No double standards: quantifying the impact of standard harmonization on trade

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Preliminary draft. Please do not circulate.

Abstract

Divergent product standards have been categorized as a major obstacle to international trade. This paper quantifies the heterogeneous trade effects of harmonizing standards on product entry and exit as well as export sales. Using a novel and comprehensive database on cross-country standard equivalences, we identify standard harmonization events at the document level. To link the standard data to international product trade flows, we create a new correspondence table between International Classification for Standards (ICS) and Harmonized System (HS) codes based on the WTO TBT and SPS notification database and keyword matching techniques. Our results show that, on average, harmonizing standards leads to a 1.1 percent increase in the growth rate of export sales (intensive margin). This effect is entirely driven by an increase in the sales volume, while export prices do not change. In terms of product entry and exit, a harmonization event reduces the probability of entry. This negative effect is more than offset by a reduction in the probability to exit, leading to an increase in the extensive margin. These findings suggest that incumbents benefit from the reduction in foreign competition brought about by the harmonization of standards, by being able to sell more at a given price.

JEL-Classification: F13, F14, F15, L15
Keywords: Non-tariff barriers, international trade, standardization, harmonization

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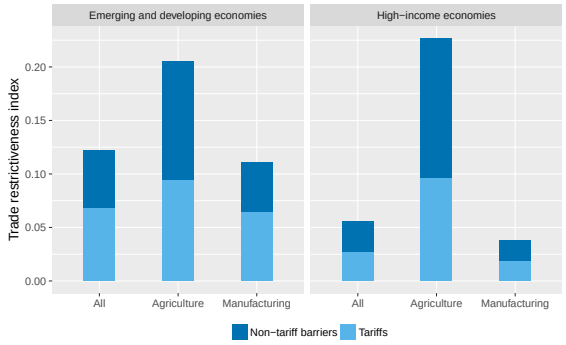
1 Introduction

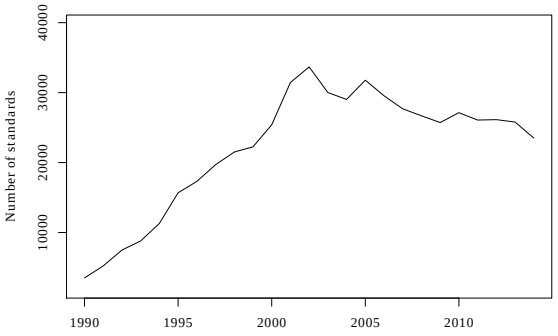
Non-tariff measures make up a large fraction of barriers to trade. This hold for high-income economies and emerging/developing economies alike (see figure 1a). As tariffs have been driven down to very low levels, the expected gains from concluding free-trade agreements (FTAs) mainly stem from eliminating non-tariff barriers to trade. Product standards have been identified as the most important non-tariff barrier to trade (World Trade Report, 2012). While it is unlikely that product standards are abandoned (as they serve important purposes such as quality assurance or compatibility), one presumable way to obtain a reduction of non-tariff barriers is standard harmonization across countries. The current state of the empirical literature, however, offers little guidance on the economic effects of standard harmonization on trade flows.

Figure 1: Trade restrictiveness and harmonized standards

(a) Trade restrictiveness (2009)



(b) Releases of harmonized standards



Notes: Panel (a) displays the Overall Trade Restrictiveness Index by Kee *et al.* (2009), split by tariff and non-tariff barriers and expressed in terms of tariff equivalents. Panel (b) displays the number of unique standards that are harmonized across at least two countries (harmonized standards) each year over the period 1990–2014.

Standard harmonization, both in terms of the accreditation of international standards as well as bilateral or regional harmonization, picked up in the 1990s and grew rapidly during this period. Since 2000, there are between 20,000 and 30,000 standards each year which are accredited by at least two industrialized countries (see figure 1b). Though not necessarily all of these accreditation sare the direct outcome of a country's trade policy, they are very likely to have an impact on bilateral trade flows.

