the firm's quality management system complies with the requirements of the standard; this certification must be renewed every three years. We will refer to the year in which the certification is first awarded as the year of adoption, although, strictly speaking, the preparations for a first certification can take 6–18 months. We will also occasionally refer to ISO 14000, the environmental management systems standard, introduced in 1996.

[1] See http://www.iso.org/iso/en/iso9000-14000/understand/selection_use/selection_use.html.

2. Literature

This paper draws on and contributes to several literatures: that on management practices and standards in general, on ISO 9000 and ISO 14000 certification in particular, and on global diffusion processes. Some of the recent theoretical perspectives on ISO 14000 are relevant for ISO 9000 as well, which is why we include them here.

Early academic surveys on ISO 9000 include the Brown et al. (1998) study of small firms' experiences with ISO 9000 and Lee's (1998) survey of ISO 9000 in Hong Kong. Terziovski et al. (1996) find no link between ISO 9000 and organizational performance among Australian firms. Anderson et al. (1999) use COMPUSTAT data to find that exports to Europe and elsewhere increase U.S. firms' likelihood of seeking ISO 9000, but they do not distinguish between early and late adopters as we do here. Terlaak and King (2006) find sales growth that is consistent with signalling models contributing to adoption of ISO 9000. Naveh and Marcus (2004), using a detailed survey of ISO 9000 in the United States, find that going beyond the requirements of the standard increases its value to the firm, and Naveh et al. (2004) find no difference between early and later adopters with respect to external pressure to seek certification. Delmas (2002) finds that institutional theory (Scott 1995) contributes to explaining early adoption of ISO 14000.

Some recent work has focused explicitly on global diffusion of ISO 9000 and ISO 14000. Mendel (2001) discusses various mechanisms driving global spread of ISO 9000. Guler et al. (2002) use national ISO 9000 certification levels to find that several forces, including trade relationships, drive global diffusion, while Delmas (2003) uses national ISO 14000 certification levels to find that reasons related to both cost minimization and legitimacy contribute to adoption. Corbett and Kirsch (2001) show that ISO 14000 certification levels by country depend on ISO 9000 certification levels, export propensity, and environmental attitudes. Christmann and Taylor (2001) find that foreign ownership and exports to more-developed countries increase the likelihood of ISO 14000 certification

among firms in China. Neumayer and Perkins (2004) use a panel data study of 142 countries to find that certifications per capita are positively correlated with, among others, stock of foreign direct investment and exports to Europe and Japan. Potoski and Pratash (2004) find that factors driving adoption of ISO 14000 within a country include the degree of adoption in export partners and the degree of regulatory flexibility in the country. Albuquerque et al. (2006) modify the Bass (1969) diffusion model to include cross-country effects and, using Bayesian estimation techniques, find that bilateral trade and geographical proximity are the strongest drivers of cross-country diffusion of ISO 9000, while cultural similarity also plays a role for ISO 14000.

There is ample anecdotal support for the view that supply chains contribute to global diffusion. During a series of interviews (Corbett and Kirsch 2000, 2001) and during later discussions with participants (from the United States and elsewhere) in a range of executive education programs, pressure from customers was cited as a common reason to seek ISO 9000 or ISO 14000 certification. According to this strictly anecdotal evidence, this pressure initially emanated from Europe, but later also from Japan and the United States. Government officials in Japan and Taiwan offered the apparent loss of sales by exporting firms in their respective countries that resulted from not seeking ISO 9000 certification early enough as a key reason behind various government policies to encourage ISO 9000 (and later also ISO 14000) certification. Given that for many firms the decision to seek ISO 9000 certification was not really voluntary, executives' experiences with the standard are mixed. Some found the process onerous and not helpful; others found it a valuable process leading to more streamlined and formalized procedures, generally improving management effectiveness, even if that was often not the original motivation for getting the certification.

The literature on diffusion of management practices is large. See, for instance, Dekimpe et al. (2000) for a review of the more limited research to date on global diffusion. Lücke (1996) finds that the level of economic development of countries affects the timing of the start of the diffusion process for weaving technology, but not the diffusion rate itself. Various other factors that drive diffusion of management practices are proposed by Abrahamson (1991) and subsequent work.

None of this work has directly asked adopters about the role of supply chains in explaining global diffusion. The contribution of the current paper is to formally state the requirements for claiming that supply chains contribute to global diffusion, to apply this framework to ISO 9000, and then to test it. In doing so, we make use of the extensive literature on survey research methods, especially that dealing with international mail surveys, reviewed in Singh (1995) and Harzing (1997).

3. Theoretical Framework

Consider a global economy, with firms in each geographic region trading goods and services with other firms, in the same and other regions. A new management practice (in our case, ISO 9000) is introduced somewhere in this global economy, and is gradually adopted by firms in many regions. A naive way of linking this global diffusion to supply chains would be to simply correlate the diffusion patterns observed with the deepening trade links between countries. Clearly, such an approach would not establish causality and would fail to account for several possible alternative explanations for any observed correlation between diffusion patterns and trade links. To rule out such alternative explanations, we decompose the statement "supply chains contributed to the global diffusion of ISO 9000" into a series of four requirements. Below, we outline these requirements; later we use them to formulate and test specific hypotheses. In Appendix A, we describe how an adaptation of the Bass model of diffusion (Bass 1969) can be used to generate largely identical hypotheses. At no time will we argue that global diffusion occurred exclusively as a result of supply chain interactions; however, if the four requirements below are met, there would be strong evidence that supply chain interactions contributed to global diffusion.

The first requirement (R1) to support the view that global supply chains contributed to global diffusion of ISO 9000 is that there must exist considerable heterogeneity in timing of adoption across geographic regions. Without such chronological heterogeneity, it would be meaningless to claim that ISO 9000 spread from one region to another at all, let alone that

any particular mechanism contributed to that spread. If this first requirement is met, we can distinguish between early- and later-adopting regions.

Assuming that this first requirement is met, the second requirement (R2) is that firms in the early-adopting regions must exert more pressure on their immediate suppliers to seek ISO 9000 certification than do firms in later-adopting regions. Without this second requirement, there would be no supply chain–related causal link between diffusion patterns in early- and later-adopting regions. (We consistently refer to "later-adopting" rather than "late-adopting" because the survey does not include truly late-adopting countries.) This pressure can take several forms. It can be explicit, e.g., by excluding non-certified firms from bidding for supply contracts (as is increasingly the case with ISO 9000). It can be implicit, e.g., by including questions about certification status in vendor selection questionnaires (as is currently becoming more common for ISO 14000). It can also be indirect, e.g., through the perception held by many non-European firms that ISO 9000 certification is a requirement for exporting to the European Union. Any of these mechanisms would put pressure on firms in later-adopting regions to seek certification.

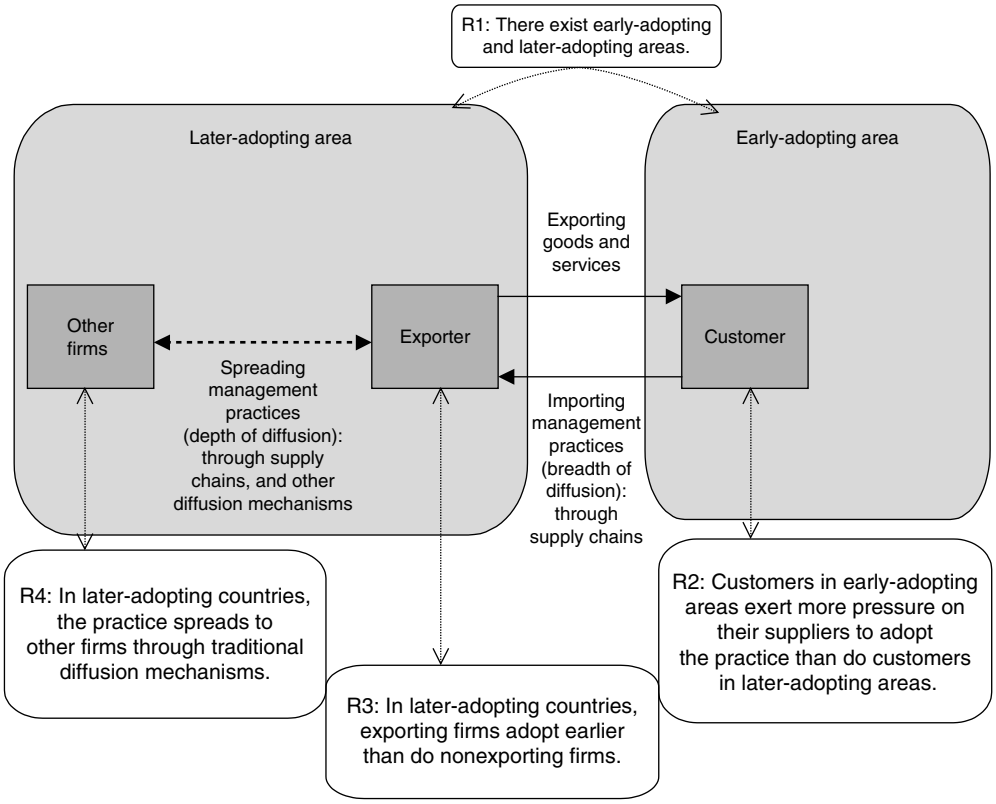
If the first two requirements are met, exporting firms in later-adopting regions experience pressure to seek certification from customers in early-adopting regions. The third requirement (R3) is that these exporters are indeed the first to seek certification within their (later-adopting) region. At that point, we can say that firms that export goods and services into another region imported ISO 9000 from that region. This third requirement addresses the breadth of diffusion from early-adopting to later-adopting regions (Dekimpe et al. 2000). If the first two requirements, but not the third, are met, adoption of ISO 9000 in other regions would not be a result of the pressure exerted by customer firms in the early-adopting regions. Note, though, that the causality can take either direction: Exporting firms may seek certification in order to protect their exports, or firms that seek certification may find themselves able to export more. Both are consistent with the supply chain diffusion perspective, so we do not need to specify a direction of causality for the third requirement.

