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The effects of cooperation in accreditation on international trade: Empirical evidence on ISO 9000 certifications

Knut Blind [a,b,*], Axel Mangelsdorf [a,c], Jakob Pohlisch [a]

[a] Technische Universität Berlin, Chair of Innovation Economics, Marchstraße 23, 10587 Berlin, Germany
[b] Fraunhofer Institute of Open Communication Systems, Kaiserin-Augusta-Allee 31, 10589 Berlin, Germany
[c] Institute for Innovation and Technology (IIT), Steinplatz 1, 10623 Berlin, Germany

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ABSTRACT

Companies use standards as a tool to signal their investments in quality upgrading and performance. We argue that the impact of this signal depends on the trust in the accreditation system and the development status of a country. Representing the workhorse of research in international trade, we use a gravity model to examine the trade effects of ISO 9000 diffusion and cooperation in accreditation. The model is estimated by applying a country-pair fixed effects regression approach with instrumental variables and multilateral resistance terms to a panel data set covering a 13-year period from 1999 to 2012. This allows us to test our hypotheses with respect to the moderating role of international cooperation in accreditation on the trade effects of ISO 9000 diffusion. We show that certification promotes trade and that signatories to the Multilateral Recognition Arrangement of the International Accreditation Forum (IAF MLA) trade significantly more. The IAF MLA is of particular importance to the trade among developing countries. For policy makers, our results highlight the importance of support for accreditation institutions in developing countries.

1. Introduction

With decreasing tariffs and quotas in developed and developing countries over the last decades, international trade has increasingly taken place in global supply chains (Baldwin and Lopez-Gonzalez, 2015). The emergence of supply chains, in which suppliers in one country produce intermediate inputs shipped to many countries, has been accompanied by the global diffusion of certifiable international management standards, such as ISO 9000, which focuses on quality, ISO 14000, which addresses environmental management (Corbett et al., 2005), and recent ethical standards (Prado and Woodside, 2015). These types of voluntary standards help to overcome barriers related to information asymmetries among different actors in the supply chain (Potoski and Prakash, 2009; Cao and Prakash, 2011).

Companies use ISO 9000 as a tool to signal their investment in quality upgrading and quality performance (King et al., 2005; Potoski and Prakash, 2009; Terlaak and King, 2006; Ferro, 2011). Signaling quality characteristics, which are difficult to be observed by customers, are especially important for developing countries because information asymmetries between developed and developing countries are larger than those between countries of a similar level of development. Developing countries increasingly use management certifications to overcome reputation problems to enter international trade activities (Hudson and Jones, 2003; Montiel et al., 2012). However, certification costs can be a barrier to trade especially because they are significant and usually higher in developing countries than in developed countries (Maskus et al., 2005; Clougherty and Grajek, 2008, 2014; Trienekens and Zuurbier, 2008; Auriol and Schilizzi, 2015). Furthermore, certifications fail to deliver the desired reputation enhancing effect when the competence of the certification body is questionable.

ISO certification's ability to signal unobserved quality characteristics depends on the credibility of the institutional complex called 'quality infrastructure' (Sanetra and Marbán, 2007; Peuckert, 2014). Surprisingly, quality infrastructure institutions have largely been ignored in the empirical literature on the trade effects of ISO 9000 certifications. These institutions comprise not only national standardization and certification bodies but also metrology institutions and accreditation organizations including their international counterparts. Certification bodies verify the correct application of the standards. The activities of certification bodies can be approved by national accreditation bodies. Accreditation ensures that auditors of certification bodies are qualified to conduct conformity assessment tasks in specific business sectors. Accountability of domestic

* Corresponding author. Technische Universität Berlin, Chair of Innovation Economics, Marchstraße 23, 10587 Berlin, Germany.
E-mail addresses: knut.blind@tu-berlin.de (K. Blind), mangelsdorf@iit-berlin.de (A. Mangelsdorf), jakob.pohlisch@tu-berlin.de (J. Pohlisch).

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accreditation bodies is ensured through international accreditation organizations. For ISO 9000, the International Accreditation Forum (IAF), which is the global organization of accreditation bodies, promotes programs to mutually recognize ISO certifications issued by certification bodies located in the countries of the exporting companies. National accreditation bodies that are signatories to the Multilateral Recognition Arrangement (MLA) are certified to assess the competence of certification bodies at the same level as other signatories of the MLA. In short, the IAF MLA is supposed to ensure that certifications are mutually recognized by all signatories. The effect of ISO 9000 is questioned when the competencies of auditors or the reputation of the certification body is dubious. This issue is particularly important because the ability to signal quality with ISO certifications depends on the reputation of the certification body (Hudson and Jones, 2003). Therefore, assuming that certifications issued by certification bodies from developing countries have a lower signaling power than those issued from developed countries is reasonable. Consequently, we argue that the signaling power of issued certificates is stronger when certification bodies are recognized by accreditation bodies that are signatories to the IAF MLA. In this study, we show through a bilateral gravity model for international trade that accreditation, which represents an essential element of a country's quality infrastructure, matters in international trade. Accreditation bodies that are internationally recognized through the IAF MLA increase the reputation of certification bodies issuing ISO 9000 certifications, which in turn strengthens the signaling effects of said certificates for the certified companies.

The remainder of this paper is organized as follows. In the second section, we provide background information on the ISO 9000 standard, namely, motivation for adoption, international diffusion, benefits of adoption for companies, and effects on international trade. In the same section, we provide information and derive hypotheses related to accreditation as part of a country's quality infrastructure necessary to ensure the international acceptance of certification. In the third section, we introduce our methodological approach: a country-pair fixed effects gravity model that accounts for endogeneity by incorporating instrumental variables and multilateral resistance terms (Baier and Bergstrand, 2009; Clougherty and Grajek, 2014). In the fourth section, we present and discuss our results. We conclude our analysis and give policy recommendations in the final section.

2. ISO 9000 certifications and the importance of accreditation

2.1. Review of the trade impacts of ISO 9000 certifications

Before we begin our empirical investigation into the role of multilateral recognition of ISO 9000 certifications, we briefly outline the existing literature on ISO certifications. The literature includes global diffusion of certifications over time and geography, motivations and benefits for companies to become certified, and the role of certifications in international trade relations.

ISO 9000 is the most successful international management standard issued by the International Organization for Standardization (ISO). The standard codifies international management practices and is the foundation for certification. In 2015, a total of 1,036,321 valid ISO 9001 certificates were issued in 195 countries (ISO, 2015). European companies were the early adopters (Franceschini et al., 2010), and this situation led to the perceived threat that European countries use ISO 9000 as a barrier to trade. Suppliers outside of Europe began to adopt the standard through the requirements set in global supply chains. Gradually, through competitive pressure, more and more domestic companies in developed countries outside the global supply chains also became ISO certified (Sampaio et al., 2009).

ISO certifications in importing countries influence the ISO 9000 diffusion in exporting countries. That is, the preference of companies at the end of supply chains for ISO certifications creates incentives for adoption in exporting countries. Moreover, ISO 9000 diffusion is affected by foreign direct investment (FDI). Management practices can cause ISO 9000 used by multinational enterprises in their home countries to be eventually transferred and adopted by subsidiaries in foreign countries (Cao and Prakash, 2011).

Researchers studying companies' motivation for ISO adoption differentiate between internal (organizational improvement) and external motivations (e.g., promotion and marketing) (Magd and Curry, 2003). For example, companies actively seek certification to become suppliers in global supply chains (Corbett, 2005). Although ISO 9000 is a voluntary standard, external pressure from foreign partners, certified competitors (Magd and Curry, 2003), and regulatory bodies (Anderson et al., 1999) constitute the important drivers for ISO 9000 adoption for firms from developing countries. With regard to the business effects of its implementation, ISO certification helps to improve organizational performance (Starke et al., 2012), leads to greater customer satisfaction (Terziovski et al., 2003), and enhances financial performance (Corbett et al., 2005). Studies on ISO 9000 certification in U.S. firms show that certification is associated with company growth because of the reduced information asymmetries in supply chains (Terlaak and King, 2006). With regard to the effects of ISO 9000 implementation in global supply chains, Quadros (2004) investigates Brazilian auto manufacturing suppliers and shows that certification induces local suppliers to upgrade quality levels. The benefits from ISO certification depend on the motivation of the management and the firms' quality culture (Terziovski et al., 2003). Companies motivated to use the standard to improve internal processes are more likely to derive internal and external benefits. By contrast, companies that seek certification only for external reasons obtain external benefits, such as enhanced company reputation (Sampaio et al., 2009).

