



# Paving the path: drivers of standardization participation at ISO

Knut Blind<sup>1,2</sup>  · Maximilian von Laer<sup>1</sup>

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## Abstract

Several studies investigating the trade effects of standardization have found a positive impact of the number of international standards in a country on its trade volumes. While international standards have so far been considered as exogenous, we investigate what drives countries to take over leading roles, i.e. secretariats, in committees of the International Organization for Standardization (ISO) using a panel dataset on the ISO participation of 12 countries. Looking at this phenomenon through the perspective of agenda setting in international institutions we expect ISO participation to be a desirable tool for shaping technological trajectories and substantiating global influence via international technology transfer. We find that, while for most countries no systematic pattern can be observed, both China and the US show a close correlation between R&D and standardization work at ISO. For China, we attribute this finding to having a strategic approach toward standardization participation, for the US to the distinct features of the decentralized US standardization system. Finally, we derive implications of findings for both research and practice.

**Keywords** Standardization · International technology transfer · Research · Trade

## 1 Introduction

Standardization is an important factor for innovation (e.g. on the impacts on design and manufacturing processes see already Allen & Sriram, 2000) and its dissemination, both within a country and internationally (Swann, 2010). We focus our research in this study on the role of voluntary standards as key component of the ‘tripartite standards regime’ consisting of standards-setting, accreditation and certification defined by Loconto and Busch (2010). In their seminal contribution to the understanding of the importance and mechanisms of global standardization, Bütthe and Mattli (2011) describe the privatization of regulation at international organizations, like ISO. They elaborate how early participation in standardization processes

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✉ Knut Blind  
Knut.Blind@TU-Berlin.de

<sup>1</sup> Chair of Innovation Economics, Technische Universität Berlin, Straße des 17. Juni 135, 10623 Berlin, Germany

<sup>2</sup> Fraunhofer Institute for Systems and Innovation Research, Breslauer Str. 48, 76139 Karlsruhe, Germany

can be very important for the commercial success of companies (compare also Wakke et al., 2016) and countries in various sectors. Those who are not actively participating in standardization miss out on the chance to shape standards according to their needs and also suffer from an informational disadvantage if information is not shared efficiently and swiftly. In this line, we argue, that holding a secretariat at ISO provides the respective country with considerable soft power, especially with regard to setting the agenda of this committee (Caillaud & Tirole, 2007). As holding a secretariat implies financing administration and staff, it seems reasonable to assume that considerable benefits arise from taking up this task.

The trade effect of standardization and of the amount of standards active within a country or economy has already been investigated by several scholars and is mostly found to be positive for international standardization (e.g. Blind & Jungmittag, 2005; Blind et al., 2017; Mangelsdorf, 2011; Swann, 2010). While the importance of standardization for international trade is generally confirmed by this literature, international standards are considered to be exogenous in these studies in contrast to the line of argument by Büthe and Mattli (2011) elaborated above. In addition, international standardization is also not addressed within the literature on international technology transfer (Noh & Lee, 2019).

We do not follow these approaches, but question, whether international standards should actually be regarded as exogenous or whether other factors, like research and development expenditures and eventually technological capacities, are important for international technology transfer that should not be neglected when investigating the impacts of international standards. A growing literature investigates the factors determining active involvement in standardization on a company level (Axelrod et al., 1995; Blind, 2006; Mattli & Büthe, 2003; Riillo, 2013) as well as companies' explicit motives to actively participate in standardization work (Blind & Mangelsdorf, 2016). To our knowledge, only Mattli and Büthe (2003) have investigated both theoretically and empirically the factors that drive the involvement of national standards bodies or companies on their behalf in international standardization. In addition, recently Baglioni et al. (2020) argue that standardization is one approach of mainly highly concentrated firms to capture value in global value chains. We complement these company-focused investigations of potential drivers for national stakeholders often represented by standards bodies to be actively involved in, and thus shape, global standardization at the International Organization for Standardization (ISO). In detail, we explore what drives countries to be more or less active in international standardization, i.e. which factors are important for the decision to spend resources in terms of money and expert time in order to hold a secretariat and thus have more influence on the shaping of global standards. Using a panel data set on the standardization participation of 12 countries over nine years, covering over 80% of all ISO-secretariats, we find important differences in the strategies of national standards bodies.

The remainder of this paper is organized as follows: In the next section we review the relevant literature and formulate two propositions. Section three describes our data sources and methods, section four presents the results of our analysis. In section five we discuss our results. Finally, we conclude with the implications for policy and present the caveats of our work.

## 2 Literature overview and propositions

### 2.1 Motives to participate in standardization

The International Organization for Standardization (ISO) states in a brochure, "Standards are never neutral. They reflect the strengths and innovations of those who develop them.