The fourth and final requirement (R4) addresses depth of diffusion within the later-adopting regions: Firms that adopt later must be less motivated by export-related factors than are early-adopting firms. In other words, ISO 9000 spreads to other firms beyond the early-adopting exporting firms through traditional single-market diffusion mechanisms. This could be through pressure from exporting firms on their domestic suppliers, or through professional societies, trade organizations, word of mouth, etc. Without this fourth requirement, the spread of ISO 9000 in later-adopting areas would be limited to exporting firms, hence failing the depth requirement.

If these four requirements are met, one can conclude that global supply chains contributed to global diffusion of ISO 9000, as depicted in Figure 1. Other factors undoubtedly also contribute to global diffusion of ISO 9000; for instance, professional societies and word of mouth also cross borders. However, if such traditional, single-market diffusion mechanisms fully explained global diffusion of ISO 9000, several of the four requirements above would not be met. For instance, if adoption of ISO 9000 in one of the later-adopting regions was the result of a government policy encouraging certification, R2 and R4 would not be met. Early- and later-adopting firms should, in that case, not differ in the degree to which they were motivated by export-related factors, hence failing R4. If the government policy first targeted exporting firms, R3 might be satisfied, but in that case one could argue that the government certification policy was merely a response to already existing supply chain pressures; otherwise, why focus on exporting firms? If that supply chain pressure did not already exist, R2 would not be met. A similar reasoning can rule out level of economic development as the sole driving force of diffusion once all four requirements are met.

If diffusion follows an exclusively geographical path, we would find a nonrandom pattern of early- and late-adopting regions in R1, but no effects for R2, R3, and R4. If cultural ties between countries were the main driver of diffusion, R3 may be satisfied if exporting firms are more exposed to other cultures, but R2 and R4 would not be met. Finding support for all four requirements enables us to rule out alternative explanations with some confidence, and to conclude that supply chains did contribute to global diffusion

Figure 1 Global Diffusion of ISO 9000 Through Supply Chains



of ISO 9000. Hence, these requirements form a concise and falsifiable basis for testing whether global supply chains contributed to global diffusion of ISO 9000. Next, we present the data used in this study, after which we reformulate the four requirements as precise hypotheses to be tested.

4. Data

Data from several sources were used in this study. Certification levels by country for each year since 1993 were obtained from ISO (2004), based on a global survey that was originally performed by Mobil and later by ISO. Global data do not exist prior to 1993. During 1997–1999 we conducted open-ended interviews in Brazil, Japan, the Netherlands, Taiwan, Uruguay, and the United States, with firms with ISO 9000 or ISO 14000 certification (or both), registrars, accreditation bodies, and government agencies. Corbett and Kirsch (2000, 2001) summarize the findings from this phase.

Our main source of data is a mail survey, conducted in 17 countries. After eliminating countries with insufficient responses, nine countries remain: Australia and New Zealand, Canada, France, Hong Kong, Japan, the Republic of Korea, Sweden, Taiwan, and the United States. In each country, the survey was administered by local researchers; Harzing (1997) finds that such domestically administered surveys achieve higher response rates. A pilot survey among 200 U.S. firms during the summer of 1999 yielded 23 responses. After slight modification, the same basic survey form was used in all countries, translated by the local partner in each case. In total, 5,295 observations were used, though the number used in any specific analysis is usually slightly lower due to missing values for some questions. Response rates, shown in Table 1, varied from 8.8% to 50.4%. These figures compare favorably with Harzing's (1997) finding that response rates for international mail surveys among an industrial population are typically in the 6%–16% range. The survey questions used here are shown in

Table 1 Response Rates by Country

Country	Questionnaires mailed	Usable responses received	Response rate (percent)
Australia and New Zealand	3,000	611	20.4
Canada	561	198	35.3
France	2,000	445	22.3
Hong Kong	1,200	131	10.9
Japan	5,000	2,261	45.2
Korea, Rep. of	1,361	120	8.8
Sweden	268	135	50.4
Taiwan	2,142	455	21.2
United States	5,000	939	18.8
Total	20,532	5,295	25.8

Appendix B. In Questions 6 and 7, it would be impossible to ask firms about the importance of and the pressure exerted by customers in each of 100 or more individual countries, hence the aggregation into larger regions. Australia and New Zealand, and Japan are not aggregated into other regions and hence appear both as separate countries and as regions in the subsequent analysis. The motivations included in Question 9b are based on findings from earlier surveys on ISO 9000 or ISO 14000 certification (or both) (see the literature review) and on our interviews.

Care was taken to avoid the pitfalls of international mail surveys, discussed in Singh (1995). These include country biases due to cultural differences in response behavior, or to differences in sampling procedures. Some differences in sampling procedures were inevitable, due to lack of national databases of ISO 9000 or ISO 14000 certifications. For the United States, certification data were obtained from WorldPreferred in Toronto. Five thousand forms were mailed in winter 2001, to all (approximately 1,100) ISO 14000 certified firms, and the remainder were mailed to randomly selected ISO 9000 certified firms. Monetary and nonmonetary incentives were used: A postcard from UCLA was included in the survey, to which a golden dollar (a U.S. dollar) coin was attached, which presumably contributed to the relatively high 18.8% response rate. A telephone follow-up to 100 nonrespondents in November 2001 yielded 37 responses; these exhibited similar breakdown by industry and number of employees worldwide as the original respondents, but had lower global sales. No material nonresponse bias was found in the questions included in the follow-up, such as year of certification and overall benefits of certification.

In Japan, national certification data were obtained from the Japan Accreditation Board (JAB). A cover letter from JAB was included with the survey, but no incentive. In France and Korea, addresses of certified companies were obtained from leading registrars. In addition to being inevitable, Keown (1985) finds that such flexibility in sampling practices is in fact desirable.

We did notice some country biases; for instance, Taiwanese respondents reported higher scores than other respondents on all motivation and benefit categories. To avoid country bias, our analysis does not compare means across countries. Only for requirement R2 do we aggregate data across countries (Tables 8 and 9), but there too we report separate results by country (Table 10). Singh's (1995) concern with separate analyses by country is that of maintaining the overall Type I error rate. This is not a problem in our case, as most of the results are significant at the 1% or even stricter significance levels.