Research on the trade impacts of ISO 9000 mainly focuses on certification as a tool for exporters to signal quality to consumers and to reduce information asymmetries and transaction costs. Certification is related to the market signaling model of Spence (1973), in which an effective signal needs to convey costs and the costs need to be negatively correlated with the productive capability (Ferro, 2011). Therefore, ISO certification is a credible mechanism through which customers can distinguish low-from high-quality production and thus reduce information asymmetries as in Akerlof's model of lemons (Akerlof, 1970). Transaction costs (e.g., costs for quality monitoring) are lower when firms can credibly signal their investments in quality upgrading. However, the positive trade effects from reduced transaction costs may be mitigated by certification costs. The latter comprises implementation costs, training of personnel as well as fees for certification audits conducted by certification bodies (Goedhuys and Sleuwaegen, 2013). Auditing costs depend on the size of the organization and technical complexity, but they are substantial. The cost of a certification audit can range from $10,000 to $1 million per organization (Cao and Prakash, 2011). In sum, positive economic effects from signaling trough certificates occur when the reduction of transaction costs outweigh the costs associated with certification.

Both firm-level and macroeconomic studies have investigated the effects of ISO 9000 on international trade. Firm-level studies are conducted either as one-country or multi-country studies. As an example of the former, Martincus et al. (2010) use firm-level data from Argentina in the period of 1998–2006 and show that ISO 9000 certification leads to an increase in export volumes and in the number of destination countries. Regarding the latter, Ferro (2011) uses the World Bank's Enterprise Survey and finds that firms from developing countries are more likely to be exporters when they are ISO certified. Using the same data source, Hudson and Orviska (2013) find that firms serving only the domestic market are least likely to adopt international standards certification, whereas firms with a focus on exports have the highest probability of adoption. Goedhuys and Sleuwaegen (2013) examine the relationship between international standard certification and sales as well as productivity. The authors use data from 59 countries and find that international certification increases productivity and sales. They conclude that

international certification is a quality signaling tool that is especially powerful in developing countries, which are disadvantaged by information asymmetries and negative reputation effects.

Macro-level studies focus initially on the diffusion of ISO 9000 (Guler et al., 2002). Clougherty and Grajek (2008) and Potoski and Prakash (2009) investigate the effect of global diffusion of ISO 9000 on FDI and international trade. In particular, Clougherty and Grajek (2008) examine whether ISO 9000 certifications have a 'push' or 'pull' effect on FDI and trade. They find that ISO 9000 has no effect on trade and FDI in developed nations but has a positive 'pull' effect on inwards FDI in developing countries. Moreover, ISO 9000 certifications have a 'push' effect on exports from developing countries to developed countries. The 'push' effect on exports from developing countries is also confirmed by Potoski and Prakash (2009). The authors find that ISO certifications in the exporting nation positively affect trade but that certifications in the host nation have no effect. Nevertheless, the export enhancing effect is only evident for less developed countries. Clougherty and Grajek (2014) examine the effect of ISO 9000 adoption on bilateral trade flows in 91 countries. Like Clougherty and Grajek (2008) and Potoski and Prakash (2009) they examine the push and pull effects of ISO 9000 standards on trade. Additionally, they introduce the common language effect, assuming that a simultaneously high diffusion of ISO 9000 in the exporting and importing would alleviate cross-firm communication problems. Within their sample they find evidence for a positive push effect of ISO 9000 diffusion on trade as well as a positive common language effect. Nevertheless, they do not find evidence for any pull effect of ISO 9000 diffusion.

The mentioned empirical studies on trade have contributed to the understanding of international certification as a quality signaling tool, especially for developing countries. The main argument of the present study is that the existing studies did not consider the underlying quality infrastructure, such as the accreditation of the certification bodies. We argue that the stringency and reputation of the certification body are relevant factors for the signaling effect of certificates. Certification bodies can increase the reputation of their services if they are accredited by an internationally recognized accreditation body, that is an IAF MLA signatory. Therefore, the main aim of our empirical investigation is to show that the underlying quality infrastructure of accreditation is important for the quality-signaling and trade-enhancing effects of ISO 9000 certifications.

2.2. The role of accreditation

To receive an ISO certification, companies require external validation conducted by an auditor from a certification body (Cao and Prakash, 2011). We argue that the signaling effects of ISO 9000 certifications depend on the quality of the institutional arrangements necessary to ensure that an organization meets the requirements of the standards. The institutional arrangements form an accountability structure, comprising services in the fields of metrology, standardization, conformity assessment, and accreditation. This structure is called quality infrastructure (Sanetra and Marbán, 2007; Guasch et al., 2007; Peuckert, 2014). In the existing literature the role of quality infrastructure in international trade has almost been ignored. This situation is particularly surprising, as quality differences exist between certification bodies and auditors across countries. For example, auditors also act as company consultants in some countries, thereby creating a conflict of interest and potentially undermining the reputation of the certification body. The quality signaling effect of ISO 9000 certifications depends on the stringency and reputation of the certification body (Hudson and Jones, 2003; Hudson and Orviska, 2013). Unreliability of the certification process creates an economic loss for the certified companies and industries because investments in quality certifications fail to create positive returns or to reduce transaction costs (Quadros, 2004). For example, anecdotal evidence from surgical instrument producers in Pakistan suggests that it is not the certification alone that reduces transaction costs but the reliability of the certification body as well. In his case study, Nadvi (2004) shows that despite their ISO certifications, multinational companies in the downstream positions of the supply chain still monitor their Pakistani suppliers in terms of quality targets. The author argues that there are concerns on the credibility of local certification bodies due to the absence of effective monitoring mechanisms in the national certification industry. Therefore, we argue that the reliability and independence of certification bodies can be ensured by accreditation. Accreditation aims to increase trust in quality infrastructure institutions by assessing the competence of organizations that conduct conformity assessment services. Therefore, accreditation leads to added trust in the service of certification bodies and the quality infrastructure system as a whole. Accreditation bodies independently provide assurance of conformity with international standards (Frenz and Lambert, 2014). These international standards ensure that the requirements for conformity assessment organizations imposed by accreditation bodies are equivalent. The ISO committee for conformity assessment (ISO CASCO) has formulated a number of international standards that are used as guidelines by national accreditation bodies (Cao and Prakesh, 2011). The guidelines include ISO 17020 for inspection bodies, ISO 17025 for laboratories, and ISO 17021 for certification bodies (Guasch et al., 2007).

All national organizations responsible for accrediting conformity assessment bodies can apply to become members of the IAF MLA. Nevertheless, they will only be admitted if they pass a rigorous peer evaluation of their operations to guarantee their full compliance with the IAF requirements (Sarin, 2001). Further, if admitted, signatories must declare their acceptance of certifications issued by other signatories as equivalent to their own to reduce economic costs from repeated certifications. For companies, this implies that all certifications bodies operate on the basis of the same standard as that in their home country (Unger and Dougherty, 2011). According to the World Trade Organization's World Trade Report, mutual recognition of accreditation systems is an advanced form of building trust and cooperation, which lowers the costs of exports (WTO, 2012).

Our line of argument is illustrated by the abovementioned case study of Nadvi (2004). If the accreditation body of Pakistan enters the arrangement, multinational companies' trust in the equivalence of the certification will increase based on the peer review process. In turn, the monitoring costs of multinational companies will decrease in the downstream positions of the supply chain.

Additionally, we argue in a similar manner with respect to the pull effect of ISO 9000. According to Clougherty and Grajek (2014), the pull effect can be positive or negative depending on whether the information or the compliance cost effect is greater, respectively. The information effect occurs when information that is critical for selling in a target market becomes available because of the diffusion of standards in the target markets, thereby reducing transaction costs. The compliance costs effect implies that foreign companies must adapt their manufacturing design to match the requirements of the importer; consequently, additional costs are introduced. We argue that the information and the compliance cost effect will increase if the importing country is a signatory to the IAF MLA. As argued above, the increasing signaling effect of the ISO certificates indicates that the importing countries ISO certifications adhere to the highest standards. This situation potentially increases the amount of local information available to firms in the exporting country. At the same time, the standards to be fulfilled by the foreign companies need to stand a high amount of rigor thus potentially increasing the information and the compliance cost effect.

As regards the common language effect introduced by Clougherty and Grajek (2014), we expect the effect to be reinforced if the exporting and importing countries are signatories to the IAF MLA. The common language effect is to reduce "the communication frictions endemic to trade relations between firms from different nations by allowing the ready communication of internal production systems" (Clougherty and Grajek, 2014, 74). We argue that both countries will only speak the same language if the certification procedure is undertaken with the same

meticulousness, that is, certifications have the same quality. If the standard adopted by the exporting and importing countries is the same on paper but not applied in the same way in practice, the efficiency of communication will be reduced (Blind, 2001) and the common language effect will be affected.