Therefore, non-participation in standardization hands decision making over to the competition” (ISO, 2012). Or, as Bütte and Mattli (2011) put it “Standards do not embody some objective truth or undisputed scientific wisdom professed by experts. And global regulatory processes are not apolitical (...)”. Participation in standardization can be considered a strategic decision, as companies can both learn from competitors during the process and shape the standard according to their own needs (Sherif, 2015). Wakke et al. (2016) elaborate how standardization participation can raise firm performance through several channels like the reduction of switching costs, an increase in demand, temporal aspects or network effects. Considering the importance of standards for the economy, surprisingly little is known about companies’ general motives to participate in standardization, the case study on Luxemburg by Riillo (2013) being one of the few examples. Blind (2006) empirically investigates explanatory factors for the participation in formal standardization processes on the company level. Besides a positive effect of company size, he finds higher R&D as well as export intensity of companies to be positively influencing participation in standardization up to a certain threshold, above which the relation becomes negative. Axelrod et al. (1995) identify firm size to be an important predictor for firms to join standardization alliances. Blind and Mangelsdorf (2013) find that the export intensity of German companies in the electrical engineering and machinery sector positively influences the decision to participate in international standardization while it has no effect on the national level. For the same sectors Blind and Mangelsdorf (2016) investigate the motives for companies to take part in formal standardization and identify several relevant factors such as knowledge seeking, finding technical solutions or preparing market access for their products. This work builds on Blind and Gauch (2009) focusing companies’ and research institutes’ motives to get involved in standardization in an emerging area, like nanotechnology, based on introducing standardization as a channel of technology transfer within the concept developed by Bozeman (2000). Wakke et al. (2016) look at the effect of participation in national committees on the performance of German firms and find a positive impact in the manufacturing sector, while the results remain inconclusive for service sector standardization.

While on the organizational level some insights have thus been gathered, to our knowledge no study exists that looks into the drivers for national standards bodies and their national stakeholders to take up leading roles in international standardization. This could be, as we argue below, by taking up secretariats, and thus more responsibility, than participating or observing members in ISO committees or in fact any other formal international standardization organization like IEC, the International Electrotechnical Commission, or ITU, the International Telecommunication Union, or other standard setting organizations (see the overview in Baron & Spulber, 2018).

## 2.2 Agenda setting in international institutions

Our research connects to the literature of agenda setting in international institution in various ways as we argue for the importance of taking leading positions in standardization participation. Pollack (1997) points out how even in the absence of formal agenda setting rights, expertise and institutional persistence of actors can lead to certain informational advantages compared to other potential agenda setters resulting in an overall strategic advantage. Austen-Smith (1993) reveals the influence that interest groups can have on policy decisions through strategic information transmission, like selective communication towards varying receivers (Farrell & Gibbons, 1989) The single-sender/multi-receiver model by Caillaud and Tirole (2007) can also be applied to the relation between the

secretariat and members of a Technical Committee (TC) within a standard-setting organization showing how they can be convinced to support a new item proposal in standardization. For example, secretariats of TCs can provide selectively information and strategically persuade their members in order to sequentially gain support for a new proposal of a standard. As external factors, they also find the size, composition and governance of a group to be important for the author of a proposal to get it approved. Finally, Farrell and Simcoe (2012) describe strategies of agents within standard setting organizations to have their own content accepted and Büthe and Mattli (2011) provide numerous examples of companies expressing their ability to influence standards through participation in ISO or national mirror committees.

Building on this literature, we claim that, while in theory the secretariat of a TC at ISO should be neutral and not biased by national interest, there might still be considerable leverage in terms of agenda setting power for the countries that hold secretariats.

### 2.3 Standards and trade

As described by Wakke et al. (2016), standards help to overcome information asymmetries that are especially important in cross-border trade. Standards can function as a signal for (minimum) quality compliance, reduce language barriers, increase transparency and efficiency and reduce costs. Hence, most scholars have found a positive relationship between international standards and trade.

The first study on the relation between standards and trade was conducted by Swann et al. (1996). The authors find differing effects of German and British standards on UK trade. Blind (2002) investigates drivers of standards output and finds the export ratio to be an important factor while imports seem not to have an effect. Swann (2010) reviews the empirical literature on the effect of standards on trade. He observes that international standards are mostly found to foster trade while the results for national standards are rather inconclusive, e.g. Mangelsdorf et al. (2012) focusing on the trade between China and Europe reveal a stronger trade enhancing effect of international standards compared to purely national ones. Moenius (2004) confirms the trade enhancing role of standards that are shared between trading partners and finds differing effects for purely national standards that work through an information cost channel and depend on the sector they are relevant for. Blind and Jungmittag (2005) revisit the work of Swann et al. (1996) using a more extensive database and find that innovative capacity is an important driver for German exports. With regards to standards their results show a positive effect of international standards on trade while the effect of national standards remains ambiguous. Clougherty and Grajek (2014) focus on one specific standard, namely ISO 9000, and the effect of related certifications on bilateral trade flows. They find evidence for a positive effect on trade when its diffusion is high for both trading partners and a positive “push” and no “pull” effect if diffusion is high in only one of two trading partners. Blind et al. (2018) highlight not only the importance of certification, but also of accreditation as a further driver for trade in particular between developing countries. However, regional standards boost imports from industrialized third countries, while reducing those from developing third countries (Chen & Mattoo, 2004). They attribute this to the disadvantage through more stringent standards and the lower ability to realize economies of scale by companies of developing countries.

Overall, the impact that standards have on trade is obviously of high interest for companies and policymakers. And the impact dimension has been in the focus of several studies as elaborated above. In all previously mentioned studies, both national and international

standards have been considered as exogenous. In this study though, we turn the coin and use trade figures as one possible driver for standardization participation within ISO, which has not been investigated before. Building on what has been investigated until now on companies' motives to participate in standardization (e.g. Blind & Mangelsdorf, 2016), we formulate our first proposition:

The more a country trades in a sector, both in relative and absolute terms, the more international standards within this sector will be of relevance for it and thus the more it will be active in international standardization within this sector.