Based on a novel dataset on international standard harmonization across 26 countries, this paper contributes to the literature by quantifying the dynamic effects of standard harmonization on international product trade flows. As a first contribution, we trace the complete history tree of a standard document and create a standard harmonization event if a country accredits a standard from a foreign country at

any given point in time. Second, in order to evaluate the economic implications of the harmonization events on entry, exit and sales, we link the standard data to international product level trade flows. We reduce the number of multiple links in the WTO notification of Technical Barriers to Trade (TBT) database via a keyword matching algorithm. Third, we quantify the impact of standard harmonization on international trade flows at the product level, also taking into account sectoral differences as well as the different margins of trade (extensive versus intensive margin).

To create our extensive database on industry product standards, we rely on the Searle Center Database and extract all standard harmonization events between 1960 and 2015. We distinguish between different types of harmonization events, in particular whether countries jointly release a standard (contemporaneous harmonizations) or whether countries unilaterally accredit standards from another country (subsequent harmonizations). We also distinguish between standards released by international standard-setting organizations (SSOs) and national ones. The nature of the harmonization event can have important implications on the effectiveness of harmonizations in increasing trade flows.

Next, we link the standard database to international trade flows at the product level. Current papers in the literature concentrate only on specific sectors, like Fontagné *et al.* (2015) who focus on Sanitary and Phyto-Sanitary (SPS) measures, Moenius (2006) who analyzes agricultural products or Reyes (2011) who looks at the harmonization of European product standards in the electronics sector. In this paper, we provide evidence across all sectors by developing a new correspondence table between the International Classification for Standards (ICS) codes and the Harmonized system (HS) codes based on the Technical Barriers to Trade Information Management System (TBT IMS) database of the WTO. As a first step, we extract the instances when WTO members report both the ICS classification of the imposed technical regulation or standard and the HS codes of the affected products. Due to misreporting and conflicting relationships, we resort to keyword matching between the HS and ICS product descriptions and reduce multiplicity of the relationships.

Based on the constructed correspondence table, we follow a Difference-in-Difference (DD) approach to quantify the impact of standard harmonizations on product level trade flows. Our results show that on average across all industries harmonizing standards leads to a 1.1 percent increase in the growth rate of trade flows (intensive margin). While the harmonization of standards between an exporting and an importing country leads to a reduction of the probability that products, which were not exported in the preceding year, are exported ("entry"), this decrease in the extensive margin is more than offset by an equally high reduction in the probability that exporters stop exporting certain products ("exit"), thus increasing the extensive margin. We interpret this as suggestive evidence that incumbents remain longer in place than in the absence of standard harmonization and that potential entrants are

deterred from entering. As a result, incumbents are able to expand their exports. We do not find any effect of harmonization on the unit value traded, suggesting that any potential cost reductions are not transmitted to prices (to the extent that we can interpret unit values as prices and assuming that the product mix does not change significantly). With respect to the different types of standardization, we find that the effect on the intensive margin is stronger for the harmonization of standards which were originally released by an international SSO.

Literature review. This paper broadly relates to two strands of literature. The first one is concerned with the impact of non-tariff barriers to trade — specifically the effect of the *introduction* of standards on trade flows. Conventional wisdom would suggest that the introduction of a new standard represents a non-tariff barrier to trade whereas the harmonization of standards between two countries facilitates trade. A first look at the literature — though relatively scarce — shows that the picture is not as clear-cut. One of the earliest contributions is Swann *et al.* (1996) who show that UK exports react positively to the introduction of UK standards: The information contained in a standard (product descriptions or internationally recognized quality characteristics) help promote the exports of the country that is releasing those standards. In addition, a large number of these standards constitute accreditations of standards that are originally released by international standard-setting organizations (SSOs); the trade-promoting effect therefore stems from the commonality of standards across countries.

The broad literature review provided in Swann (2010) summarizes the literature up to 2009: The accreditation of international standards by a specific country leads to an increase of both the country's exports and imports. The release of national standards (standards only released by the country in question) leads to larger exports, but the impact on its imports is ambiguous: while imports sometimes decrease (especially when standards are mandatory, such as in the case of technical regulations), the evidence is not consistent across studies.