Therefore, we derive the following hypotheses:

H1a. Being a signatory to the IAF MLA increases the export-enhancing push effect of ISO 9000 certifications.

H1b. If the importing country is a signatory to the IAF MLA, the efficacy of the pull effect of ISO 9000 will increase (pull effect).

H1c. If both the exporting and importing countries are signatories to the IAF MLA, the common language effect will increase.

Subsequently, we distinguish among the different levels of development of a country. Following our argument above and given the results of Clougherty and Grajek (2008) and Potoski and Prakash (2009), we expect the signaling effect of the increased level of trust, reliability, and credibility on ISO 9000 certifications to be larger for developing countries than for developed countries. This effect may be triggered to a large extent by the great challenges encountered by developing countries to adhere to given quality standards. Summing up the reasoning of Clougherty and Grajek (2008), the signaling power of less developed countries is lower than that of developed countries because of two inherent phenomena: First, developing countries are more engaged in vertical relations in international trade, which increases cost and hold up problems (Williamson, 1985). Second, developing countries have less institutional intermediaries, which increase transaction costs and are likely to induce high information asymmetries between the exporting and importing countries. These problems imply that less developed countries have issues in signaling their "product quality, internal production processes and conflict free relations" (Clougherty and Grajek, 2008, p. 621). The authors argue further that the institutional void is exactly the vantage point at which ISO certifications reveal their full signaling potential and are able to reduce transaction costs and information asymmetries.

Along with the discussion that leads to H1, we argue that the IAF MLA membership has a greater effect on the export-enhancing push effect of less developed countries than that of developed countries. We assume that there is less trust in the actual and perceived quality of certification institutions and the issued certificates of developing countries. According to Clougherty and Grajek (2008), ISO 9000 certification may be more beneficial to companies in developing countries than to those in developed countries because the established institutions do not provide the means to identify companies adhering effectively to quality standards. The authors argue that ISO 9000 presents an opportunity for companies in developing countries to signal their quality. Nevertheless, we contend that this signal may be even stronger when there is increased trust in the competence of certification bodies. Consequently, for less developed countries, the export-enhancing indirect effect hypothesized in H1 is likely fostered by IAF MLA membership. Therefore, we expect the indirect positive effect of being a signatory to the IAF MLA to be even greater for less developed countries than for developed countries.

With respect to the pull effect, we maintain that the increase in the information effect of ISO 9000 certificates due to the IAF MLA membership will be greater if the importer is a developing country because the quality signal of information increases when the certification process is more rigorous. However, the quality of an OECD member country may be safely assumed to be higher than that of a developing country a priori. Therefore, as the IAF MLA membership ensures the same quality of certification in all member countries, the information effect will be leveled between the developed and less developed countries.

We follow a similar line of reasoning for the common language effect. The effect of having a common language through ISO certifications is assumed to be high if both countries are signatories to the IAF MLA. The language effect presumes that the certified companies in both countries adhere to the same standard in the same way. However, this assumption may not be true because differences in the quality of certification bodies may exist. We claim that the greater the indirect IAF MLA effect is, the greater the potential threat of miscommunication is a priori. As mentioned above, it seems safe to assume that less developed countries are more likely to have problems with their quality infrastructure. Therefore, we argue that the common language effect will be enhanced by bilateral IAF MLA membership if one or both countries are developing countries.

Accordingly, we derive our second set of hypotheses:

H2a. IAF MLA membership has a greater impact on the push effect of ISO 9000 diffusion of less developed countries than that of developed countries.

H2b. IAF MLA membership has a greater impact on the pull effect of ISO 9000 diffusion of less developed countries than that of developed countries.

H2c. The effect hypothesized in H1c will increase if both the importing and exporting countries are developing countries.

3. Data and methodology

3.1. Data sources and descriptive statistics

In this section, we describe the dataset used in this study and provide descriptive statistics for the main variables used in our econometric model. The data set is restricted to the years 1999–2012 due to data availability issues in some of our model variables. Although the ISO 9000 standard has been updated repeatedly, we follow the argument by Clougherty and Grajek (2014) that the standards are homogeneous enough to assume unbiased estimates. Further, the assumption constitutes a common practice in the literature on ISO 9000 diffusion (Guler et al., 2002; Terlaak and King, 2006; Prakash and Potoski, 2006, 2007; Clougherty and Grajek, 2008, 2014). Additionally, we conducted a test for a structural break in the ISO 9000 diffusion variables of the exporter and the importer in the year 2008 (Greene, 2003). As a result, we were not able to reject the null hypothesis that there is in fact no structural break.

The United Nation Statistical Division's COMTRADE Database is used as the data source for our dependent variable: bilateral total trade (UN Comtrade). Data on the number of ISO 9000 and ISO 14000 certifications per country are compiled from the latest ISO survey in 2015. The survey is published annually by the ISO Secretariat in Geneva, Switzerland, and compiles data from all ISO national member institutes (ISO, 2015). In 2012 and across all sectors, about 1.015 million organizations in 184 countries had valid ISO 9000 certifications. This can be regarded as a tremendous success story when compared with the 0.343 million ISO 9000 certifications in 55 countries that were valid in 1999. For ISO 14000, the picture is comparable with 13,994 certified organizations in 73 countries in 1999 and 260,852 organizations in 167 countries in 2012.

We hypothesize that the quality infrastructure plays an important role in the signaling effect of ISO 9000. Consequently, we argue that the mutual recognition of certification through the international cooperation of accreditation bodies increases the signaling power of certifications. To operationalize the impact of accreditation, we include a dummy variable in our model that is equal to one if the country has an internationally recognized accreditation body (i.e., the national accreditation body is a signatory to the IAF MLA). The arrangement was initially signed by 16 accreditation bodies in 1998, but 78 accreditation bodies signed the MLA by April 2017. Information on the signatories to the IAF MLA is available on the IAF homepage (www.iaf.nu).

To test our second hypothesis, dividing the countries into developed and less developed countries is necessary. Our segmentation approach is based on the classification of OECD member countries, i.e. OECD

member countries are classified as developed countries and non-member countries as less developed countries.

Data on the gross domestic product (GDP) and the population is taken from the World Bank's World Development Indicators Database (World Bank). Data on the preferential trade agreements are based on Baier and Bergstrand (2007) and are accessed through the database provided by Bergstrand (http://www.nd.edu/~jbergstr). Following Clougherty and Grajek (2014), our FTA dummy is one if two countries are members of the same trade agreement, which is defined as a preferential trade agreement, free trade area, customs union, common market, or economic union.

We include variables that mirror the infrastructure development of the exporting and importing countries. Clougherty and Grajek (2014) argue that physical infrastructure is possibly correlated to with the number of ISO 9000 certifications because they represent a form of soft infrastructure. This would cause our procedure to overestimate the ISO 9000 effect and potentially also the IAF MLA effect. Hence, similar to their approach, we base our indicator on the simple average of i) the number of departing passengers from the nation's airports per million inhabitants, and ii) the number of main-line telephones per million inhabitants. As data on road-pavement coverage per square kilometer is no longer available, we employ data on the goods transported (in million tons) via railways per million inhabitants as a third measure entering the simple average.

As we use a fixed effect regression approach, information on time constant variables, such as geographic distances, contiguity, common language, and colony, can be neglected. Table 1 shows the descriptive statistics of all the model variables.