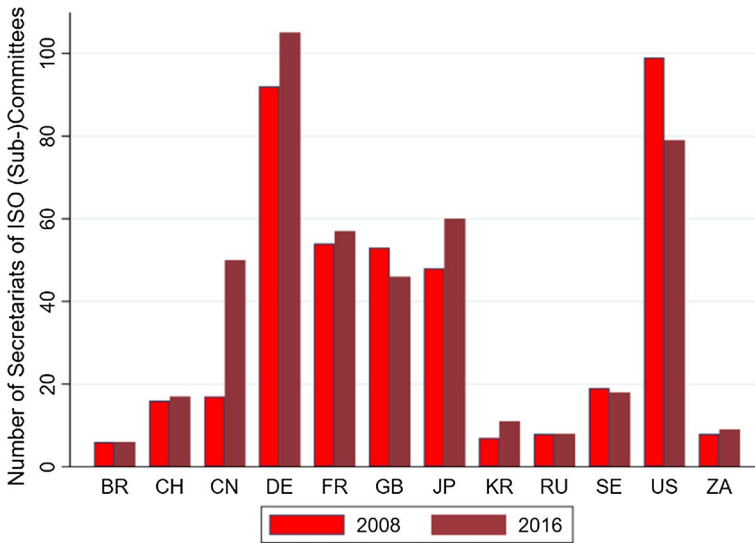
## 2.4 Standards and innovation

Standards, like patents, codify knowledge (Blind & Jungmittag, 2008). They are also often seen as a measure of the state of the art of technology (Borraz, 2007). Actors, who develop new technologies, have an incentive to implement them into standards. This can be either because they own patents which they want to position them as the base of a standard and then to declare them as standard-essential (Lerner & Tirole, 2015). Another strategy is that they want to profit from the wider diffusion of their technology (Teece, 2018), because the demand for their own proprietary technologies complementary to the standard increases. There are several studies on company level about the role of R&D (Blind, 2006) and innovation expenditures (Wakke et al., 2015), but also patents as indicators of innovation (Blind & Mangelsdorf, 2013) for the decision to join standardization bodies. In general, they reveal a positive relation with the exception of companies being at the leading edge of innovation. However, at the macroeconomic level we expect investments in R&D and standardization to be correlated assuming the latter to be a channel of technology transfer (Blind & Gauch, 2009), leading to our second proposition:

The higher a country's R&D activity within a sector, measured by patent applications, the more it will be active in international standardization within this sector.

## 2.5 The organizational structure of technical work at ISO

The standardization work at ISO is organized in committees in which experts from national standards bodies that are members of the committee meet in regular intervals to do the actual standardization work (ISO, 2016). Membership can either be "participating" (P-membership) or "observing" (O-membership) (ISO, 2016). Additionally, the Technical Management Board (TMB), the ISO body that is in charge of the general management of the technical committee structure, allocates one country to undertake the secretariat of a committee (ISO, 2018b). The secretariat is in charge of the technical and administrative procedures of the committee and is financed by the national member body (ISO, 2018b). It also nominates the chairperson that heads committee meetings, subject to approval by the TMB. The chairperson is supposed to act in a neutral manner and can be nominated for a maximum of six years, while this term can be extended up to a total of nine years (ISO Directives, 2018). Both appointment and extension need to be approved by a two third majority of the committee's P-members (ISO Directives, 2018). In case of more than one member body wishing to undertake a secretariat, some guidelines on the decision process can be found in the working procedures of the TMB (ISO TMB, 2018). The TMB members though are free to deviate from those (ISO TMB, 2018). Murphy and Yates (2009) even state that "This board [the TMB] holds most of the agenda-setting power in ISO".



**Fig. 1** Secretariats of active ISO (sub-) committees held by selected countries in the years 2008 and 2016 (BR: Brasil; CH: Switzerland; CN: China; DE: Germany; FR: France; GB: Great Britain; JP: Japan; KR: South Korea; RU: Russia; SE: Sweden; US: United States; ZA: South Africa)

Sub-committees can be formed or dissolved by a two thirds majority of the P-members of the parent committee which has to be ratified by the TMB (ISO Directives, 2018). In principle, they are organized just like committees, the difference being that they work under the thematic umbrella of their parent committee (ISO Directives, 2018). We argue that holding a secretariat leads to more soft power and greater influence on the agenda of a committee.

### 3 Data and methodological approach

Between 2008 and 2016, there are a few remarkable observations that can be made related to the number of secretariats of active (sub-)committees that were held by the countries in our sample (see Fig. 1). First, the number of secretariats held by ANSI, the American National Standards Institute, has decreased sharply. The standardization system in the United States is characterized by a multiplicity of private and competing standard setters with overlapping areas of activity (Büthe & Mattli, 2011). While ANSI represents the interests of US stakeholders in international standardization organizations like ISO or IEC, it does not develop standards on its own. It rather accredits the procedures of many different standards developing organizations (ISO, 2018a). ANSI encourages stakeholders to develop own initiatives and to think and act global (ANSI, 2005, 2015). As ANSI states in the United States Standards Strategy: “A sectoral approach recognizes that there is no simple prescription that can be handed down to fit all needs. Sectors must develop their own plans” (ANSI, 2005, 2015). ANSI is not co-financed by the government (see Appendix 1) and many US standards organizations regard the willingness to pay for participation as the best measure for interest in standardization (Büthe & Mattli, 2011). There is thus no support for financially weaker interest groups and hence a narrower basis of consensus that standards are built on (Büthe & Mattli, 2011).