Table 2 provides descriptive statistics on the demographics of the respondents, while Tables 3–5 show correlations between responses to the survey questions used here. Unsurprisingly, firms that export heavily to one region are also more likely to export

Table 2 Descriptive Statistics: Demographics

	N	Mean	Median	Min.	Max.	St. dev.
Q1b Employees worldwide (7-point scale)	4,911	3.53	3	1	7	1.69
Q5a Year of initial ISO 9000 certification	5,118	1,997.21	1998	1983	2001	2.53

	% of respondents		% of respondents
Q3 Ownership		Q4b Activity (manufacturing)	
Publicly owned	16.06	Communications	3.12
Privately owned	75.17	Computer equip. or peripherals	3.58
State owned	2.54	Electronics	9.73
Foreign ownership	8.97	Semiconductors	1.61
Q4a Nature of business		Mechanical	15.48
Services		Automation	2.22
Manufacturing	25.91	Food	4.32
Construction	59.19	Plastic	7.36
Software	14.96	Chemical	8.25
	1.65	Textile	1.74
		Metal	14.84
		Pharmaceutical	3.12
		Others	3.58

Table 3 Correlations for Survey Question 6: Location of Immediate Customers

	Emp.	Year	Europe E	Japan J	North America NA	South America SA	Australia and New Zealand AZ	Asia w/o Japan AS	Africa A
Mean	3.53	1,997.21	2.38	3.15	2.54	1.66	1.73	2.47	1.20
St. dev.	1.69	2.53	1.61	1.78	1.75	1.09	1.38	1.56	0.62
N	4,911	5,118	5,026	5,026	5,026	5,026	5,026	5,026	5,026
Emp.	1.00	−0.35	0.28	−0.01	0.35	0.29	0.01	0.27	0.15
Year		1.00	−0.26	0.36	−0.33	−0.24	−0.40	−0.31	−0.23
E			1.00	−0.05	0.52	0.57	0.13	0.31	0.34
J				1.00	−0.05	0.13	−0.26	0.12	−0.01
NA					1.00	0.63	0.20	0.31	0.39
SA						1.00	0.26	0.44	0.51
AZ							1.00	0.12	0.52
AS								1.00	0.28
A									1.00

to others, and if the firms' customers in one region exert pressure to seek ISO 9000 certification, customers in other regions are also more likely to do so (reflecting the degree to which such pressures are industry specific). To assess whether multicollinearity is a concern, we perform several robustness checks, including varying the model specification and estimation method, and conclude that our structural findings are robust.

5. Methodology and Results

Here we reexamine the four requirements for supply chains to have contributed to global diffusion of ISO 9000, and discuss our methodology for testing each of these and the results obtained. For brevity, we use *area* to refer to the specific countries in which the survey was conducted or to the geographic region to which the respondent firms export.

5.1. Requirement 1: Heterogeneity Across Areas of Timing of Adoption

This part of the analysis is based on the global certification data from ISO. To assess the extent of adoption in a country at any given time, we would ideally compare the number of certifications to the maximum number of potential certifications, e.g., the number of establishments, but the only global data that come close to this, published by United Nations Industrial Development Organization (UNIDO) (2003), have notable shortcomings for our purposes. To overcome these limitations, we use four different methods to assess R1: ranking of certification levels deflated by

Table 4 Correlations for Survey Question 7a: Proportion of Customers Requiring ISO 9000 Certification

	Emp.	Year	Europe E	Japan J	North America NA	South America SA	Australia and New Zealand AZ	Asia w/o Japan AS	Africa A
Mean	3.53	1,997.21	3.37	3.08	3.12	2.43	2.77	2.76	1.94
St. dev.	1.69	2.53	1.24	1.11	1.24	1.21	1.32	1.17	1.15
N	4,911	5,118	2,310	3,126	2,344	1,499	1,131	2,518	532
Emp.	1.00	−0.35	0.10	0.05	0.09	0.09	0.04	0.07	0.13
Year		1.00	−0.15	−0.04	−0.12	−0.08	−0.15	−0.17	−0.19
E			1.00	0.64	0.71	0.62	0.66	0.61	0.49
J				1.00	0.62	0.60	0.71	0.68	0.59
NA					1.00	0.69	0.61	0.59	0.50
SA						1.00	0.69	0.68	0.75
AZ							1.00	0.64	0.68
AS								1.00	0.64
A									1.00

Table 5 Correlations for Survey Question 9b: Motivations for Seeking ISO 9000 Certification

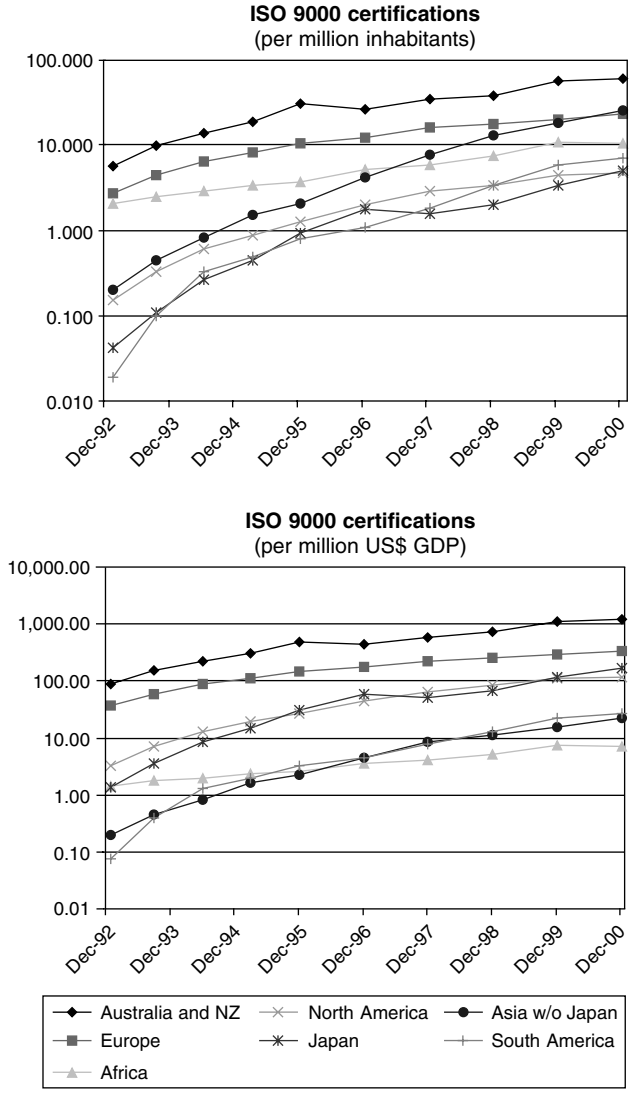
	Emp.	Year	Cost reductions Q9b1	Quality improvements Q9b2	Marketing advantage Q9b3	Customer pressure and customer demands Q9b4	Many competitors already ISO 9000 Q9b5	Benefits experienced by other certified Q9b6	Avoid potential export barrier Q9b7	Capturing workers' knowledge Q9b8	Relations with authorities Q9b9	Relations with communities Q9b10	Corporate image Q9b11
Mean	3.53	1,997.21	3.08	4.23	3.81	3.42	2.84	2.39	2.40	3.37	2.60	2.54	4.02
St. dev.	1.69	2.53	1.06	0.81	0.97	1.16	1.17	0.99	1.29	1.06	1.19	1.13	0.87
N	4,911	5,118	4,890	5,040	5,000	4,995	4,968	4,912	4,873	4,963	4,909	4,930	5,015
Emp.	1.00	−0.35	0.00	−0.02	0.00	0.08	0.11	0.08	0.19	−0.03	−0.04	−0.05	0.00
Year		1.00	0.02	0.08	−0.14	−0.17	−0.06	−0.14	−0.29	0.13	0.00	0.07	0.00
Q9b1			1.00	0.42	0.11	0.04	0.07	0.29	0.16	0.36	0.20	0.29	0.20
Q9b2				1.00	0.15	0.02	0.02	0.17	0.08	0.37	0.15	0.22	0.26
Q9b3					1.00	0.39	0.27	0.23	0.22	0.09	0.20	0.15	0.37
Q9b4						1.00	0.44	0.28	0.27	0.02	0.22	0.14	0.20
Q9b5							1.00	0.48	0.30	0.09	0.28	0.22	0.21
Q9b6								1.00	0.39	0.25	0.37	0.37	0.22
Q9b7									1.00	0.19	0.25	0.23	0.18
Q9b8										1.00	0.29	0.37	0.33
Q9b9											1.00	0.63	0.30
Q9b10												1.00	0.36
Q9b11													1.00

GDP, population, number of establishments, and a ranking by relative growth rates derived from the Bass diffusion model. Our data do not allow meaningful statistical tests of the relative timing of adoption, so our discussion of the first requirement will necessarily be more qualitative than that of the other three. Two other potential methods also do not apply here. First, one cannot subject the cumulative diffusion curves to tests of first-order stochastic dominance, such as the one-sided Kolmogorov-Smirnov test or the Wilcoxon-Mann-Whitney test, because this would require knowing the maximum number of potential certifications. Second, ranking countries by comparing mean year of adoption across countries does not work because, for all countries, the bulk of certifications took place in the late 1990s. The mean year of certification for all countries based on the sample is between 1995.2 and 1998.6, with seven out of nine countries in the 1995–1997 range, too close to be able to distinguish statistically. Simple numerical experiments based on the Bass diffusion model also confirm that the difference between average year of certification in two countries is much smaller than the difference between year of first certification in those countries.