Table 1
Descriptive statistics of model variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Exports in billions of 2000 US$	140757	0.80	6.73	0	353.78
ISO 9000 certificates exporting country per mln inhabitants	140757	173.32	302.61	0	2417.53
ISO 9000 certificates importing country per mln inhabitants	140757	226.78	354.66	0	2417.53
ISO 14000 certificates exporting country per mln inhabitants	140757	26.91	57.15	0	632.88
ISO 14000 certificates importing country per mln inhabitants	140757	40.17	77.51	0	632.88
IAF MLA ISO 9000 Dummy exporting country	140757	0.32	0.47	0	1
IAF MLA ISO 9000 Dummy importing country	140757	0.32	0.47	0	1
IAF MLA ISO 14000 Dummy exporting country	140757	0.18	0.38	0	1
IAF MLA ISO 14000 Dummy importing country	140757	0.19	0.40	0	1
GDP exporting country in billions of 2000 US$	140757	462.36	1479.46	0.06	16155.25
GDP importing country in billions of 2000 US$	140757	566.56	1862.14	0.21	16155.25
Population exporting country in millions	140757	70.21	202.42	0.02	1350.70
Population importing country in millions	140757	50.69	166.59	0.02	1350.70
Infrastructure index of exporting country	140757	398060	679070.5	178.16	9429825
Infrastructure index of importing country	140757	448821.4	829494	178.16	9429825
Preferential Trade Agreement	140757	0.36	0.48	0	1
Distance between exporting and importing country	140757	7396.18	4642.32	59.62	19812.04
Exporting country is developed country (OECD)	140757	0.22	0.42	0	1
Importing country is developed country (OECD)	140757	0.29	0.45	0	1

3.2. Methodological approach

We use a gravity model approach to estimate the effects of quality management standards and their quality signaling or trade reducing effects. Specifically, we base our empirical investigation on an extended gravity model widely used in the trade literature (Eaton and Kortum, 2002; Anderson and van Wincoop, 2003; Clougherty and Grajek, 2014). The gravity model has been used in many applications as the workhorse model to explain trade flows. It explains the magnitude of bilateral trade flows with the economic size and the geographical distance between two countries (van Bergeijk and Brakman, 2010). Gravity models predict that trade depends proportionally on economic mass, which is usually proxied by the GDP, and negatively on the geographical distance between the two countries. Moreover, gravity models usually contain additional variables that influence bilateral trade. These additional variables can be related to trade policy (e.g., tariffs), cultural relationships (e.g., common language), and historical links (e.g., former colonial ties).

The presented macroeconomic studies on the trade impact of ISO certifications by Clougherty and Grajek (2008, 2014) and Potoski and Prakash (2009) also employ a gravity model. Our approach builds on their model but additionally incorporates the signaling power of the certification of a country's quality infrastructure, which is proxied by a dummy that is one if an accreditation body of the country is a signatory to the IAF MLA. We also include data on tariffs that have not been included in the aforementioned studies.

To test our hypotheses, our empirical strategy consists of the following steps. First, we estimate a full-country model that includes developed and developing countries as exporting and importing countries. In the second step, we control for potential endogeneity problems with instrumental variables. Third, we segment our data into sub-models to evaluate the effect on developing countries: a model only for less developed countries (LDC→LDC) and two sub-models in which the developed country is the exporter and the less developed country is the importer, and vice versa (DC→LDC, LDC→DC). Finally, we add a model were the exporter and importer is a developed country.

Our extended gravity model is expressed as follows:

$$\begin{aligned} lnEXPORT_{ijt} = {} & \beta_0 + \beta_1 lnISO9000_{it} + \beta_2 lnISO9000_{jt} \\ & + \beta_3 lnISO9000_{it} lnISO9000_{jt} + \beta_4 lnISO9000_{it} IAFMLA_{it} \\ & + \beta_5 lnISO9000_{jt} IAFMLA_{jt} \\ & + \beta_6 lnISO9000_{it} \beta_2 lnISO9000_{jt} IAFMLA_{it} IAFMLA_{jt} \\ & + \beta_7 lnGDP_{it} + \beta_8 lnGDP_{jt} + \beta_9 lnPOP_{it} + \beta_{10} lnPOP_{jt} \\ & + \beta_{11} lnINFRA_{it} + \beta_{12} lnINFRA_{jt} + \beta_{13} FTA_{ijt} + \beta_{14} lnDIST_{ijt} \\ & + \delta_t + \varepsilon_{ijt}, \end{aligned} \tag{1}$$

where $EXPORT_{ijt}$ is the value of exports from country i to country j in year t in billion US dollars; $ISO9000_{it}$ and $ISO9000_{it}$ represent the number of ISO 9000 certifications per million inhabitants in the respective countries in year t; $IAFMLA_{it}$ and $IAFMLA_{jt}$ are dummy variables indicating whether country i and country j are signatories to the IAF MLA in year t,

respectively; GDP_{it} and GDP_{jt} are the GDPs of country i and country j in year t in billion US dollars; $lnPOP_{it}$ and $lnPOP_{jt}$ represent the number of inhabitants in country i and j in year t; $INFRA_{it}$ and $INFRA_{jt}$ are the infrastructure indices of country i and j in year t; FTA_{ijt} is a dummy variable indicating whether a preferential trade agreement exists between country i and country j year t; and δ_t are year dummies to control for importer and exporter invariant macroeconomic effects. Employing cluster-robust standard errors, where clusters are defined as country pairs, allows us to control for potential heteroskedasticity and autocorrelation (ε_{ijt}).

Gravity models using policy variables usually encounter the endogeneity problem of explanatory variables. That is, policy variables fail to be strictly exogenous in the sense that the policy variable depends on the trade performance of a country. At the same time, trade performance depends on the policy variable and leads to a circular causality between trade and trade-related policy decisions. In our case, we may have simultaneity between exports and ISO 9000 certifications. Higher export intensity can induce higher levels of certification (Blind, 2002) instead of the hypothesized trade increase resulting from higher standardization intensity (Clougherty and Grajek, 2008; Potoski and Prakash, 2009). To avoid biased estimates, we utilize an instrumental variable approach. From an econometric point of view, instrumental variables are correlated with the potential endogenous variable and uncorrelated with the error term of the regression model (Wooldridge, 2002).

For our gravity model to provide unbiased estimates, we instrument the number of ISO 9000 certifications with the number of ISO 14000 certification per country and year. The same is done for the interaction with the IAF MLA 9001 dummy, i.e. we instrument the IAF MLA 9000 with the dummy of the IAF MLA 14000 dummy. This procedure is possible as there exists a multilateral recognition arrangement for ISO 9000 and for ISO 14000. Furthermore, we instrument all interactions of the IAF MLA 9000 dummy with the ISO 9000 diffusion variables with the respective ISO 14000 equivalent. The ISO 14000 is a standard developed to overcome the immense challenge of sustainable development that was declared at the United Nations Conference on Environment and Development in 1992. Currently, it represents the most widely accepted environmental management system, assisting private and public organizations in understanding and managing the environmental impacts of their activities (ISO, 2010).

Consistent with Clougherty and Grajek (2014), we argue that the number of ISO 14000 certifications in a country is an appropriate instrument for the ISO 9000 diffusion. First, evidence shows that ISO 9000 and ISO 14000 diffusion are highly correlated (Corbett and Kirsch, 2001; Prakash and Potoski, 2006, 2007) and that both standards follow similar diffusion patterns (Viadiu et al., 2006). Second, previous studies did not find a connection between exports (Prakash and Potoski, 2007) or export orientation (Prakash and Potoski, 2006) and ISO 14000 diffusion. Third, and most importantly, the ISO 14000 environmental standard was specifically designed to facilitate the implementation of both ISO 9000 and ISO 14000. It was realized by a strong cooperation among the responsible technical committees ISO/TC 207 (ISO 14000) and ISO/TC 176 (ISO 9000). As a result, the auditing guidelines for environmental and quality management systems are even codified in the common standard ISO 19011 (ISO, 2010).

Tests for under-identification and weak instruments are shown in Tables 2 and 3 for the respective models. The tests confirm our trust in the chosen instruments and the resultant estimation results.

Following Clougherty and Grajek (2014), we control for multilateral resistance terms. They argue, based on Anderson and van Wincoop (2003), that gravity equations need to incorporate multilateral resistance terms to account for general equilibrium effects. As Clougherty and Grajek (2014), we employ the approach by Baier and Bergstrannd (2009) who suggests using first-order log-linear Taylor-series expansion. Analogously to their approach, we define the multilateral resistance term for the ISO interaction as:

$$MRTISO_{ijt} = \sum_{k=1}^{N} \theta_{kt} lnISO_{it} lnISO_{kt} + \sum_{m=1}^{N} \theta_{mt} lnISO_{jt} lnISO_{mt} - \sum_{k=1}^{N} \times \sum_{m=1}^{N} \theta_{kt}\theta_{mt} lnISO_{kt} lnISO_{mt} \quad (2)$$

Table 2
Regression results.