Second, the number of secretariats held by Germany and the Asian countries in our sample have increased and that for most other countries has not changed significantly in relative terms. The huge step in the number for China represents the most prominent increase in the sample, both in absolute as well as in relative terms. While the US systems described above have evolved over many decades, the development of the current Chinese standardization system is more recent and still ongoing even though standardization itself has an impressively long tradition in China (Weissinger, 1985). During the period of study, standardization in China happened in four layers: National, sectoral, regional and company level standardization.<sup>1</sup> Except for company standards, all standardization happened under the authority of governmental institutions like ministries, regional governments or the Standardization Administration of the People's Republic of China (SAC), the national standards institute which edits and publishes all national standards and represents China internationally. As the remarkable jump in taking over responsibility in the secretariats of ISO committees suggests, China has pursued the topic of standardization in a well planned and strategic manner: Upon entering the WTO in 2001 the importance of a more modern standardization system became apparent as China since had to fulfill the rules of the Technical Barriers to Trade (TBT) agreement and hence the "Code of Good Practice for the preparation, adoption and application of standards" (Wang et al., 2010). A standardization strategy was one of three major strategies implemented by China's Ministry of Science and Technology (MOST) upon joining the WTO. These were a human resource strategy, a patent strategy and a standards strategy (MOST, 2018). The MOST also commissioned a major research project, the "Study on the Strategy of Technical Standards Development Project". This study triggered the development of standardization plans at multiple layers by government departments (Wang et al., 2010). The SAC formulated the "outline of the eleventh five-year development plan for standardization", which was followed by various regional or sectoral bodies also developing standardization plans. It hence is apparent that the standardization strategy in place is designed by the government and built with a strategic approach in mind (Wang et al., 2010). Weithmann (2018) and Laer (2017) look into the recent reform of the Chinese standardization system that is aiming at making it more versatile and innovation friendly in order to strengthen China's position also in global standardization. Koch (2018) investigates the participation of China in the development of standards for the Industrial Internet of Things (IIoT) and finds that, while being high in terms of quantity, the quality of contributions was rather low, though it is steadily increasing over time. The recent surge in Chinese participation in international standardization is in line with this strategy.

Overall, countries' involvement at ISO is thus constantly evolving. However, we have to note that the involvement of developing countries is only at the very beginning and rather low levels, which can be explained by their focus on the implementation of standards and not on their development (Zoo et al., 2017).

Based on this background, the data used for our econometric investigation was compiled from the following sources.

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<sup>1</sup> For a detailed account of the Chinese Standardization system and its recent reform refer to (Laer, 2017; Weithmann, 2018).

### 3.1 Committee membership

While it is easy to access the current membership status of countries in committees on the ISO-website, unfortunately no information on historic membership within ISO-committees is readily available.<sup>2</sup> However, the internet archive had saved ISO's website including the pages stating countries' membership status and it was thus possible for us to retrieve this data for the years 2008 to 2016. We compiled the membership status, i.e. observing member, participating member or secretariat, for all ISO (sub-)committees for 12 countries.<sup>3</sup> These countries account for more than 80% of committee secretariats during the period of observation. We only keep committees that had at least one active standards project during our time of observation. This obviously reduces the number of secretariats that we cover, but ensures that we only regard relevant committees that have actually done standardization work.

ISO classifies standards in the "International Classification of Standards" (ICS). Unlike standards, committees are not attributed to ICS classes by ISO. We hence assign an ICS class to each committee according to the ICS class that its standards most frequently belong to.<sup>4</sup> ICS classes are our unit of observation and after accounting for those, which we had to drop or merge during the matching process,<sup>5</sup> we remain with the full data available for 30 classes. For each of these ICS classes we thus have the number of secretariats, P- and O-memberships that a country held. Dividing these by the total numbers of active committees in the respective ICS class in a given year we obtain a fractional variable that contains the share of secretariats (O-, P-memberships) within one ICS class that were held by a country in a given year. Using this fractional variable (secfrac) makes it possible to compare ICS classes, which would otherwise be difficult given their different sizes. It also allows us to account for relative dominance of countries within ICS classes and thus conveys more information than e.g. a binary variable could.

### 3.2 Patent data

The use of patent data as a measure of research and development (R&D) dates back several decades. Basberg (1987) reviews the literature on this issue and discusses several difficulties when dealing with patents as an indicator for R&D. These mainly are the heterogeneity in patenting behaviour across firms and industries, the lack of uniformity of patent value and the difficulties in comparing patent systems across countries. He concludes that, given the investigated difficulties, using patent data might still be the best route to take to investigate the questions concerned. Especially with respect to soaring patent applications in China, Dang and Motohashi (2015), amongst others, address the concern about differing qualities of patent applications. Hagedoorn and Cloodt (2003) compare and combine several indicators for innovative performance, like R&D inputs and patent counts in high tech sectors, and find that both are highly correlated. Acknowledging the difficulties discussed in the literature, we use transnational patent

<sup>2</sup> Upon request, ISO stated that this data could only be reconstructed from committee protocols in its archive.