Finally, note that R1 only requires that there exists considerable heterogeneity in timing of adoption; we will see below that does appear to be the case. For R2–R4 we also need to identify which regions and countries were early adopters, which is an inherently more challenging task. Alternatively, one could bypass R1 and the attempts at classifying countries and regions into early and later adopters by simply postulating the conventional wisdom that Europe was the early-adopting region and that (Western) European countries were the early-adopting countries. We prefer to let the ranking emerge endogenously from the data, despite the resulting imperfections, but the heart of the theory being tested in this paper lies below in R2–R4.

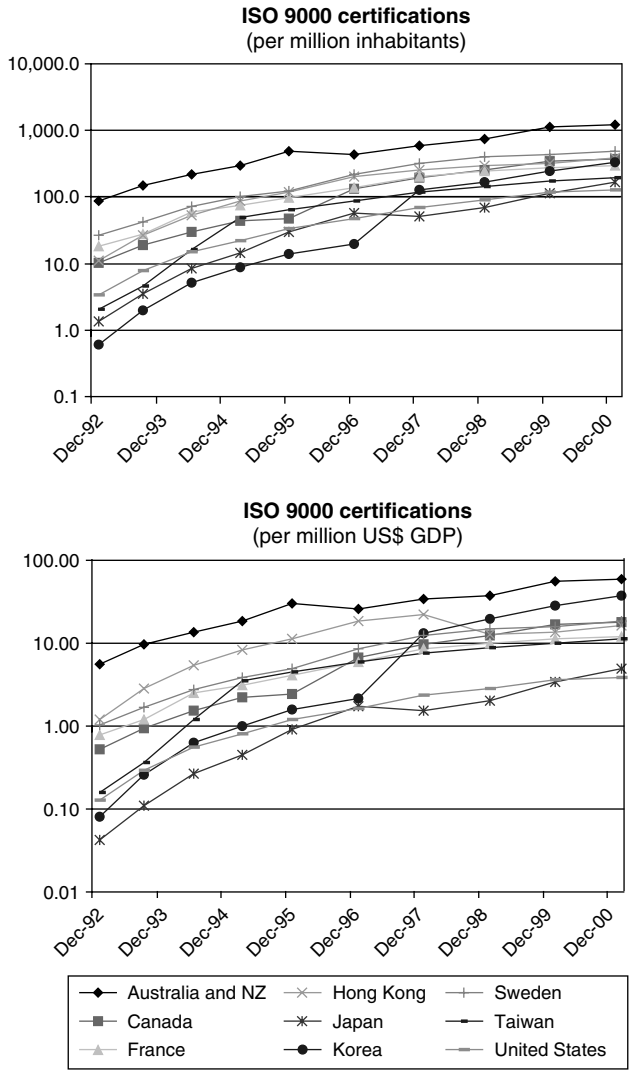
The first two approaches to ranking regions and countries by timing of adoption involve deflating certification counts using GDP and population, respectively, both imperfect but not unreasonable measures for this purpose. GDP has been used as a deflator in Guler et al. (2002) and Corbett and Kirsch (2001); however, this overcorrects in developed countries such as the United States and Japan, relative to developing countries. Deflating by population does the opposite, overcorrecting in large developing countries such as China and India relative to small developed countries. Figure 2 shows the diffusion by region, starting in January 1993 with the earliest existing data. At that time, ISO 9000 had existed for seven years and had been adopted by some 27,000 sites in 48 countries (ISO 2004). Inspection of Figure 2 shows that ISO 9000 first spread within Australia and New Zealand, and

Figure 2 ISO 9000 Certificates by Region



Notes. The upper chart is certifications per million inhabitants; the lower is certifications per million US$ GDP. Both charts are shown on a logarithmic scale.

Figure 3 ISO 9000 Certificates by Country



Notes. The upper chart is certifications per million inhabitants; the lower is certifications per million US$ GDP. Both charts are shown on a logarithmic scale.

Europe, with other regions following later, regardless of whether one deflates by GDP or population. (Regions include all countries within the usual geographical boundaries, not just those included in the survey. For example, *Europe* includes certifications in all of Europe, not just France and Sweden, the two European countries included in our survey.)

Similarly, Figure 3 indicates that Australia and New Zealand, Canada, France, Hong Kong, and Sweden were early-adopting countries, with Japan, Korea, Taiwan, and the United States following later.

Turning to our third method for assessing the first requirement, we use the UNIDO (2003) data on number of establishments by country. These data do not distinguish establishments by size or sector, so they are not an accurate estimate of the total market potential for ISO 9000 certification in a country; moreover, no data are available for Taiwan. Tables 6 and 7 provide the rankings of regions and countries based on certifications as of January 1993, divided by estimated number of establishments in 1993. (Using certification and establishment data for 1994 yields an almost

Table 6 Ranking of Regions According to Earliness of ISO 9000 Adoption Using Four Different Criteria

	Cum. certifications Jan. 1993	New certifications Sept. 1993	GDP 1993 (in million US$)	Population 1993 (in million inhabitants)	Establishments 1993	Cum. cert./GDP Jan. 1993	Rank	Cum. cert./pop. Jan. 1993	Rank	Cum. cert./est. Jan. 1993 (%)	Rank	New cert. Sept. 1993/cum. cert. Jan. 1993	Rank
Australia and NZ	1,862	1,322	328,649	21	60,665	5.666	**1**	88.318	**1**	3.07	**1**	0.71	**3**
Europe	23,092	14,682	8,600,484	630	1,265,815	2.685	**2**	36.612	**2**	1.82	**3**	0.64	**2**
Africa	825	184	404,795	573	34,440	2.038	**3**	1.440	4	2.40	**2**	0.22	**1**
North America	1,201	1,412	7,886,889	375	442,401	0.152	5	3.195	3	0.27	4	1.18	4
Japan	165	269	3,947,971	123	396,632	0.042	6	1.337	5	0.04	5	1.63	6
Asia w/o Japan	644	773	3,222,152	3	1,755,483	0.200	4	0.202	6	0.04	6	1.20	5
South America	27	113	1,402,918	362	229,123	0.019	7	0.074	7	0.01	7	4.19	7

Note. Regions that are substantially earlier than the rest are indicated in bold.

identical ranking, and does not change the classification into early- and later-adopting areas.) Here, the three early-adopting regions are Australia and New Zealand, Africa, and Europe. With respect to the ranking of countries, Table 7 shows that the only change compared to the earlier ranking is that Hong Kong now moves into the later-adopting category.

For the fourth perspective, consider that the Bass model implies that the ratio of new adoptions ΔN_t to cumulative past adoptions N_{t-1} must always be declining over time (see Appendix A). Tables 6 and 7 rank the regions and countries by their $\Delta N_t/N_{t-1}$ values for September 1993. Africa, Europe, and Australia and New Zealand have the lowest scores, implying that they were farthest along the diffusion curve in 1993. In the country ranking, Hong Kong would again be a later adopter, but otherwise the ranking is consistent with the earlier approaches.

In conclusion, widespread adoption occurred first in Europe, though Australia and New Zealand and, by some criteria, Africa also can be considered early-adopting regions. In Africa, the bulk of all certifications in 1993 were in South Africa. North America, South America, Japan, and Asia (without Japan) are the later-adopting regions. This is largely consistent with the view held widely among scholars and practitioners of ISO 9000 that diffusion of ISO 9000 started in Europe (e.g., Anderson et al. 1999) or in countries with close ties to the United Kingdom, where the BS 5750 standard, a partial predecessor of ISO 9000, was already well established when ISO 9000 was introduced (Guler et al. 2002). Australia and New Zealand, and certainly Africa, despite being early adopters by our relative measures, may not have sufficiently high absolute numbers of adoptions or be sufficiently large economic regions to actually drive adoption elsewhere. Initially, we do keep the possibility open that any or all of these (Africa, Australia and New Zealand, Europe) could have driven global diffusion. Below, we see that Africa fails our second requirement (suppliers do not perceive sufficient pressure from customers in Africa), and Australia and New Zealand only weakly meets it. We are ultimately left with Europe as the only region that was both an

Table 7 Ranking of Countries According to Earliness of ISO 9000 Adoption Using Four Different Criteria