Dependent Variable is lnExport					
Independent Variables	(1)	(2)	(3)	(4)	(5)
ISO 9000 exporting country	0.233***(0.0193)	0.00476(0.0359)	0.133***(0.0140)	0.133***(0.0193)	0.165***(0.0188)
ISO 9000 importing country	0.0455*(0.0184)	0.983*(0.481)	0.0388**(0.0142)	0.0388(0.0218)	0.0626***(0.0175)
GDP exporting country	0.688***(0.0309)	−0.0381(0.369)	0.662***(0.0215)	0.662***(0.0307)	0.676***(0.0309)
GDP importing country	0.308***(0.0339)	0.413***(0.0431)	0.372***(0.0221)	0.372***(0.0355)	0.374***(0.0354)
Population exporting country	0.455***(0.125)	0.305(0.182)	0.658***(0.0848)	0.658***(0.136)	0.666***(0.136)
Population importing country	0.280**(0.0963)	1.436*(0.631)	0.311***(0.0683)	0.311**(0.108)	0.277*(0.108)
Infrastructure index exporting country	0.0824***(0.0172)	0.116***(0.0195)	0.0516***(0.0123)	0.0516**(0.0185)	0.0536**(0.0182)
Infrastructure index importing country	0.0191(0.0138)	−0.0853(0.0568)	0.0152(0.0102)	0.0152(0.0140)	0.0157(0.0140)
Preferential Trade Agreement	0.110***(0.0330)	0.0169(0.0752)	0.0913***(0.0257)	0.0913**(0.0341)	0.0183(0.0276)
Distance	−1.453***	–	–	–	–
	(0.00808)	–	–	–	–
Year dummies	YES	YES	YES	YES	YES
Multilateral Resistance Terms	NO	NO	NO	NO	YES
Constant	–	–	−14.10***	–	–
	–	–	(0.326)	–	–
Observations	140,757	140,757	140,757	138,299	138,299
R-squared	0.65	0.18	0.16	0.16	0.16
Kleibergen-Paap rk LM Chi-squared statistic				560.88***	686.04***
Kleibergen-Paap rk F statistic				95.98	118.23
SW conditional F statistics					
ISO 9000 exporting			34703.73***	9987.04***	4814.12***
ISO 9000 importing			30933.60***	7395.99***	9237.91***
ISO 9000 exporting X ISO 9000 importing			13650.30***	3102.91***	3879.40***
ISO 9000 exporting X IAF MLA			3385.04***	745.45***	1031.52***
ISO 9000 importing X IAF MLA			4307.74***	769.59***	1010.58***
Full interaction ISO 9000 and IAF MLA			5140.69***	1273.70***	1515.94***

All variables in logarithms – except for dummy variables.
Robust standard errors in parentheses; ***p < 0.001, **p < 0.01, *p < 0.05.

Table 3
Regression results for the trade between developed and less developed countries.

Dependent Variable is lnExport	(6)	(7)	(8)	(9)
Independent Variables	DC→DC	LDC→LDC	DC→LDC	LDC→DC
ISO 9000 exporting country	0.269*(0.111)	0.251***(0.0319)	0.344***(0.0953)	0.339***(0.0455)
ISO 9000 importing country	0.0344(0.0849)	0.0454(0.0269)	0.0665*(0.0295)	0.169(0.0964)
ISO 9000 exporting country X ISO 9000 importing country	−0.0176(0.00922)	0.00229(0.00173)	−0.00533(0.00347)	0.0184***(0.00451)
ISO 9000 X IAF MLA exporting country	−0.0317(0.0789)	0.244***(0.0235)	−0.0793(0.0419)	0.121(0.0713)
ISO 9000 X IAF MLA importing country	0.0817(0.0773)	0.204***(0.0319)	−0.00333(0.0388)	0.0474(0.0576)
Full interaction ISO 9000 and IAF MLA	−0.00906(0.00700)	−0.0390***(0.00625)	0.00268(0.00637)	−0.00851(0.00967)
GDP exporting country	1.053***(0.149)	0.609***(0.0425)	0.779***(0.0512)	0.890***(0.141)
GDP importing country	0.537***(0.0997)	0.382***(0.0526)	0.388***(0.0796)	0.506***(0.0738)
Population exporting country	0.700(0.496)	0.778***(0.180)	4.480***(0.777)	0.957***(0.251)
Population importing country	−1.551**(0.583)	0.290*(0.140)	0.335*(0.138)	0.963(0.727)
Infrastructure index exporting country	0.0139(0.0329)	0.0384(0.0252)	0.181***(0.0346)	0.132***(0.0371)
Infrastructure index importing country	−0.0193(0.0315)	0.00217(0.0188)	0.0126(0.0237)	0.0517(0.0489)
Preferential Trade Agreement	0.128(0.0958)	0.0934*(0.0400)	0.110*(0.0468)	0.115(0.0788)
Year dummies	YES	YES	YES	YES
Multilateral Resistance Terms	YES	YES	YES	YES
Observations	8719	76,527	21,776	31,106
R-squared	0.50	0.15	0.33	0.12
Kleibergen-Paap rk LM Chi-squared statistic	45.43***	730.77***	122.90***	180.24***
Kleibergen-Paap rk F statistic	8.08	158.83	29.85	39.65
SW conditional F statistics				
ISO 9000 exporting	49.61***	4593.99***	307.39***	1580.69***
ISO 9000 importing	90.99***	4856.28***	1336.87***	522.09***
ISO 9000 exporting X ISO 9000 importing	202.53***	1963.35***	406.08***	1136.41***
ISO 9000 exporting X IAF MLA	26.20***	1446.11***	191.33***	74.57***
ISO 9000 importing X IAF MLA	43.05***	1103.26***	94.43***	257.10***
Full interaction ISO 9000 and IAF MLA	53.00***	538.49***	168.64***	110.80***

All variables in logarithms – except for dummy variables.
DC and LDC stand for developed country and less developed country, respectively.
Robust standard errors in parentheses; ***p < 0.001, **p < 0.01, *p < 0.05.

θ_{lt} is defined as $\theta_{lt} = \frac{GDPlt}{\sum_{n=1}^{N} GDPnt}$. The multilateral resistance terms for the distance and free trade agreements are constructed analogously. The resistance terms are added to Equation (1) and included in specifications (5)–(9) in Tables 2 and 3. Their coefficient estimates are restricted to have reversely signed coefficients, i.e. $-\beta_3$, $-\beta_{13}$, $-\beta_{14}$.

4. Results

4.1. Baseline model

The estimation results of our models are reported in Table 2. In specification (1), we estimate Equation (1) using standard ordinary least squares regression. Regression specification (2) employs fixed effects. To deal with the potential endogeneity introduced by our independent variables of main interest, we instrument the ISO 9000 variables with their ISO 14000 equivalents (see section 3.2). The results are given by specification (3). To deal with potential issues of heterogeneity, specification (4) is estimated by using a fixed effects regression with a country-pair cluster-robust covariance matrix and standard errors. The specification contains 2464 less observations because they represent singleton groups and therefore do not contain within-group variation. In the last specification (5), we include multilateral resistance terms as a further robustness check. The variables of main interest are the ISO 9000 certifications in the importing and exporting countries and their interaction terms with the IAF MLA dummies. These variables enable us to test our first set of hypotheses on the moderating effects of the IAF MLA signatory status on the effect of the ISO 9000 certifications on trade.

We find a positive and significant trade-increasing effect of ISO 9000 certifications of the exporting countries for all model specifications. This result confirms the findings of Clougherty and Grajek (2014) with respect to the push effect of ISO 9000 diffusion. For the pull effect, our results are somewhat ambiguous. Nevertheless, the effect is almost always positive (except for the simple pooled regression model), and our most sophisticated specification shows a highly significant positive pull effect. Therefore, we find that the information effect of ISO 9000 prevails in our sample, consistent with the finding of Clougherty and Grajek (2008). However, Clougherty and Grajek (2014) discover that most of their models indicate a prevailing compliance cost effect. The results in section 4.2 validate our conjecture that the differences in the findings are caused by the heterogeneity in the development of the countries in our sample. Further validating their study, we find a positive and mostly significant common language effect of ISO 9000 diffusion.

The interaction variables of ISO 9000 diffusion and IAF MLA membership for the exporting country are also significant and positive for all our specifications, thus providing support for H1a. The moderating effect of being a signatory to the IAF MLA is given for exporting countries in our dataset; that is, the push effect of ISO 9000 is greater for IAF MLA members. The same is evident for the pull effect of ISO 9000 certificates. The coefficients for the interaction of ISO 9000 diffusion and the IAF MLA dummy of the importing country are positive and significant for all specifications in Table 2. These results indicate that the pull effect is positively moderated by IAF MLA membership and lends strong support for H1b. Moreover, combined with the ambiguous results for the direct trade effect of ISO 9000 diffusion, our result suggests that the pull effect of ISO 9000 diffusion depends on the international recognition of accreditation of the importing county. With respect to H1c, we expect a positive and significant coefficient of the full interaction of our ISO 9000 diffusion and IAF MLA variables. However, we observe a negative and significant effect, which seems to contradict our hypothesis. Despite the negative influence, the effect of the IAF MLA remaining positive must be emphasized. We will elaborate on this issue in section 4.2, as the more detailed differentiation between developing and developed countries will enable us to analyze this issue in more depth.