<sup>3</sup> Country list: Brazil, Switzerland, China, Germany, France, UK, Japan, Korea, Russia, Sweden, USA, South Africa.

<sup>4</sup> The created concordance table are available upon request by the corresponding author.

<sup>5</sup> Classes 01, 03, 07, were dropped, 17 + 19 and 73 + 93 merged in the matching process.



applications as proposed by Frietsch and Schmoch (2009) as an indicator for R&D activities. These include only international applications through the Patent Cooperation Treaty (PCT) or at the European Patent Office (EPO) and are cleaned for double counting, thus mitigating potential biases through different national procedures.

Following Frietsch and Schmoch (2009), we use transnational patent applications in fractional count, our variable *FractCount*, to control for R&D activities. This transnational patent data consists of patent applications at EPO and PCT, cleaned for double counting and classified by the International Patent Classification (IPC) on a four digit level. By using transnational patent data, we avoid potential biases from using patent data from national patent offices, as patent application and granting processes are not the same in every country, making it very difficult to compare national application numbers in a meaningful way (Frietsch & Schmoch, 2009).

### 3.3 Trade data

We retrieve export data from the United Nations Comtrade database, classified according to the Standard International Trade Classification (SITC revision 2). The variable *tradeshare* measures, within each ICS class, the share of a country's exports over the sum of total exports by all countries within our sample. It thus captures the relative global importance of the exporting country in this sector in terms of export volume. Unfortunately, no sector output data is available on an ICS level for our sample countries and matching it from existing data would entail an unjustifiable loss of precision. As we are concerned with international standardization though, we expect export data to be much more important for our analysis. We hence control for countries' absolute sector exports with our variable *ICSexports*. To match both patent (IPC) and trade (SITC) data comparable with the standards data, it was based on the International Classification of Standards (ICS, two digits) using Blind's (2004) concordance table.

### 3.4 Standards data

We use Perinorm data to create the stocks of national and international standards for each country. We define the stock as the number of standards published until the end of the respective year minus the number of standards that have been withdrawn until this year. While Perinorm has many shortcomings, such as a bias towards Europe and its coverage of only formal standards, to our knowledge it is the most complete standards database at this point.

Table 1 summarizes our variables and data sources as well as their expected effects derived in the previous section. We thus have data on countries' membership status in ISO committees (*secfract*), the relative importance of a country's exports within ICS classes (*tradeshare*), international patent applications (*FractCount*), sector exports by ICS class (*ICSexports*) and the national and international stocks of standards (*n-istdbbyICS*).

Other factors that could be of relevance for our dependent variable *secfract*, such as the level of development, measured e.g. by the Human Development Index (HDI) or the size of the economy, measured by GDP or more aggregate trade figures, are absorbed by the panel level effects of our model and can thus be considered to be accounted for.

**Table 1** Summary of variables

Variable name	Description	Source	Expected effect
Secfract	fraction of secretariats held within one ICS class	<a href="http://www.archive.org">www.archive.org</a> , own calculation	/
Tradeshare	Country's share of total sample ICS-class exports	Worldbank (Comtrade), own calculation	+
FractCount	transnational patent filings, fractional count	Patstat	+
ICSexports	Country's export within ICS class	Worldbank (Comtrade), own calculation	+
nstdbyICS	Stock of national standards	Perinorm	-
istdbbyICS	Stock of international standards	Perinorm	+

### 3.5 Model

We regress the share of secretariats a country holds within one ICS class on its own lagged value and the lagged explanatory variables described above, i.e. trade share, patent applications, exports and the stock of national and international standards. As secretariats are held for several years (ISO Directives, 2018) the membership status in one year is not independent of this value in the previous year. Hence, we cannot apply conventional fixed effects panel regression as it does not allow for the use of the lagged dependent variable as an explanatory variable. In such cases the important assumption of the error term being orthogonal to the regressors does not hold, i.e. the error term is not uncorrelated to the regressors (Bond, 2002; Greene, 2003). For our statistical analysis we therefore use the Arellano and Bond estimator, an augmented Generalized Method of Moments (GMM) approach, as proposed by Arellano and Bond (1991) following Holtz-Eakin et al. (1988). The Arellano-Bond estimation uses first differences to account for group effects and then a combination of lags of the regressors as instruments for them (Greene, 2003). In order to validate the appropriateness of our model we also conduct the Arellano-Bond test for autocorrelation (Arellano & Bond, 1991). It tests whether the  $H_0$  of zero autocorrelation between first-differenced errors can be rejected. If it can, then there might be autocorrelation and the Arellano Bond approach is correct, i.e. its assumptions satisfied. The Arellano-Bond test confirms our model selection for the full sample as well as for China, Sweden and the US.<sup>6</sup>

Choosing this dynamic panel model allows us to include lagged values of our dependent variable, the share of secretariats, as an explanatory variable. Roodman (2009) provides excellent guidance for the specification and practical implementation of dynamic panel models. We assume all our regressors, obviously except for the lagged *secfract*, to be exogenous. By introducing all independent variables in lagged form, we ensure that no causality can run from the dependent to the independent variables as it would be impossible for a variable in  $t=1$  to have an impact on another variable in  $t=0$ . Also, procedures

<sup>6</sup> For the other countries, the Arellano-Bond test does not encourage this approach and their individual results can thus at most be regarded as suggestive evidence.

in standardization sometimes run a little slower, so we cannot reasonably expect e.g. trade figures to have an instantaneous effect on ISO-participation within the same year.