Moenius (2004) shows that the introduction of national, i.e. non-harmonized, standards is actually promoting trade, suggesting that the positive externalities from reducing information asymmetries outweigh the additional burden stemming from additional costs due to compliance procedure and product adaptation. Fontagné *et al.* (2015) specifically analyze the impact of restrictive Sanitary and Phyto-Sanitary (SPS) measures on the extensive and intensive margins of trade. They use firm-level data and are thus able to show that these restrictive regulatory standards have a detrimental impact on trade flows, but less so for larger (and presumably more productive) firms.

Apart from the analysis of new standard introductions, a second strand of literature concerns the effect of cross-country standard *harmonization* on trade flows.

One of the few papers in this field is Chen and Mattoo (2008). Using information on EU/EFTA harmonization and mutual recognition agreements, they find that trade flows increase between participating countries, but exports of excluded countries can actually decrease. Disdier *et al.* (2015) also show that harmonization between Northern and Southern countries is associated with increasing trade flows, but they point out the trade-deflecting effect on South-South trade. The evidence provided in Moenius (2004) also points towards unambiguous positive effects of standard harmonization on trade flows. One of the rare studies to use firm-level data is Reyes (2011) who shows that the harmonization of EU electronics standards led to an increase of the number of US firms exporting to the EU in that sector. This increase in the extensive margin is driven by the entry of more productive firms into the EU market. In contrast to most studies, Reyes (2011) analyzes the impact of harmonization between two countries (i.e. intra-EU harmonization) on third countries (the US).

This paper aims to improve upon existing studies in several dimensions: (1) *coverage* — using a comprehensive database on standard equivalences, we are able to analyze bilateral trade flows of all major economies across all industries and types of standards, thus aiming for a broad picture about the effects of standard harmonization on trade; (2) *industry-level mapping* — by creating a correspondence table between the HS (Harmonized System) and ICS (International Classification for Standards) classification systems, we are able to conduct our analysis on the HS-4 digit-level, thus allowing for a finer assignment of standardization events to each industry; (3) *identification* — most studies ignore the fact that standards might be introduced or harmonized *as a response* to trade flows; in this paper, we specifically tackle this issue by opting for a very stringent econometric specification; (4) *focus on harmonization* — whereas the majority of studies analyzes the effect of new standard introductions on trade flows, we specifically look at standard harmonizations, which have become a highly debated topic in the context of regional trade agreements.

The rest of the paper is organized as follows. Section 2 explains the data and stylized facts on cross-country standard harmonization. In section 3, we outline the theoretical framework and discuss the different expected effects of standard harmonization on trade. Section 4 describes the correspondence table, while Section 5 discusses our empirical strategy and presents the main results and their interpretations.

2 Cross-country standard harmonization

We use the Searle Center Database for the construction of our database on standard releases and harmonizations. Its main source is Perinorm, a bibliographical repository of standard documents. For the purpose of our analysis, we specifically rely on

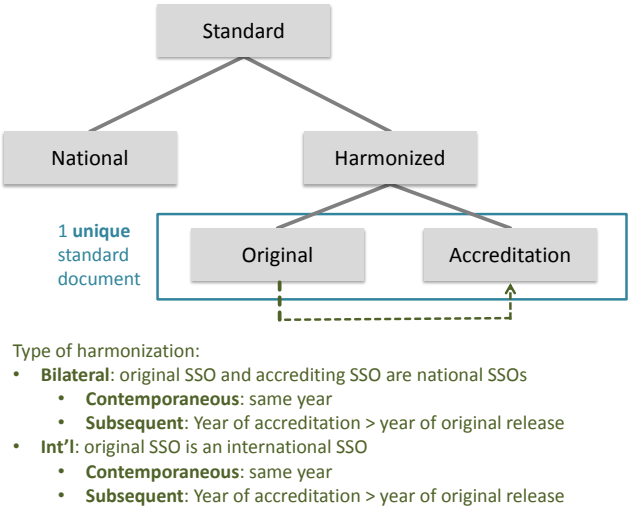
Perinorm's information on standard equivalences in order to identify cross-country standard harmonization. The original dataset comprises individual standards for which the date of release, the ICS class, the nationality of the standard-setting organization (SSO) as well as the duplicate versions in other SSO are known ("equivalences" with other standards). These equivalences constitute the core of our analysis: A standard can be released by more than one SSO. Even within one country, several SSOs can release the same standard. For the question of cross-country harmonization, we are only interested in equivalent standards released by SSOs of different nationalities. The nationality of an SSO can either be a country ("national") or an international SSO ("international").