In terms of the coefficients of mass, the variables have the expected signs and magnitude: GDP and population size of the importing and exporting countries have a positive effect on bilateral trade and are statistically significant at the 0.1% level (except for population of the importing country, which is significant at the 1% and 5% level, in specifications (4) and (5), respectively). As predicted, the trade between

two countries significantly increases when both are members of the same trade agreement. Nevertheless, this effect turns insignificant when multilateral resistance terms are introduced, consistent with the findings of Clougherty and Grajek (2014). In contrast to their results, our infrastructure variable of the exporting country positively affects trade, and that of the importing country has the expected sign but seems to be of no relevance to trade because it is not significant. The distance has the expected sign and is significant. However, the effect is only reported in specification (1) because it is time-invariant.

To evaluate the importance of taking into account the possible effects of endogeneity, we test for the differences in the coefficients between model (2) and (3) using a Hausman specification test (Hausman, 1978). The test rejects the null hypothesis of non-systematic differences at all conventional levels ($x(26) = 177.77, p - value < 0.001$). Therefore, our endogeneity concerns are justified. Next, we test if our instrumental variable approach is valid with respect to the relevance of our instruments. That is, we test if the instruments are correlated with the endogenous regressors. As a cluster robust estimator is used in specifications (4) and (5), we apply the LM version of the Kleibergen–Paap rank statistic to test for under-identification (Kleibergen and Paap, 2006). A p-value of less than 0.0001 indicates a strong rejection of the null hypothesis, confirming the relevance of our instruments. Nevertheless, weak instruments can cause estimators to perform poorly (Stock et al., 2005). Therefore, a weak identification test is run to test for weak instruments. The resulting Kleibergen–Paap rk Wald F statistics of 95.98 and 118.23 strongly reject the null hypothesis of weak identification. As we have multiple endogenous regressors, we also look at the Sanderson–Windmeijer first-stage conditional F-statistics (Sanderson and Windmeijer, 2016). The null hypothesis that one of the endogenous regressors is weakly identified is rejected for all our instrumented variables and specifications (p-value < 0.0001 in all tests).

Consequently, our results show that the signatories to the IAF MLA enjoy increased levels of trust in the auditing competences of their domestic certification bodies, which in turn increase the signaling effect of the ISO 9000 certifications. In other words, we find that the positive signaling effect of ISO certifications is enhanced by the international recognition of the accreditation body of the exporting and the importing country.

4.2. Country models

The results in section 4.1 and the presented reasoning in section 2 call for a differentiation in our analysis between developing and developed countries. Specifications (6)–(9) replicate regression specification (5), but here we segment the data into four samples to test our second set of hypotheses. Specification (6) depicts the trade effects among developed countries (DC→DC), and specification (7) reports the effects among less developed countries (LDC→LDC). In regression specification (8), we only regard the case of developed countries exporting to less developed countries (DC→LDC). In regression specification (9), we only consider cases in which the exporter is a developing country and the importer is a developed country (LDC→DC).

The results of the four models are shown in Table 3. With respect to our control variables, the results on the GDP and population variables are qualitatively similar to those in the baseline specification (5) in Table 2. However, the constructed infrastructure index seems to be important only for the exporting country in trade between a developed and a less developed country, and vice versa. The coefficient for the trade agreement variable is positive as expected. However, it is only significant for trade among less developed countries and for trade from a developed to a less developed country. In terms of our variables of main interest, we find interesting differences in the comparison with our baseline specification (5) and across the country specifications. These differences show that the approach to separate the effects for different development levels is justified.

First, we analyze the trade among developed countries (6). We observe that ISO specification still has a positive push effect on trade but find no evidence of a pull or common language effect. Additionally, none of the interaction effects with the IAF MLA variables are significant. This outcome may be explained by the already highly functional institutional intermediaries and the fact that developed countries have more horizontal trade relations (Clougherty and Grajek, 2008). Therefore, soft institutions such as ISO have no evident additional benefit on trade.

Second, we analyze trade among less developed countries (7). The push effect of ISO 9000 diffusion from the overall model is confirmed, but no evidence of a direct positive pull effect for the importing country is found. The positive and significant interaction term indicates that the signaling effect of the IAF MLA further increases the push effect on trade for the exporting country. For the importing country, the results show that the pull effect of certification is only evident if the importing country's accreditation body is a signatory to IAF MLA. These results indicate the trust-increasing effect of the IAF MLA, which is particularly important for trade among developing countries, where trust issues may be of exceptional relevance. Although we find no direct common language effect, we observe a negative and significant common language effect when both countries are IAF MLA members. This result directly contradicts H2c, rendering it counterintuitive at first. Further, as the effect is only negative and significant in this specification, the overall negative effect is driven by trade among developing countries. We provide three possible explanations for this result: First, as pointed out by Clougherty and Grajek (2008), the common language effect is more likely to be relevant in countries engaged in vertical trade relations because of the high transaction costs and hold-up issues. However, we argue that vertical trade relations among less developed countries are likely to be of low relevance, which may explain why the common language effect of the two countries is negative. Second, developing countries that are signatories to the IAF MLA may already be producing at a higher quality level, thus having already entered into price competition, which leads to lower trade volumes in financial terms. Third, the negative interaction effect can be represented in a positive common language effect because the ISO 9000 variables in the model are in logs and can attain negative values for low levels of ISO 9000 diffusion. Therefore, the common language effect is present only when both countries are IAF MLA members and one of them has low ISO 9000 diffusion levels. This point indicates the importance of the IAF MLA for developing countries with low ISO 9000 diffusion levels when conducting trade with a developing country that has already attained significantly higher ISO 9000 diffusion levels. Although this result seems to contradict the idea of the common language effect, which assumes high levels of ISO 9000 in both countries, we argue that the IAF MLA membership itself constitutes the bases for the common language effect in this case.

Third, we turn to specification (8), which includes cases only featuring the exporter as a developed and the importer as a less developed country. Again, we find a positive and significant push effect of ISO 9000. Similar to specification (6), the push effect is not increased by IAF MLA membership, which indicates that IAF MLA membership is not a necessary requirement for developed countries to signal the quality of their ISO 9000 certifications. However, this specification is the only one in which we observe a positive and significant pull effect. Therefore, this model drives the pull effect in specification (5). In contrast to the LDC→LDC specification, the pull effect is not reinforced by IAF MLA membership. This difference suggests that although ISO 9000 fills an institutional void in the less developed importing country, the additional effect of IAF MLA is only important when the exporting country is a less developed country. This effect may be explained by the fact that companies in developed countries have more sophisticated means and financial resources to control their trade partners, which is not the case for companies from less developed countries. Again, we find no evidence of a common language effect or a bilateral IAF MLA membership effect.

Fourth, we consider our final subsample (9), in which the exporting country is a less developed country and the importing country is a developed country. Although no evidence of a barrier to trade or a pull

effect on the side of the importer is found, we observe a strong and significant push effect of ISO 9000 diffusion. However, this effect is not strengthened by IAF MLA membership. Therefore, the positive signaling effect of the IAF MLA does not additionally increase the trust of companies and consumers in products coming from less developed countries. We follow our explanation on the effects in specification (8) that this effect may be due to companies in developed countries using other means, such as company specific standards, to ensure the quality of the ISO 9000 certificates of their business partners (here suppliers); this mechanism is missing in the bilateral trade among developing countries. Further, specification (9) is the only one showing a positive common language effect.

Our results show that developed and less developed exporting countries can benefit from ISO 9000 certifications. This effect is even more evident when domestic certification bodies are accredited by internationally recognized domestic accreditation bodies. However, it is only evident when a developing country is exporting to a developed country. Therefore, we find only partial evidence supporting H2a. The positive pull effect is only evident in less developed importing countries and strongly moderated by IAF MLA membership. For trade among developing countries, IAF MLA membership is a requirement for a positive pull effect of ISO 9000 diffusion; for trade from developed to less developed countries, the pull effect is not dependent on IAF MLA membership. These findings provide partial evidence for H2b. The results also provide mixed evidence for H2c. First, we only find a direct positive common language effect for LDC→DC trade. Second, the LDC→LDC specification is the only one in which we observe a significant effect of bilateral IAF MLA membership on the common language effect. We argue that the positive effect of the common language effect is only evident when one of the developing countries possesses a low level of ISO 9000 diffusion and both countries are IAF MLA members. For trade among developed countries, we only find a positive push effect for ISO 9000 diffusion but no pull effect. We also do not observe a moderating effect of IAF MLA membership.