	Cum. certifications Jan. 1993	New certifications Sept. 1993	GDP 1993 (in million US$)	Population 1993 (in million inhabitants)	Establishments 1993	Cum. cert./GDP Jan. 1993	Rank	Cum. cert./pop. Jan. 1993	Rank	Cum. cert./est. Jan. 1993 (%)	Rank	New cert. Sept. 1993/cum. cert. Jan. 1993	Rank
Australia and NZ	1,862	1,322	328,649	21	60,665	5.666	**1**	88.318	**1**	3.07	**2**	0.71	**3**
Canada	292	238	557,079	29	31,630	0.524	**5**	10.245	**5**	0.92	**4**	0.82	**4**
France	1,049	537	1,322,384	57	22,438	0.793	**4**	18.377	**3**	4.68	**1**	0.51	**1**
Hong Kong	69	92	57,266	6	36,847	1.205	**2**	11.226	**4**	0.19	6	1.33	7
Japan	165	269	3,947,971	123	396,632	0.042	9	1.337	8	0.04	7	1.63	8
Korea	27	60	335,101	44	88,864	0.081	8	0.615	9	0.03	8	2.22	9
Sweden	229	136	219,625	9	8,153	1.043	**3**	26.379	**2**	2.81	**3**	0.59	**2**
Taiwan	43	53	267,539	21	n/a	0.161	6	2.056	7	n/a	n/a	1.23	5
United States	893	1,166	6,960,440	261	403,614	0.128	7	3.420	6	0.22	5	1.31	6

Note. Countries that are substantially earlier than the rest are indicated in bold.

early adopter (R1) and that exerted sufficient pressure on its suppliers (R2). (Clearly, using absolute numbers of certifications in the early 1990s rather than the relative measures we use here, Europe with its 23,092 certifications would be classified as the early-adopting region, ahead of Australia and New Zealand with 1,862, or Africa with 825.)

Similarly, we can classify Australia and New Zealand, Canada, France, and Sweden as the early-adopting countries, with Japan, Korea, Taiwan, and the United States being the later-adopting countries; we cannot unambiguously classify Hong Kong. In summary, Figures 2 and 3 and Tables 6 and 7 show that the first requirement is met: There exists considerable heterogeneity among areas with respect to timing of widespread adoption, both among countries and among regions.

5.2. Requirement 2: Firms in Early-Adopting Regions Exert More Pressure

Having classified Africa, Australia and New Zealand, and Europe as early-adopting regions and the rest as later-adopting regions, the second requirement can be reformulated as follows:

Hypothesis R2. *The proportion of customers in Africa, Australia and New Zealand, and Europe requiring ISO 9000 certification is higher than that in other regions.*

To test this, we used Question 7a in the survey (see Appendix B), which asks for the proportion of customers in each region that require ISO 9000 certification, where 1 means no customers in that region require certification, and 5 means that all customers do. Table 8 shows mean responses by country and for the entire sample. In the global sample and in all countries except Hong Kong, firms report that the

Table 8 Hypothesis R2: Proportion of Customers in Different Regions Requiring Certification, by Country (Survey Question 7a)

	Customer region						
Respondent countries	Europe	Japan	North America	South America	Asia w/o Japan	Australia and NZ	Africa
Australia and New Zealand	2.57 (1.54)	2.29 (1.46)	2.36 (1.53)	1.75 (1.23)	2.38 (1.32)	2.92 (1.22)	1.59 (1.02)
Canada	3.54 (1.38)	2.74 (1.52)	3.49 (1.23)	2.23 (1.44)	2.34 (1.27)	2.40 (1.45)	1.62 (0.99)
France	3.04 (1.24)	2.29 (1.57)	2.45 (1.52)	2.07 (1.33)	2.31 (1.40)	n/a	n/a
Hong Kong	3.22 (1.13)	2.67 (1.33)	2.40 (1.22)	2.31 (1.20)	3.36 (1.01)	2.67 (1.23)	2.14 (1.23)
Japan	3.42 (1.05)	3.19 (0.86)	3.07 (1.04)	2.44 (0.92)	2.72 (0.94)	n/a	n/a
Korea	3.92 (1.05)	3.66 (1.15)	3.72 (1.20)	3.03 (1.14)	3.53 (1.08)	3.23 (1.17)	2.55 (1.03)
Sweden	3.59 (1.00)	2.85 (1.49)	2.81 (1.50)	2.30 (1.39)	2.27 (1.26)	2.63 (1.45)	1.82 (1.15)
Taiwan	3.81 (1.25)	3.61 (1.32)	3.58 (1.27)	3.02 (1.31)	3.24 (1.13)	3.23 (1.35)	2.11 (1.14)
United States	3.38 (1.35)	2.71 (1.41)	3.20 (1.20)	2.43 (1.32)	2.49 (1.30)	2.44 (1.32)	1.93 (1.18)
Global	3.37 (1.24)	3.08 (1.11)	3.12 (1.24)	2.43 (1.21)	2.76 (1.17)	2.77 (1.32)	1.94 (1.15)

Notes. The first number in each cell indicates the mean proportion of customers from the column region requiring respondents in the row country to seek certification; the second number (between brackets) is the standard deviation. Example: The mean Canadian response for Europe is 3.54, indicating that between some (3) and most (4) European customers require ISO 9000 certification. Tables 9 and 10 show results of tests for differences between regions. The French and Japanese surveys omitted Africa and Australia and New Zealand from the list of regions.

Scale: 1 = none, 5 = all.

Table 9 Hypothesis R2: Mean Difference Between Proportion of Customers in Different Regions Requiring ISO 9000 Certification, Using Pooled Data (Survey Question 7a)

	Europe	Japan	North America	South America	Asia w/o Japan	Australia and New Zealand	Africa
Europe		***0.30***	***0.28***	***0.94***	***0.65***	***0.69***	***1.29***
		0.000	0.000	0.000	0.000	0.000	0.000
		32.2%	31.0%	57.2%	49.1%	43.9%	60.6%
Japan	***−0.30***		***0.01***	***0.64***	***0.39***	***0.14***	***0.78***
	0.000		0.719	0.000	0.000	0.000	0.000
	13.3%		25.1%	46.6%	39.5%	24.4%	40.6%
North America	***−0.28***	***−0.01***		***0.63***	***0.33***	***0.42***	***1.06***
	0.000	0.719		0.000	0.000	0.000	0.000
	10.2%	22.1%		45.0%	35.4%	39.4%	58.0%
South America	***−0.94***	***−0.64***	***−0.63***		***−0.30***	***−0.22***	***0.38***
	0.000	0.000	0.000		0.000	0.000	0.000
	2.8%	7.0%	3.6%		10.2%	13.2%	26.6%
Asia w/o Japan	***−0.65***	***−0.39***	***−0.33***	***0.30***		***−0.06***	***0.65***
	0.000	0.000	0.000	0.000		0.085	0.000
	6.1%	9.2%	14.4%	31.0%		20.7%	41.4%
Australia and New Zealand	***−0.69***	***−0.14***	***−0.42***	***0.22***	***0.06***		***0.59***
	0.000	0.000	0.000	0.000	0.085		0.000
	5.3%	13.8%	13.3%	26.4%	23.1%		37.5%
Africa	***−1.29***	***−0.78***	***−1.06***	***−0.38***	***−0.65***	***−0.59***	
	0.000	0.000	0.000	0.000	0.000	0.000	
	1.0%	3.3%	3.5%	3.6%	2.7%	2.0%	

Notes. The first number in each cell indicates the mean difference (row minus column), the second gives the p value for the one-sided Wilcoxon signed-rank test, and the third indicates the percentage of respondents reporting a strictly higher score for the row region than for the column region. For example, firms worldwide reported more European than North American customers requiring ISO 9000 certification; the mean difference between Europe and North America was 0.28. Of those respondents, 31% reported a strictly higher score for Europe, 10.2% reported a strictly higher score for North America. The number of observations for each comparison depends on the number of firms responding about exports to both regions, but was always between 490 and 2,518, hence the high degrees of significance.

proportion of customers in Europe requiring certification is higher than that in other regions. For instance, in the global sample the mean for Europe is 3.37, so the proportion of customers requiring certification lies between some (3) and most (4). The scores for Australia and New Zealand, and especially Africa, are much lower.

To test whether these differences are significant, we need nonparametric methods because the responses to Question 7a are not normally distributed. The appropriate test with paired observations is the one-sided Wilcoxon signed-rank test (Miller et al. 1999), which involves computing all pairwise differences between regions, and calculating a test statistic based on the ranking of the absolute differences and their signs. We used PROC UNIVARIATE in SAS for the latter part of this procedure.