The model that we estimate has the form:

$$y_{it} = \alpha y_{i,t-1} + v_i + \varepsilon_{it} \quad i = 1, \dots, N \quad t = 1, \dots, T_i \tag{1}$$

where  $y_{it}$  is the fraction of secretariats,  $x$  is an  $1 \times m$  vector of exogenous regressors,  $\beta$  is an  $m \times 1$  vector of parameters,  $v_i$  are panel effects and  $\varepsilon$  are independent and identically distributed (i.i.d.) residuals,  $i$  denotes individuals, here ICS-classes,  $t$  denotes time.

The full equation that we are estimating thus is:

$$\begin{aligned} \text{sefrac}_{it} = & \alpha * \text{sefrac}_{i,t-1} + \beta_1 * \text{tradeshare}_{i,t-1} \\ & + \beta_2 * \text{FractCount}_{i,t-1} + \beta_3 * \text{ICSexports}_{i,t-1} \\ & + \beta_4 * \text{nstdbyICS}_{i,t-1} + \beta_5 * \text{nstdbyICS}_{i,t-1} + v_i + \varepsilon_{it} \quad i = 1, \dots, N, t = 1, \dots, T \end{aligned} \tag{2}$$

### 4 Results

The results from our regression can be found in Table 2. Columns 1–3 show the results for our baseline regression for the entire sample (1), China (2) and the United States (3).<sup>7</sup> Besides the lagged fraction of secretariats, *sefrac*, we introduce only the *tradeshare* and our patent variable *FractCount*. As expected, the fraction of secretariats held in one year has a strong and positive effect on the fraction of secretariats held in the subsequent year. The share of sector exports, which a country accounts for on the other hand seems not to be relevant for our question, unlike we had expected in our first proposition. Our second proposition though is confirmed by the results, as a positive and significant effect from patent applications on ISO participation becomes obvious.

In the next step (columns 4–6) we introduce sector exports into our model in order to control for the importance of the export market in that sector for a country. While their introduction slightly reduces the significance of the coefficients of the patent variable for the US, unlike we had expected in our first hypothesis, sector exports show no significant effect themselves. In a third step (columns 7–9), we introduce the sector stocks of national and international standards, in order to capture any other standardization related aspects, as additional controls. While having only insignificant coefficients, the introduction of the standards stocks does not change our results categorically, though it reduces the size and significance of the patent variable in the China sample, while increasing both in the US sample.

The different sizes of our units of observation, i.e. the number of committees within an ICS class, could represent a potential source of bias, giving secretariats in ICS classes with fewer committees a greater weight than those in “larger” ICS classes. While there is nothing we can do about the composition of ICS classes, we do check whether the exclusion of very large or small ICS classes changes our results, which it does not.

<sup>7</sup> As noted above, the Arellano-Bond method allows us to draw meaningful conclusions only for the full sample, China, Sweden and the US. The results for Sweden are not significant which is why we focus on these two countries here.

Table 2 Regression results

VARIABLES	(1) all	(2) CN	(3) US	(4) all	(5) CN	(6) US	(7) all	(8) CN	(9) US
<i>Y=secfract</i>									
L <sub>i</sub> secfract	0.8703*** (0.05)	0.6714*** (0.08)	0.8573*** (0.08)	0.8734*** (0.04)	0.6238*** (0.10)	0.8794*** (0.09)	0.8687*** (0.04)	0.6212*** (0.11)	0.8276*** (0.19)
L <sub>i</sub> tradeshare	0.0391 (0.05)	-0.2449 (0.36)	0.0308 (0.05)	0.0460 (0.06)	-0.4415 (0.50)	-0.0053 (0.07)	0.0451 (0.06)	-0.5200 (0.52)	-0.0205 (0.07)
L <sub>i</sub> FractCount	0.0929** (0.05)	0.3048** (0.15)	0.1147*** (0.04)	0.0964** (0.04)	0.3035** (0.13)	0.1098** (0.04)	0.1025** (0.04)	0.1438* (0.09)	0.1364*** (0.04)
L <sub>i</sub> ICSexports				-0.0371 (0.07)	0.8371 (0.75)	0.2342 (0.25)	-0.0270 (0.06)	0.8281 (0.74)	0.2644 (0.24)
L <sub>i</sub> nstdbyICS							0.0077 (0.02)	0.0462 (0.06)	-0.0418 (0.06)
L <sub>i</sub> stdbyICS							-0.0289 (0.02)	0.2458 (0.23)	-0.0822 (0.12)
Constant	0.0032 (0.01)	0.0884 (0.09)	-0.0031 (0.02)	0.0029 (0.01)	0.1035 (0.10)	-0.0069 (0.02)	0.0096 (0.01)	0.0409 (0.07)	0.0638 (0.11)
Observations	2,465	210	210	2,465	210	210	2,420	210	210
Number of i.i.d. residuals	359	30	30	359	30	30	352	30	30
No. of instruments	31	31	31	32	32	32	34	34	34
Wald Chi <sup>2</sup> (df)	357*** (3)	3408*** (3)	205*** (3)	410*** (4)	1964*** (4)	234*** (4)	479*** (6)	1938*** (6)	381*** (6)