In order to identify those events that are relevant for the question of non-tariff barriers to trade, we restrict the sample to those standards that constitute the first publication ("original") across all SSOs/nationalities as well as the accreditations of these original standards by another country (technically specking, by a SSO of another nationality than the one of the SSO that releases the original standard). International SSOs thus also constitute a "country" (country code "IX" in figure 6). If two countries each released a standard at the same time, the respective standard is counted both as an original standard as well as an accreditation. However, if an international SSO and a national SSO release a standard at the same time, we consider that this standard originated in the international SSO and was accredited by the national one.

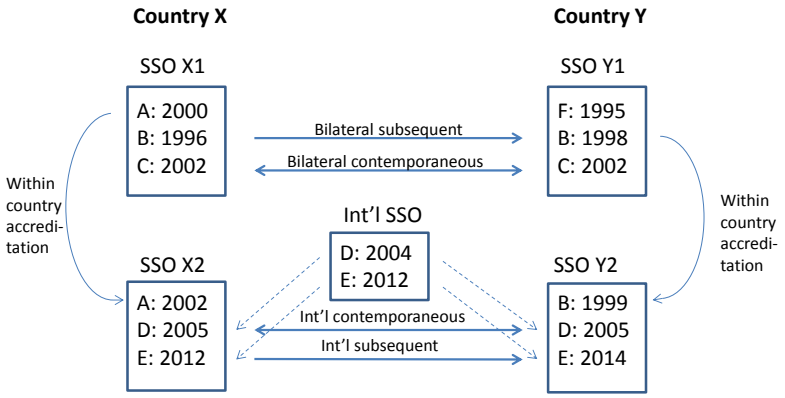
This paper uses a number of definitions. Figure 2 exemplifies the different types of standards and the terminology we use in the remainder of this paper to designate them. A standard document can either be a national standard, meaning that it was released by a national SSO and never accredited by a SSO of another nationality (such as standards A and F in figure 2 (b)), or a harmonized standard, meaning that at least two versions of the same unique standard document have been released by at least two SSOs of different nationality (such as standards B, C, D and E in figure 2 (b)). For the construction of stylized facts, we differentiate between whether a standard represents the original release or an accreditation. An "original standard" designates the standard that was first released by a national or international SSO. Subsequent releases of equivalent versions of this original standard are designated as "accreditations". As such, a standard can be accredited by more than one SSO of different nationalities. When the accreditation concerns a standard originally released by a national SSO, we designate this type of harmonization as "bilateral". On the contrary, we talk of "international harmonization" whenever a standard, which is originally released by an international SSO, is accredited by two different national SSOs. We also differentiate between "contemporaneous" harmonizations, i.e. happening in the same year, and "subsequent" ones, where the year of the accreditation is different from the year of the original release.