For each pair of regions, Table 9 shows the mean difference in proportion of customers from those regions requiring certification, using the pooled data across all countries. For instance, respondents reported on average a 0.28 higher score for proportion of customers in Europe than in North America requiring certification, and this is significant with a p value of 0.000. This difference of 0.28 between Europe and North America is close to, but not equal to, the difference between the European mean of 3.37 and the North American mean of 3.12 in Table 8, because the means in Table 8 are computed over all firms that responded to the question pertaining to that one region (e.g., Europe) while the means in Table 9 are taken over all firms that responded to the questions pertaining to both regions concerned (e.g., Europe and North America). From Table 9 we see that Europe

Table 10 Results for Hypothesis R2: Countries that Report Significantly Higher Proportion of Customers in the Row Region Requiring ISO 9000 Certification than in the Column Region (Question 7a)

	Europe	Japan	North America	South America	Asia w/o Japan	Australia and New Zealand	Africa
Europe		***C***, ***F***, ***S***, ***U*** *A*, *J*, *T*	***F***, ***J***, ***S***, ***T***, ***U*** *A*, *H*, *K*	***C***, ***F***, ***H***, ***J*** ,***K***, ***S***, ***T***, ***U*** *A*	***A***, ***C***, ***F***, ***J***, ***S***, ***T***, ***U***	***C***, ***K***, ***S***, ***T***, ***U*** *H*	***C***, ***H***, ***K***, ***S***, ***T***, ***U***
Japan			***J***	***C***, ***F***, ***J***, ***K***, ***S***, ***T***, ***U***	***C***, ***J***, ***S***, ***T***, ***U***	***K***, ***T***, ***U*** *C*	***C***, ***K***, ***S***, ***T***, ***U***
North America		***C***, ***U***		***C***, ***F***, ***J***, ***K***, ***S***, ***T***, ***U***	***C***, ***J***, ***S***, ***U*** *T*	***C***, ***K***, ***T***, ***U***	***C***, ***K***, ***S***, ***T***, ***U*** *H*
South America							***K***, ***T***, ***U*** *C*
Asia w/o Japan		***H***	***H***	***A***, ***F***, ***H***, ***J***, ***K***, ***U*** *C*, *S*, *T*		***K*** *H*, *U*	***A***, ***C***, ***H***, ***K***, ***S***, ***T***, ***U***
Australia and NZ		***A***	***A***	***A***, ***S*** *C*, *K*	***A*** *S*		***A***, ***C***, ***K***, ***S***, ***T***, ***U*** *H*
Africa							

Notes. If respondents in country *i* report a significantly higher proportion of customers in Region A requiring certification than in Region B, that country's letter is entered in Row A, Column B. This uses the one-sided Wilcoxon signed-rank test at the 5% (italics) and 1% (bold italics) significance levels. For instance, the entries "***K***, ***T***, ***U***," and "*C*" in row Japan and column Australia and New Zealand indicate that among Korean, Taiwanese, and U.S. respondents the average response for Japan was significantly higher than that for Australia and New Zealand at the 1% level and for Canadian respondents at the 5% level. In many cases, a positive difference was not significant because too few respondents in country *i* had answered the questions about exports to Regions A and B. The short interpretation of this table is: The more countries entered in a region's row, the more pressure customers in that region exert (relative to other regions), and the more countries entered in a region's column, the less pressure that region exerts (relative to other regions). Europe, with many entries in its row and none in its column, is the dominant region.

has the highest proportion of customers requiring ISO 9000 certification, followed by North America and Japan, then Asia (without Japan), Australia and New Zealand, South America, and Africa.

Given the large sample size, finding highly significant differences between regions is not surprising. More insightful is to compare the percentage of respondents experiencing higher pressure from Region A than Region B, with the percentage experiencing higher pressure from Region B than Region A. For instance, 31.0% of all respondents report a strictly greater proportion of customers in Europe than in North America requiring ISO 9000 certification, and only 10.2% report the opposite. The same pattern is largely replicated within each country, though due to the smaller sample sizes within countries, some differences are no longer significant. Table 10 shows, for each country, which differences are positive and significant at the 1% and 5% levels. The row Europe has many entries, indicating that respondents in many countries report higher pressure from customers in Europe than from other regions (in the columns). The column Europe has no entries, indicating that no region was perceived as exerting more pressure than Europe in any of the nine countries.

Overall, our findings are consistent with the hypothesis that a higher proportion of customers from Europe require certification than from other regions, but not with the corresponding hypothesis for Africa, and only weakly with that for Australia and New Zealand, whose firms exert much more pressure than those in Africa or South America but less than those in Europe, Japan, and North America. Hence, we drop Africa as a potential driver of ISO 9000 certification from here on.

5.3. Requirement 3: In Later-Adopting Areas, Firms with Higher Exports to Early-Adopting Areas Adopt Earlier

Our third and fourth requirements focus on countries in which diffusion started relatively late, i.e., Japan, Korea, Taiwan, and the United States. Including the appropriate control variables, Requirement 3 becomes:

Hypothesis R3. *In Japan, Korea, Taiwan, and the United States, firms with higher exports to Australia and*

New Zealand or to Europe certified earlier, after correcting for size and other exports.

Our dependent variable here is ISO9Year, the year of original certification for each respondent. We get Exports to other regions by computing the mean of the responses to Question 6 over all regions except Australia and New Zealand, and Europe. Controlling for size is slightly more involved: Questions 1 and 2 asked about employees and sales, respectively, but many respondents only answered one of the two questions, so that any analysis using the original scores for Questions 1 or 2 would miss many responses. We define a company as *large* (Large = 1) if it has more than 1,000 employees worldwide (Question 1b) or falls within the top quartile (within its country) with respect to world sales (Question 2b). This new dummy variable exhibits high Spearman rank correlation with the two original size variables, generally in the 0.75–0.85 range and always greater than 0.60, so it is an acceptable proxy for size. Setting the cutoff point at 5,000 employees worldwide gives similar results, as does the analysis based on either of the original variables but therefore using fewer observations.

Hypothesis R3 then predicts that in the later-adopting countries ISO9Year is negatively associated with Exports to Australia and New Zealand and with Exports to Europe when correcting for size and exports to all other regions. Note that R3 makes no prediction about the early-adopting countries. It also does not preclude finding significant effects for exports to other regions, though if significance and magnitude of such effects are as large or larger than for Europe and Australia and New Zealand, it would become hard to argue that the impact of early-adopting regions was greater than that of others.

In testing this, we face two challenges. We need to allow for the possibility that there exist interactions

Table 11 Results for Hypothesis R3: Explaining Year of Adoption by Country as a Function of Firm Size and Exports

	N	Intercept	Large	Exports to Europe	Exports to Australia and NZ	Exports to other regions
Country	log *L*	Estimate *p* value	Estimate *p* value	Estimate *p* value	Estimate *p* value	Estimate *p* value
Australia and NZ	576 −1,291	1997*** <0.0001	−1.2717*** <0.0001	−0.0242 0.8366	−0.1663 0.1692	−0.1065 0.5375
Canada	181 −433.3	1998*** <0.0001	−1.8577*** 0.0011	0.0116 0.9598	−0.6923* 0.0688	0.0414 0.9411
(France)	*424* *−760.7*	*2013**** *<0.0001*	*−2.2694* *0.0025*	*−1.4717**** *0.0060*	n/a	*−3.1341**** *<0.0001*
Hong Kong	112 −223.7	2001*** <0.0001	−4.8316*** <0.0001	0.8993 0.1483	0.0858 0.8877	−1.0853 0.3556
Japan	2,164 −3,613	2004*** <0.0001	−2.1383*** <0.0001	−0.5800*** <0.0001	n/a	−1.2455*** <0.0001
Korea	111 −219.7	1997*** <0.0001	−1.5909*** 0.0029	−0.6196*** 0.0061	0.3642 0.1996	0.1894 0.6923
Sweden	133 −285.9	2001*** <0.0001	−2.7881*** 0.0002	−0.4915 0.4807	0.7579 0.0972	−0.9727* 0.0541
Taiwan	434 −886.9	1997*** <0.0001	−0.6611*** 0.0024	−0.3177*** 0.0030	0.0313 0.8022	−0.2603 0.2150
United States	891 −1,935	1998*** <0.0001	−0.9226*** <0.0001	−0.1725** 0.0229	0.1489 0.1487	−0.4689*** 0.0057

Notes. These results are maximum likelihood estimates for the truncated regression by country. The first column shows the sample size and the log likelihood for each country. Significance at the 1% level is shown by ***, at the 5% level by **, and at the 10% level by *. The figures for France are not reliable, because some respondents may have reported the most recent recertification rather than the year of original certification, and firms must recertify to ISO 9000 every three years. However, as Hypotheses R3 and R4 focus on later-adopting countries, the results for (early-adopting) France do not affect our conclusion in support of Hypotheses R3 and R4. Note, also, that the classification of France as an early-adopting country was based on national certification data, not on the survey data. The results for France are shown only for completeness.

between firm size and each of the export variables, which would lead to nonequal slopes for smaller and larger firms. We also need to incorporate the fact that ISO9Year is truncated above (Maddala 1983, §6.9), because the data do not include certifications that occurred after the survey was administered. No established estimation procedure takes both of these issues into account, so we deal with them separately. We tested for interactions using analysis of covariance (ANCOVA; see Hair et al. 1998), using PROC GLM in SAS, but found a significant interaction effect only in Japan, due to that country's large sample. This justifies focusing on the truncation problem while ignoring interaction effects. Therefore, we use the maximum likelihood estimator for truncated regression (Maddala 1983) as implemented in PROC QLIM in SAS, setting the upper truncation for each country equal to the year of its most recent certification in the survey.