In sum, our results confirm the trade-enhancing potential of ISO 9000 certifications and provide first evidence of the supporting role of accreditation. They also indicate that the trust-increasing effect of internationally recognized accreditation bodies can reduce barriers to trade, especially among developing countries as found in other studies (Bown, 2013; Hoekman and Nicita, 2011).

As with our full model, we test for under-identification and for weak identification of our models. The test results are reported in Table 3 and cause no doubt on the adequacy of our instrumental variable approach.

5. Discussion & conclusion

International trade is accompanied by the emergence of certifiable standards such as ISO 9000. By signaling investment in quality upgrading, ISO certifications help to reduce information asymmetries and transaction costs between buyers and sellers. Therefore, ISO certification can assist in overcoming reputation problems, especially for exporters located in developing countries. Moreover, ISO certification can represent barriers to trade, particularly when companies face high certification costs and when such costs outweigh the benefits from reduced transaction costs. This is especially true when the competence of the certification body issuing ISO certificates is questionable. In this contribution, we empirically show that the signaling effect of ISO certifications depends on the credibility of the national quality infrastructure. More precisely, the signaling effect of ISO 9000 depends on the national accreditation bodies' membership in the international network of accreditation organizations (IAF MLA). ISO certifications in a country with an accreditation body that is favorably assessed by the IAF, thus becoming a signatory to the IAF MLA, are positively associated with higher levels of trade. Signatories to the IAF MLA enjoy increased levels of trust in the auditing competencies of domestic certification bodies, which in turn increase the trust in the ISO 9000 certification itself.

In our empirical analysis, we find that ISO 9000 certification intensity in the exporting country signals the quality performance of firms to potential buyers. The results confirm that ISO 9000 can lower information asymmetries between sellers and buyers, lower transaction cost, and increase trade. Our results are consistent with those of Clougherty and Grajek (2008, 2014), and Potoski and Prakash (2009), who also find a positive trade effect especially for developing countries aiming to access markets in developed countries. However, we show that the signaling effect depends on the level of development of the national quality infrastructure measured by membership in IAF MLA. Specifically, our empirical results show that the signaling effect of ISO certifications depends on the international recognition of the accreditation bodies in the trading countries. The trade effect of ISO certifications is significant and positive for all our specifications. However, for trade among developing countries, the push effect can be significantly increased if the accreditation bodies of the trading countries are members of the IAF MLA. Signatories to the IAF MLA from less developed countries enjoy better market access to other less developed countries through the increased levels of trust in the auditing competences of local certification bodies. We find the positive pull effect of ISO 9000 diffusion on trade to be only relevant for less developed importers. However, this effect is again moderated by IAF MLA membership. For trade among developing countries, the pull effect is only evident for IAF MLA signatories; for trade from developed countries to less developed countries, the effect is not affected by IAF MLA membership status. Further, we find that IAF MLA membership positively affects the common language effect of ISO 9000 diffusion on trade among developing countries if one of the countries has low diffusion levels.

From a policy perspective, our results imply that the implementation of international standards in less developed countries helps to reduce reputation problems and is therefore a policy tool to overcome the structural disadvantages of less developed countries in the global trade. However, it is not sufficient to support firms in signaling their quality performance through ISO 9000 certification. Increasing trust in the auditing competencies of the certification bodies is also important. The international network of accreditation institutions has developed an agreement, the IAF MLA, which verifies equivalent accreditation programs through peer evaluation among their members. Joining the IAF MLA promotes the worldwide acceptance of certification results and consequently the market access of domestic companies. Therefore, policy makers should consider that not only the harmonization of standards but also the harmonization of requirements for accreditation bodies affects global trade. For developing countries, our results imply that technical assistance for accreditation bodies may be an effective tool to increase companies' trade activities because it promotes the development of competent institutions that are ready to become signatories to the IAF MLA. Our data and applied empirical analysis, which for the first time includes information on a country's accreditation system, reveal that the previous simple model of inspecting ISO 9000 certifications fails to adequately recognize a country's level of quality infrastructure.

Nevertheless, our study has some limitations. The assumption that the IAF MLA membership has the same export-enhancing effect on all ISO 9000 certifications issued within a country may be flawed. The effect of accreditation alone may still be heterogeneous. For example, the effect of ISO 9000 certificates and, consequently, accreditation may depend on the complexity of technology and products, which are different among sectors. Further, we have no information on the absolute and relative certification and accreditation costs. They are clearly important, as already observed by Clougherty and Grajek (2014). Accordingly, future research should address these various dimensions of heterogeneity in the data, namely, the effectiveness of countries' national quality infrastructures and companies' specific benefits and costs of ISO 9000 certifications issued by accredited certification bodies. For example, qualitative case studies could be conducted to better understand how and when firms benefit from certifications issued from accredited certification bodies to reveal the company- and country-specific effects.

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References

Akerlof, G.A., 1970. The market for "lemons": quality uncertainty and the market mechanism. Q. J. Econ. 84 (3), 488–500. https://doi.org/10.2307/1879431.

Anderson, J.E., van Wincoop, E., 2003. Gravity with gravitas: a solution to the border puzzle. Am. Econ. Rev. 93 (1), 170–192. https://doi.org/10.1257/000282803321455214.

Anderson, S.W., Daly, J.D., Johnson, M.F., 1999. Why firms seek ISO 9000 certification. Regulatory compliance or competitive advantage? Prod. Oper. Manag. 8 (1), 28–43. https://doi.org/10.1111/j.1937-5956.1999.tb00059.x.

Auriol, E., Schilizzi, S.G., 2015. Quality signaling through certification in developing countries. J. Dev. Econ. 116, 105–121. https://doi.org/10.1016/j.jdeveco.2015.03.007.

Baier, S.L., Bergstrand, J.H., 2007. Do free trade agreements actually increase members' international trade? J. Int. Econ. 71 (1), 72–95. https://doi.org/10.1016/j.jinteco.2006.02.005.

Baier, S.L., Bergstrand, J.H., 2009. Bonus vetus OLS. A simple method for approximating international trade-cost effects using the gravity equation. J. Int. Econ. 77 (1), 77–85. https://doi.org/10.1016/j.jinteco.2008.10.004.

Baldwin, R., Lopez-Gonzalez, J., 2015. Supply-chain trade. A portrait of global patterns and several testable hypotheses. World Econ. 38 (11), 1682–1721. https://doi.org/10.1111/twec.12189.

Blind, K., 2001. The impacts of innovations and standards on trade of measurement and testing products. Empirical results of Switzerland's bilateral trade flows with Germany, France and the UK. Inf. Econ. Pol. 13 (4), 439–460. https://doi.org/10.1016/S0167-6245(01)00047-6.

Blind, K., 2002. Driving forces for standardization at standardization development organizations. Appl. Econ. 34 (16), 1985–1998. https://doi.org/10.1080/00036840110111158.

Bown, C.P., 2013. Emerging economies and the emergence of south-south protectionism. J. World Trade 47 (1), 1–44.

Cao, X., Prakash, A., 2011. Growing exports by signaling product quality. Trade competition and the cross-national diffusion of ISO 9000 quality standards. J. Pol. Anal. Manag. 30 (1), 111–135. https://doi.org/10.1002/pam.20546.

Clougherty, J.A., Grajek, M., 2008. The impact of ISO 9000 diffusion on trade and FDI. A new institutional analysis. J. Int. Bus. Stud. 39 (4), 613–633. https://doi.org/10.1057/palgrave.jibs.8400368.

Clougherty, J.A., Grajek, M., 2014. International standards and international trade. Empirical evidence from ISO 9000 diffusion. Int. J. Ind. Organ. 36, 70–82. https://doi.org/10.1016/j.ijindorg.2013.07.005.

Corbett, C.J., 2005. Global diffusion of ISO 9000 certification through supply chains. SSRN Electron. J. https://doi.org/10.2139/ssrn.913812.

Corbett, C.J., Kirsch, D.A., 2001. International diffusion of ISO 14000 certification. Prod. Oper. Manag. 10 (3), 327–342. https://doi.org/10.1111/j.1937-5956.2001.tb00378.x.

Corbett, C.J., Montes-Sancho, M.J., Kirsch, D.A., 2005. The financial impact of ISO 9000 certification in the United States. An empirical analysis. Manag. Sci. 51 (7), 1046–1059.