Robust standard errors in parentheses; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

**Table 3** Core sectors

ICS code	ICS description	Made in China 2025 key sectors
27	energy and heat transfer engineering	energy equipment and technology
45	railway engineering	advanced rail and equipment
47	shipbuilding and marine structures	advanced marine equipment and high-tech vessels
49	aircraft and space vehicle engineering	aviation and aerospace equipment
67	food technology	agricultural machinery and technology
73, 77, 59	mining and minerals, metallurgy, textile and leather technology	new and advanced materials
55	packaging and distribution of goods	
61	clothing industry	

Source: Kenderdine (2017) and own attribution

## 5 Discussion

The results of our panel regression confirm on the one hand our proposition, that the higher a country's R&D activity within a sector measured by patent applications, the more it will be active in international standardization within this sector. Furthermore, holding secretariats in one year has a strong and positive effect on the likelihood to hold them in subsequent years, which reveals a kind of path dependency. On the other hand, our proposition that the more a country trades in general and within specific sectors, the more international standards within this sector will be of relevance for it and thus the more it will be active in international standardization within this sector, has not been confirmed. As well the implementation of national or international standards in a country has no relation to countries' engagement in international standardization.

Although, we know from the review by Swann (2010) and further follow-up studies that domestically implemented standards have a positive influence on countries' export performance, a significant influence of the latter both on the aggregate and the sector specific level on holding secretariats cannot be shown. Trade flows are driven by technology-related, but also by cost- and eventually price-related parameters, which are eventually even more relevant for the majority of trade flows. One further explanation is that holding secretariats is driven by technological capacity, which is confirmed by the significant results related to our second proposition. Consequently, we cannot reveal a positive influence of trade flows on holding secretariats at ISO.

In contrast, our second proposition about the influence of countries' R&D specialization patterns is confirmed for the panel of all countries. This finding is in line with findings of the very few studies on the sector level (e.g. Blind, 2002) and the several studies at the company-level (Blind & Mangelsdorf, 2013; Wakke et al., 2015; Blind et al., 2021) revealing a close relationship between R&D intensity and involvement in standardization.

If we focus on the significant country results related to the influence of R&D on taking over secretariats at international standards, we find those for China and the USA. Consequently, we have to look at both countries in a little more detail:

In 2015, China launched the "Made in China 2025" initiative which aims at upgrading its industrial capacities by becoming more innovative and even self-sufficient by the year 2025 (MERICS, 2016). Table 3 lists the core sectors that the initiative considers important for the development of China (Kenderdine, 2017). Many of the sectors that are mentioned

as strategic in this document had already been part of the previous five year plans of 2005 and 2010 (CBI, 2011; NDRC, 2006). The ICS classes in which China held more than 15% of all secretariats (i.e.  $\text{secrect} > 0,15$ ) and more than one secretariat in absolute numbers match well with the strategic industries, outlined in the “Made in China 2025” initiative as can be seen in Table 3. The only ICS classes that had no counterpart in the “Made in China 2025” initiative are ICS 55 “packaging and distribution of goods” and ICS 61 “clothing industry”. While China has traditionally been strong in exports of clothing (ICS 61), it does not represent a strategic goal as an effort is made to move the economy away from low value added manufacturing (Zhang et al., 2014). The ICS 55 (packaging and distribution of goods) thus remains the only class that is not mentioned in the made in China 2025 strategy or accounted for otherwise in which China shows an increased presence at ISO.<sup>8</sup> Hence, China takes over secretariats in sectors that it considers strategically important and in which it is doing a lot of R&D. This substantiates our claim of a more strategic and planned approach of China with respect to standardization.

In addition, the close and strategic relationship between R&D and innovation on the one side and standardization on the other side has been recently revealed by several Chinese studies. Chinese researchers start to publish about their companies’ technology oriented standardization strategies (Zhang et al., 2020b), innovation (Zhang et al., 2020a) and product performance (Wen et al., 2020).

In the US system, sectors can formulate and pursue their own plans. Hence, sector level standardization bodies are rather free to set their agendas, which might involve strong international involvement wherever research is especially strong. Whether the US system encourages a more direct linkage from R&D to standardization is a promising field for future research. Some first evidence for this was found by Fenton et al. (2018) who look at the link between publishing and standardization and find that publications from US institutions are dominating scientific references in ISO standards. We, hence, conclude that the sectoral approach of the US standardization system might lead to a more direct link between national R&D and participation in international standardization and therefore a more efficient channel of technology transfer.