Table 11 shows that Exports to Europe is significant at the 1% level in Japan, Korea, and Taiwan, and at the 5% level in the United States. This means that Exports to Europe are a significant factor in explaining early adoption in all four later-adopting countries, after correcting for size and exports to all other regions. Exports to Australia and New Zealand have little or no effect on adoption timing in most countries. To assess the magnitude of these effects, consider Table 12, where each region is included separately, which facilitates comparison of magnitudes across regions. The parameter estimate of −0.50 for Exports to Europe in the model for Japan means that a one-point increase in importance of exports to Europe (on our five-point scale) corresponds to year of certification being up to 0.5 year earlier. Note that that is "up to," because the marginal effect in a truncated regression is always less than the corresponding coefficient (Greene 1997, p. 955). To determine the marginal effect strictly within the (truncated) sample of responding firms, one would multiply the coefficient with a factor that reflects the degree of truncation; to determine the effect in the entire (untruncated) population of firms, one would use the coefficient itself. The standard deviation of the Exports to Europe variable (Question 6) across all respondents is 1.61, so a one standard deviation increase in this variable would correspond to certification taking place up to 0.8 years earlier.

There is, of course, some correlation between Exports to Australia and New Zealand, Exports to Europe, and Exports to other regions; the correlation coefficients vary between 0.06 and 0.45. The consequence of multicollinearity is usually to inflate the standard errors and hence reduce the significance of the parameter estimate (Greene 1997, pp. 418–427), so if a parameter is significant despite multicollinearity, that indicates that whatever multicollinearity is present is not a major concern. Various robustness tests confirm that the structural results are stable, which further reduces concern about the effect of multicollinearity. To avoid this correlation, we can also combine all the Exports to… variables into one sin-

Table 12 Results for Hypothesis R3: Explaining Year of Adoption

	Parameter estimate and significance level for exports to						
Country	Europe	Japan	North America	South America	Asia w/o Japan	Australia and New Zealand	Africa
Australia and NZ	−0.04	0.24**	−0.14	−0.02	−0.18**	−0.14	0.15
Canada	0.03	0.03	1.26***	0.04	−0.03	−0.63*	−0.13
(France)	*−1.47****	*−0.33*	*−0.61**	*−0.19*	*−0.81***	n/a	n/a
Hong Kong	0.29	−0.39	−0.02	0.97	−1.58***	−0.01	−0.07
Japan	−0.50***	0.08	−0.35***	0.18*	−0.40***	n/a	n/a
Korea	−0.62**	−0.02	0.00	0.19	−0.04	0.27	0.19
Sweden	−0.53	−0.07	0.13	−0.40	−0.43	0.83*	−0.39
Taiwan	−0.35***	−0.02	−0.12	0.14	−0.15	0.02	−0.19
United States	−0.15**	0.10	0.16	−0.04	−0.34***	0.15	−0.10

Notes. These results are maximum likelihood estimates for the truncated regression by country. Significance at the 1% level is shown by ***, at the 5% level by **, and at the 10% level by *. The figures for France are not reliable and are shown only for completeness; see note in Table 11.

gle variable: Global exports (results not reported). This new variable is significant at the 1% level for Japan, Taiwan, and the United States, but is not significant for Korea. To examine the magnitude of each region's impact separately, at the expense of exacerbating multicollinearity, we repeat the analysis with separate Export to… variables for each region, shown in Table 12. Exports to Europe are again significant in Japan, Korea, Taiwan, and the United States. Exports to North America drive earlier certification in Japan but later certification in Canada; Exports to Asia cause earlier certification in Australia and New Zealand, Hong Kong, Japan, and the United States. Exports to Africa and Exports to Australia and New Zealand have little or no effect. In most cases, the parameter estimate for Exports to Europe is the largest (in absolute terms), indicating that Exports to Europe is a stronger driver of early certification than exports to any other individual region. Overall, this is consistent with the hypothesis for the third requirement with respect to Europe, but not with respect to Australia and New Zealand.

5.4. Requirement 4: In Later-Adopting Countries, Firms that Adopt Later Are Less Motivated by Export-Related Factors

To examine this, we need to define *early-* and *later-adopting* firms. Firms with certification year in the first tertile within each country are defined as *early adopters*, those with certification year in the third tertile as *later adopters*, leaving out the middle third. (Using other classifications, based on quartiles or median, and with or without omitted middle groups, gives highly similar results.)

Question 9b asked about motivations for certification. The motivation that explicitly addresses exports is "avoid potential export barrier." The hypothesis corresponding to our fourth requirement is then:

Hypothesis R4. *In Japan, Korea, Taiwan, and the United States, firms that adopt later are less motivated by export protection than are earlier adopters.*

A bias would occur if early adopters reported higher scores for all motivations; therefore, we normalize each motivation score by dividing it by the sum over all 11 motivation factors. Let $\mathrm{MOT}(k)_i$ be respondent i's score for motivation k; the relative score for motivation k is $\mathrm{RELMOT}(k)_i := \mathrm{MOT}(k)_i / \sum_{j=1}^{11} \mathrm{MOT}(k)_j$. The normalized variable for the export motivation is RELMOTEXP. (Using the raw scores gives similar results.)

The test is now whether, in the four later-adopting countries, firms classified as early adopters have higher scores than later adopters for RELMOTEXP. The customer pressure motivation factor (RELMOTCUST) does not distinguish between domestic and foreign customers, so our set of requirements does not predict how the importance of this factor differs between early and late adopters.

The normalized motivation scores are not normally distributed, so we apply nonparametric analysis of variance (ANOVA), using the one-sided Wilcoxon two-sample test (Miller et al. 1999), which is based on a test statistic calculated using the ranks of each observation within its respective group. We used PROC NPAR1WAY in SAS. (Note that multivariate ANOVA, or MANOVA, is not appropriate here, because we are interested in the effect of early adoption on individual motivation factors, not on all motivations jointly.) Table 13 shows significant differences (at the 1% level) in RELMOTEXP between early and later adopters in the expected direction in all four later-adopting countries. (The hypothesis does not preclude finding the same pattern in early-adopting countries, as we do in Australia and New Zealand.) This is not a mere sample size effect: In Japan, for instance, almost any difference would be significant due to the large sample, but the magnitude of the difference is also larger than for most other motivations. The descriptive statistics in Table 5 serve as a reminder that other factors contribute to explaining adoption, because most other motivations display higher average scores than export protection does. However, the variance of the scores for export protection is the highest, and it is the only motivation that strongly distinguishes early and later adopters in the four later-adopting countries, which is consistent with Hypothesis R4.

6. Discussion, Conclusions, and Future Research

Although our findings do not (and are not intended to) rule out other drivers of global diffusion of ISO 9000 certification, they are consistent with the hypothesis that the following process contributed to global

Table 13 Results for Hypothesis R4: Differences in Relative Motivation Factors Between Early and Later Adopters

	Relative motivation factors: See Question 9b in Appendix B										
Country	Cost reductions 1	Quality improvements 2	Marketing advantage 3	Customer pressure/ customer demands 4	Many competitors were already ISO 9000 certified 5	Benefits experienced by other certified companies 6	Avoid potential export barrier 7	Capturing workers' knowledge 8	Relations with authorities 9	Relations with communities 10	Corporate image 11
Australia and NZ		−−−		+++			+++		−−	−−−	−−−
Canada									+++	++	
(France)	−			++	++		++		−−	−−	
Hong Kong		−−		++	++		−	−−			
Japan	−−−	−−−		+++		++	+++	−−−	−−−	−−−	−−−
Korea			−				+++	−		−−−	−−
Sweden			+			−−−					
Taiwan	−	−	+	+	−		+++				−
United States	−	−−				−−	+++	−			

Notes. These results are based on nonparametric ANOVA by country, using the t-approximation for the one-sided Wilcoxon two-sample test of differences of means. A "+" indicates that early adopters have a higher score; "−" indicates a lower score; +++ indicates significance at the 1% level, ++ at 5%, and + at 10%; likewise for −− and −−−. "Early" and "later" adopters are defined as the first and third tertile respectively; the middle tertile is omitted. The results for France are unreliable and are shown only for completeness; see note in Table 11.

diffusion. Diffusion of ISO 9000 started (primarily) in Europe in large numbers, although Australia and New Zealand and Africa were also early to adopt, relative to their sizes. From Europe, it spread to other regions, as customers in Europe pressured foreign suppliers to seek ISO 9000 certification more strongly than did customers in other regions. Those suppliers in other countries then sought certification as protection against the perceived threat of ISO 9000 becoming an export barrier. After exporting firms in other countries had adopted the standard, domestic diffusion by traditional mechanisms picked up, and other firms in those countries started adopting ISO 9000 too, resulting in more than 560,000 certifications in 152 countries by 2003. The findings in this paper suggest that at least part of those certifications can be explained by pressure exerted by downstream customers through global supply chains on upstream firms in other countries. This implies that firms exporting goods or services into a region may also simultaneously import management practices from that region back into their home country.