Eaton, J., Kortum, S., 2002. Technology, geography, and trade. Econometrica 70 (5), 1741–1779. https://doi.org/10.1111/1468-0262.00352.

Ferro, E., 2011. Signaling and Technological Marketing Tools for Exporters. https://doi.org/10.1596/1813-9450-5547. World Bank Policy Research Working Paper No. 5547.

Franceschini, F., Galetto, M., Maisano, D., Mastrogiacomo, L., 2010. Clustering of European countries based on ISO 9000 certification diffusion. Int. J. Qual. Reliab. Manag. 27 (5), 558–575. https://doi.org/10.1108/02656711011043535.

Frenz, M., Lambert, R., 2014. The economics of accreditation. NCSLI Meas. 9 (2), 42–50. https://doi.org/10.1080/19315775.2014.11721682.

Goedhuys, M., Sleuwaegen, L., 2013. The impact of international standards certification on the performance of firms in less developed countries. World Dev. 47, 87–101. https://doi.org/10.1016/j.worlddev.2013.02.014.

Greene, W.H., 2003. Econometric Analysis. Prentice Hall, Upper Saddle River, N.J.

Guasch, J.L., Racine, J.-L., Sanchez, I., Diop, M., 2007. Quality Systems and Standards for a Competitive Edge. The World Bank.

Guler, I., Guillén, M.F., Macpherson, J.M., 2002. Global competition, institutions, and the diffusion of organizational practices. The international spread of ISO 9000 quality certificates. Adm. Sci. Q. 47 (2), 207–232. https://doi.org/10.2307/3094804.

Hausman, J.A., 1978. Specification tests in econometrics. Econometrica 46 (6), 1251. https://doi.org/10.2307/1913827.

Hoekman, B., Nicita, A., 2011. Trade policy, trade costs, and developing country trade. World Dev. 39 (12), 2069–2079. https://doi.org/10.1016/j.worlddev.2011.05.013.

Hudson, J., Jones, P., 2003. International trade in 'quality goods'. Signalling problems for developing countries. J. Int. Dev. 15 (8), 999–1013. https://doi.org/10.1002/jid.1029.

Hudson, J., Orviska, M., 2013. Firms' adoption of international standards. One size fits all? J. Pol. Model. 35 (2), 289–306. https://doi.org/10.1016/j.jpolmod.2012.04.001.

ISO, 2010. Environmental Management - the ISO 14000 Family of International Standards.

ISO, 2015. ISO Survey. https://www.iso.org/the-iso-survey.html. (Accessed 30 April 2017).

King, A.A., Lenox, M.J., Terlaak, A., 2005. The strategic use of decentralized institutions. Exploring certification with the ISO 14001 management standard. Acad. Manag. J. 48 (6), 1091–1106. https://doi.org/10.5465/AMJ.2005.19573111.

Kleibergen, F., Paap, R., 2006. Generalized reduced rank tests using the singular value decomposition. J. Econom. 133 (1), 97–126. https://doi.org/10.1016/j.jeconom.2005.02.011.

Magd, H., Curry, A., 2003. An empirical analysis of management attitudes towards ISO 9001:2000 in Egypt. TQM Mag. 15 (6), 381–390. https://doi.org/10.1108/09544780310502714.

Martincus, C.V., Castresana, S., Castagnino, T., 2010. ISO standards. A certificate to expand Exports? Firm-Level evidence from Argentina. Rev. Int. Econ. 18 (5), 896–912. https://doi.org/10.1111/j.1467-9396.2010.00915.x.

Maskus, K.E., Otsuki, T., Wilson, J.S., 2005. The Cost of Compliance with Product Standards for Firms in Developing Countries: an Econometric Study. The World Bank.

Montiel, I., Husted, B.W., Christmann, P., 2012. Using private management standard certification to reduce information asymmetries in corrupt environments. Strat. Manag. J. 33 (9), 1103–1113. https://doi.org/10.1002/smj.1957.

Nadvi, K., 2004. The Effect of Global Standards on Local Producers: a Pakistani Case Study. Edward Elgar Publishing number 2824.

Peuckert, J., 2014. What shapes the impact of environmental regulation on competitiveness? Evidence from Executive Opinion Surveys. Environ. Innov. Soc. Transit. 10, 77–94. https://doi.org/10.1016/j.eist.2013.09.009.

Potoski, M., Prakash, A., 2009. Information asymmetries as trade barriers. ISO 9000 increases international commerce. J. Pol. Anal. Manag. 28 (2), 221–238. https://doi.org/10.1002/pam.20424.

Prado, A.M., Woodside, A.G., 2015. Deepening understanding of certification adoption and non-adoption of international-supplier ethical standards. J. Bus. Ethics 132 (1), 105–125. https://doi.org/10.1007/s10551-014-2301-x.

Prakash, A., Potoski, M., 2006. Racing to the Bottom? trade, environmental governance, and ISO 14001. Am. J. Polit. Sci. 50 (2), 350–364. https://doi.org/10.1111/j.1540-5907.2006.00188.x.

Prakash, A., Potoski, M., 2007. Investing up. FDI and the cross-country diffusion of ISO 14001 management systems. Int. Stud. Q. 51 (3), 723–744. https://doi.org/10.1111/j.1468-2478.2007.00471.x.

Quadros, R., 2004. Global Quality Standards and Technological Upgrading in the Brazilian Auto-components Industry. Chapters.

Sampaio, P., Saraiva, P., Rodrigues, A.G., 2009. ISO 9001 certification research: questions, answers and approaches. Int. J. Qual. Reliab. Manag. 26 (1), 38–58. https://doi.org/10.1108/02656710910924161.

Sanderson, E., Windmeijer, F., 2016. A weak instrument F-test in linear IV models with multiple endogenous variables. J. Econom. 190 (2), 212–221.

Sanetra, C., Marbán, R.M., 2007. The Answer to the Global Quality Challenge: a National Quality Infrastructure. Physikalisch-Technische Bundesanstalt.

Sarin, S., 2001. International accreditation based on global quality assurance process. In: International Conference on Engineering Education.

Spence, A., 1973. Job market signaling. Q. J. Econ. 87 (3), 355–374.

Starke, F., Eunni, R.V., Manoel Martins Dias Fouto, N., Felisoni de Angelo, C., 2012. Impact of ISO 9000 certification on firm performance. evidence from Brazil. Manag. Res. Rev. 35 (10), 974–997. https://doi.org/10.1108/01409171211272697.

Stock, J., Yogo, M., Andrews, D.W., 2005. Testing for Weak Instruments in Linear IV Regression. Cambridge University Press.

Terlaak, A., King, A.A., 2006. The effect of certification with the ISO 9000 Quality Management Standard. A signaling approach. J. Econ. Behav. Organ. 60 (4), 579–602. https://doi.org/10.1016/j.jebo.2004.09.012.

Terziovski, M., Power, D., Sohal, A.S., 2003. The longitudinal effects of the ISO 9000 certification process on business performance. Eur. J. Oper. Res. 146 (3), 580–595. https://doi.org/10.1016/S0377-2217(02)00252-7.

Trienekens, J., Zuurbier, P., 2008. Quality and safety standards in the food industry, developments and challenges. Int. J. Prod. Econ. 113 (1), 107–122. https://doi.org/10.1016/j.ijpe.2007.02.050.

UN Comtrade. United Nations Commodity Trade Statistics Database. https://comtrade.un.org/db/. Accessed Mai 2017.

Unger, P., Dougherty, R., 2011. Benefits of the ILAC & IAF Multilateral Mutual Recognition Arrangement. Geneva, Switzerland.

van Bergeijk, P., Brakman, S., 2010. The Gravity Model in International Trade. Advances and Applications. Cambridge University Press.

Viadiu, F.M., Fa, M.C., Saizarbitoria, I.H., 2006. ISO 9000 and ISO 14000 standards: an international diffusion model. Int. J. Oper. Prod. Manag. 26 (2), 141–165. https://doi.org/10.1108/01443570610641648.

Williamson, O.E., 1985. The Economic Intstitutions of Capitalism. Simon and Schuster.

Wooldridge, J.M., 2002. Econometric Analysis of Cross Section and Panel Data. MIT, Cambridge, Masschusetts.

World Bank. World Development Indicators. http://data.worldbank.org/data-catalog/world-development-indicators. Accessed Mai 2017.

WTO, 2012. World Trade Report 2012. Trade and Public Policies: a Closer Look at Non-tariff Measures in the 21st Century. Geneva, Switzerland.