We have, thus, found evidence for R&D to be an important driver for international standardization participation both for China, which is catching up in standardization, as well as for the US that has been a leading contributor to global standardization for a long time. However, for the European countries we find no significant relationship between their R&D profiles and the secretariats they hold at ISO. There are different explanations for this missing link. First, the European countries are significantly smaller than China and the US. Consequently, their R&D expenditures are in general lower, also in the areas, in which they are specialized in. Therefore, it is more difficult for them to position themselves in leading positions even in these scientific and technological fields. Second, the coordination of standardization activities among European countries via the European standardization system requires on the one hand resources for the activities at the European level, which are then not available for taking over leading positions at the international level. On the other hand, the opportunities by a coordinated approach among the European countries to take over secretariats at the international level are not exploited. In contrast, finding consensus

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<sup>8</sup> Sectors that are mentioned as “China 2025 key sectors” but that are not found in this list, partly because they would be covered by the IEC, are “integrated circuits & new generation IT”, “new energy vehicles”, “biopharmaceutical & high-end medical equipment” and “advanced manufacturing control equipment & robotics”.

at the European level might even weaken the assertiveness of single European countries in taking over leading positions in international standardization. However, this explanation has to be investigated in further depth via a more qualitative approach.

## 6 Conclusion

So far, international standards have mainly been treated as exogenous parameters in particular in investigating their influence on international trade flows. However, this exogeneity has to be questioned. Therefore, the driving forces to take over leading roles, i.e. secretariats, in committees of the International Organization for Standardization (ISO), have to be investigated. Consequently, we examined the share of secretariats that national standard bodies hold within ICS classes at ISO and analyzed its potential drivers for a panel of 12 countries. Firstly, we found that R&D is an important factor while trade volumes, as well as national and international stocks of standards, showed no significant effect. Secondly, we also identified significant effects on an individual country level for both China and the US, covering both ends of a spectrum of public vs. private funding of national standards bodies. Consequently, our findings show that international standards cannot be treated as exogenous parameters in the analysis of trade flows, but also other investigations, e.g. of economic growth. Much more comprehensive approaches, like two-stage methods, are needed, i.e. revealing first the influencing forces of international standardization and standards and then taking these results into account in the assessment of their impact.

However, our findings have already policy implications. Most importantly, influence in international standardization is not a random outcome but driven by countries' interests and strategies. Our findings suggest that some countries can translate their R&D more directly into international standards than others, i.e. being more successful in the international technology transfer. Obviously, the consensus-driven standardization approach in Europe taking the interest of all relevant stakeholders into account is not able to leverage the large European investment in R&D into influencing international standardization. First efforts in the research programme Horizon 2020 try to better integrate standardization in R&D and innovation projects. National technology transfer programmes of European countries, like Germany, attempt to bridge the gap between research and standardization. However, the success of these initiatives is obviously not yet reflected in the results of our analysis. For policy makers in Europe, the revealed mismatch between the own R&D profile and the influence on strategic positions at ISO ask for further investigations, whether this has also negative implications for the competitiveness of European countries and, if so, which modifications of the European standardization systems are needed to improve the interface between the European and the international standardization system. Furthermore, the global power structure in standardization is shifting towards Asian countries, especially China, and this process must be both carefully observed and constructively embraced by the international community in order to substantiate the long term success and fairness of international standardization.

Finally, our work has several shortcomings that we want to briefly address. Firstly, the availability of data for the question that we investigated is difficult. While we were able to retrieve a lot of information on individual committees from the internet archive, the matching on the ICS basis is rather rough and needs refinement. A more detailed ICS-SITC concordance table may be available in the future that will make it possible to broaden the analysis and split it into more detailed units of observation. This would

also make it possible to account for sectors in a more refined way. Secondly, the period of observation is rather short and, especially for China, characterized by transition in many areas. It also includes the years of and after the global financial crisis. Whether our observed effects hold true in the long run can only be observed with longer time series that will become available as time progresses. Thirdly, if we compare our results on the country level with the microeconomic evidence of a positive significant relationship between R&D and participation in standardization in particular for European companies, we have noted some discrepancies. Obviously, the framework conditions of the Chinese and the US standardization systems allow a more effective technology transfer between their national R&D activities and their positioning in international standardization. This calls for more research efforts to conduct internationally comparable studies on the company level, like conducted by Mattli and Büthe (2003), which take into account the different institutional framework conditions related to standardization.

While being explorative in nature our study provides important insights into the heterogeneity of approaches in international standardization and highlights the importance of a fair and transparent system.

## Appendix 1: Data on national member bodies of ISO for the year 2008

Appendix 1 summarizes information on ISO members compiled from its 2009 membership report (ISO, 2009). National standardization institutes can be categorized according to the share of funding that they receive from their governments: ANSI, the American National Standards Institute does not receive any government funding (0%). The institutes in European and a few other countries received between 2% (UK) and 88% (Russia) and those in the Asian countries in our sample are 100% government funded (Table 4).

**Table 4** Data on national member bodies of ISO for the year 2008

ISO membership report 2009	Annual budget (m Swiss francs)	% (Government funding)	Staff (of ISO member)	Number of national TCs + SCs	% (Voluntary standards)
Brazil	9	2	110	110	100
Switzerland	12	14	38	613	100
China	11	100	82	1026	86
Germany	94	18	377	3439	100
France	213	10	914	1141	99
UK	349	2	2445	1278	100
Japan	31	100	100	31	100
Korea	64	100	277	405	100
Russia	52	88	180	476	60
Sweden	31	10	175	350	100
USA	31	0	106	553	100
South Africa	63	24	1265	451	91



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