Figure 2: Terminology

(a) Types of standards

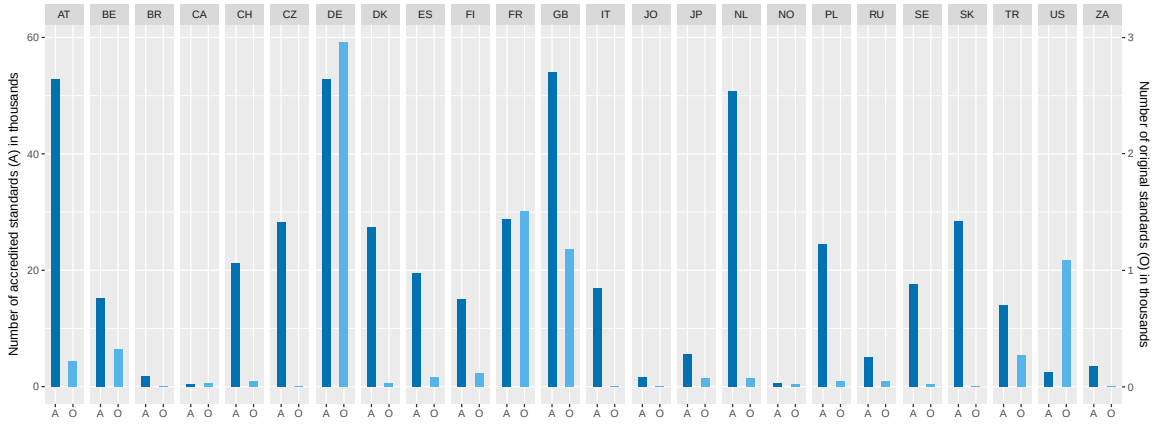


(b) Example



The country distribution of original and accredited standards is displayed in figure 3. One first notes that the number of standards which represent accreditations of standards from other countries or international standards outnumber the number of original standard by more than one order of magnitude. This is due to the fact that a original standard is often accredited by more than one country and that a lot of these accreditations are international standards.

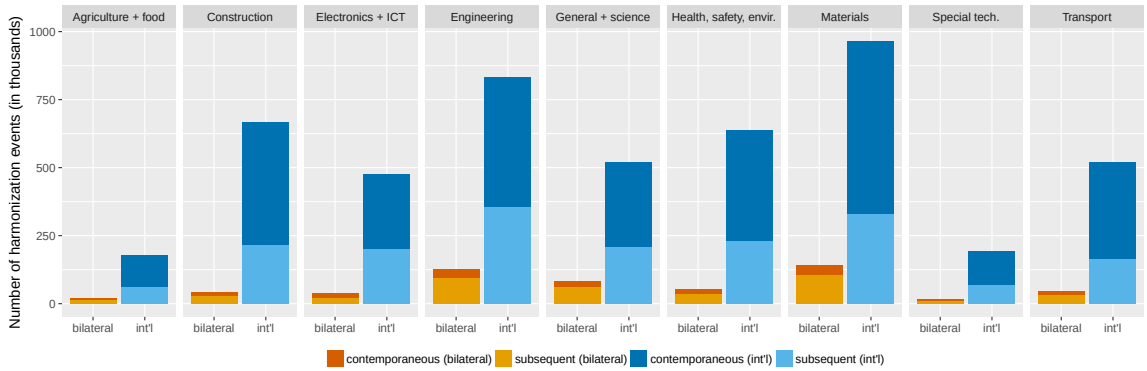
Figure 3: Original and accredited standards, by country



Notes: The figure displays the number of original and accredited standards that are either part of international or bilateral harmonizations, broken down by major ICS categories, after having excluded within-country accreditations. The categories are Agriculture and food technology [ICS 65–67], Construction [ICS 91–93], Electronics and ICT [ICS 31–37], Engineeering technologies [ICS 17–39], Generalities, infrastrcutures and sciences [ICS 01–07], health, safety and environment [ICS 11–13], Materials technologies [59–87], Special technologies [95–97] and Transport and distribution of goods [ICS 43–55]. The data are summed over the years 1960–2015 and all SSOs.

A few large countries dominate the standard-setting process: Germany, France, Great Britain and the United States are the countries whose standards are the most often accredited by other countries. One might argue that these countries simply dominate the ranking of original standards as they are very large or simply release a large number of standards. However, those countries that release a large number of accreditations are Austria, Germany, Great Britain and the Netherlands.