Firms in Africa and in Australia and New Zealand, the other regions that we classify as early adopting by our relative measures, did not exert as much pressure on suppliers elsewhere to seek certification and appear to have contributed less or not at all to the global diffusion of ISO 9000 despite being early adopters themselves. One might speculate that this is due to the fact that, individually and collectively, most firms in Africa and in Australia and New Zealand are smaller and less powerful than those in Europe, but our data do not allow us to verify that.

This paper aims to contribute to the diffusion literature by explicitly examining the role of supply chains in explaining global diffusion of management practices, and by formulating precise requirements for claiming that supply chains contribute to global diffusion. This paper also aims to contribute to the literature on ISO 9000 by testing hypotheses derived from these requirements and showing that observed diffusion patterns are consistent with the view that ISO 9000 did diffuse worldwide through global supply chains.

This study has several inevitable limitations. It does not include truly late-adopting countries; attempts were made to administer the survey in Argentina, Mexico, and Southeast Asia, but these attempts were largely unsuccessful. The survey, administered around 2000, is an imperfect way of obtaining information about motivations for certifications that occurred long before; however, the bulk of all certifications, including those in early-adopting countries, occurred in the mid to late 1990s, which partially mitigates this problem. Despite these and other limitations that are inherent in survey research, two factors

lend additional credibility to the results. First is their face validity: The picture that emerges from this analysis is consistent with anecdotal views of global diffusion of ISO 9000. Second is their robustness: Each of the tests reported here was performed n several different ways, without leading to substantially different results.

This study has only examined ISO 9000, so we cannot conclude that other management practices or standards diffuse through global supply chains, too. Documenting similar findings for ISO 14000 and other standards and practices is necessary to assess the generalizability of our findings beyond ISO 9000. However, this author's original interest was in ISO 14000, the environmental management systems standard introduced in 1996 and adopted by more than 66,000 sites in 113 countries by December 2003 (ISO 2004). The design of the ISO 14000 standards is analogous to that of ISO 9000, even though its scope is different. If one can demonstrate that an environmental management standard such as ISO 14000 diffuses through global supply chains, that would imply that the notion of greening the supply chain is indeed a feasible nongovernmental market-based mechanism for spreading environmental practices to other countries. A similar argument applies to the ISO 26000 guidance standard for social responsibility, currently under development. The current study cannot answer these questions for ISO 14000 or ISO 26000, which are left for future research, but this paper will hopefully contribute indirectly to that debate by showing that this mechanism did occur for their predecessor, ISO 9000.

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Appendix A. Relating Our Framework to the Bass Diffusion Model

The Bass (1969) diffusion model relates ΔN_t, the number of new adoptions in period t, to cumulative past adoptions N_{t-1} through the following relationship:

$$\Delta N_t := N_t - N_{t-1} = \left(a + b\frac{N_{t-1}}{M}\right)(M - N_{t-1}), \qquad (1)$$

where M is the saturation level, a a constant diffusion rate, and b the coefficient of the imitation effect. This model gives rise to the classic S-shaped diffusion curve. Note that

$$\frac{\Delta N_t}{N_{t-1}} = \left(\frac{a}{N_{t-1}} + \frac{b}{M}\right)(M - N_{t-1})$$

is always decreasing in t, the observation underlying our fourth method for classifying regions and countries into early and later adopters.

To model a global diffusion process, one could attach a country index i to all variables in (1), estimate the resulting diffusion curves, and compare the resulting coefficients a_i, b_i, and M_i across countries. This is the approach taken in Lücke (1996). To explicitly capture diffusion across K countries, we can use the following adaptation, which more recently was also the basis for Albuquerque et al. (2006):

$$\Delta N_{it} := N_{it} - N_{i,t-1} = \left(a_i + \sum_{j=1}^{K} b_{ij}\frac{N_{j,t-1}}{M_j}\right)(M_i - N_{i,t-1}). \qquad (2)$$

New adoptions in country i in period t depend on the constant diffusion rate a_i and the domestic imitation effect $b_{ii}N_{i,t-1}/M_i$, but also on $\sum_{j\neq i} b_{ij}N_{j,t-1}/M_j$, where b_{ij} denotes the influence of country j on country i. This is analogous to the multiproduct diffusion model in Bayus et al. (2000).

Expression (2) implies that the effect of country j on country i becomes stronger with the penetration level in country j, resembling our second requirement. In later-adopting countries, in the early years, the domestic imitation effect $b_{ii}N_{i,t-1}/M_i$ is small compared to the cross-country effect $\sum_{r=1}^{R} b_{ir}N_{r,t-1}/M_r$ because, by definition, $N_{i,t-1}/M_i$ is small relative to at least some of the other countries' $N_{r,t-1}/M_r$. Over time, $N_{i,t-1}/M_i$ may catch up with $N_{r,t-1}/M_r$, so that the domestic imitation effect gains strength relative to the cross-country effect. Therefore, in countries in which diffusion started late, the cross-country effect should play a larger role for early-adopting firms than for later-adopting firms. This is consistent with our third and fourth requirements, where exports are the cross-country effect.

Appendix B. Excerpts from Questionnaire Used

1. How many employees work at your company, at the same facility as you? And how many work at your company, counting all locations worldwide?

1a. At your facility	1: 1–19 2: 20–99 3: 100–499 4: 500–999 5: 1,000–4,999 6: 5,000–24,999 7: 25,000 or more
1b. Worldwide	1: 1–19 2: 20–99 3: 100–499 4: 500–999 5: 1,000–4,999 6: 5,000–24,999 7: 25,000 or more

2. Please estimate the total annual sales generated by your facility and the total global annual sales of your company, in US$.

Total annual sales at your facility (US$)
Total global, annual sales of your entire company (US$)

6. Please tell us where your *immediate* customers are located, by indicating how important sales in each of the following geographic regions are for your company.

	Not at all important	Not important	Moderately important	Important	Very important
North America	1	2	3	4	5
South America	1	2	3	4	5
Europe	1	2	3	4	5
Africa	1	2	3	4	5
Australia and New Zealand	1	2	3	4	5
Japan	1	2	3	4	5
Asia (except Japan)	1	2	3	4	5

7a. Please indicate how many customers in each of the following regions require ISO 9000 certification or are expected to do so soon.

	No customers in this region	Proportion of customers requiring ISO 9000 (now or in near future)				
		None	Few	Some	Most	All
North America	0	1	2	3	4	5
South America	0	1	2	3	4	5
Europe	0	1	2	3	4	5
Africa	0	1	2	3	4	5
Australia and New Zealand	0	1	2	3	4	5
Japan	0	1	2	3	4	5
Asia (except Japan)	0	1	2	3	4	5

9b. Please indicate how important each of the following reasons was for seeking, maintaining, or seriously considering ISO 9000 certification. (If you do not have ISO 9000 certification and are not considering it, please do not answer this question.)

Appendix B. (cont'd.)

	Not important at all	Not important	Somewhat important	Important	Extremely important
Cost reductions	1	2	3	4	5
Quality improvements	1	2	3	4	5
Marketing advantage	1	2	3	4	5
Customer pressure/customer demands	1	2	3	4	5
Many competitors were already ISO 9000 certified	1	2	3	4	5
Benefits experienced by other certified companies	1	2	3	4	5
Avoid potential export barrier	1	2	3	4	5
Capturing workers' knowledge	1	2	3	4	5
Relations with authorities	1	2	3	4	5
Relations with communities	1	2	3	4	5
Corporate image	1	2	3	4	5

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