Figure 4: Means of standard harmonization, by major ICS categories

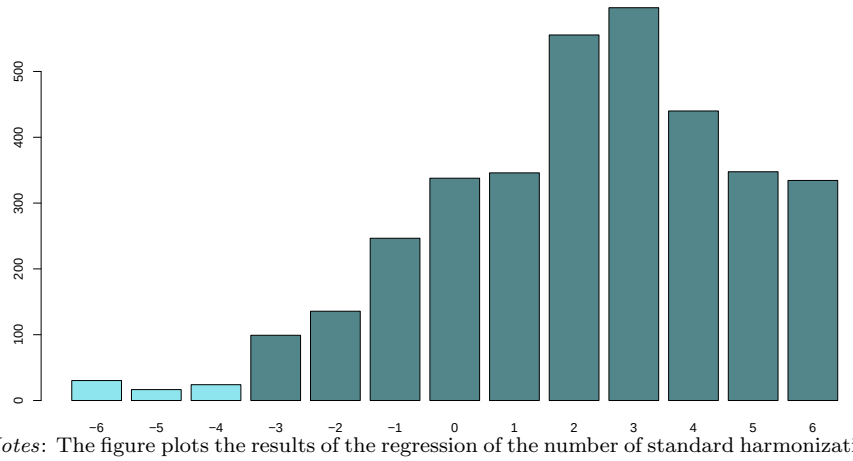


Notes: The figure displays the number of standard accreditations, broken down by major ICS categories, after having excluded within-country accreditations. The categories are Agriculture and food technology [ICS 65–67], Construction [ICS 91–93], Electronics and ICT [ICS 31–37], Engineering technologies [ICS 17–39], Generalities, infrastrcutures and sciences [ICS 01–07], health, safety and environment [ICS 11–13], Materials technologies [59–87], Special technologies [95–97] and Transport and distribution of goods [ICS 43–55]. The data are summed over the years 1960–2015 and all SSOs.

Figure 4 shows that cross-country standard harmonization is very prevalent in materials technologies, construction as well as engineering. A a large number of standards originate within international SSOs. Many countries accredit these international standards which is why accreditations of standards that originated in international SSOs make up roughly three quarters of the universe of standards that comprise original and accredited standards. In terms of the release of original standards, the population of international original standards is one order of magnitude larger than the one of national original standards, thus implying that international SSOs play a key role in the standard-setting process. With regards o the timing of harmonization events, figure 4 shows that international harmonizations are rather balanced between contemporaneous and subsequent harmonizations. On the contrary, bilateral harmonizations are dominated by subsequent timing.

We extract information on the date of entry into force and the signatories of regional free trade agreements (FTAs) from the WTO. In a simple regression of the number of standard harmonizations between two countries in a given year (across all sectors) on an indicator of entry into force of an FTA (as well as exporter-importer and time fixed effects), we find that FTAs are significantly associated with a higher number of standard harmonizations. Leads and lags of the FTA indicator are also significant. In figure 5, we plot the size of the estimated coefficient as a function of whether the FTA indicator is included as a lagged (-6 to -1 years), contemporaneous (0) or lead variable (1 to 6 years). Dark blue bars indicate statistical significance at the 1% level. As can be seen from figure 5, three years prior to the entry into force of an FTA, i.e. during the time when FTAs are negotiated, the coefficient is highest.

Figure 5: Impact of FTA indicator on standard harmonizations



Notes: The figure plots the results of the regression of the number of standard harmonizations between two countries on an indicator of whether these two countries entered a FTA in a given year (as well as exporter-importer and year fixed effects). The data span the years 1960–2011. The explanatory variable is included respectively as a lagged, contemporaneous or lead variable. The figure plots the size of the estimated coefficient as a function of whether the FTA indicator is included as a lagged (-6 to -1 years), contemporaneous (0) or lead variable (1 to 6 years). Dark blue bars indicate statistical significance at the 1% level.

Table 1 expresses the population of original standards and accreditations in percentages. Clearly, a large number of standards originate within international SSOs. Many countries accredit these international standards which is why accreditations of standards that originated in international SSOs make up roughly three quarters of the universe of standards that comprise original and accredited standards. In terms of the release of original standards, the population of international original standards is one order of magnitude larger than the one of national original standards, thus implying that international SSOs play a key role in the standard-setting process.

Table 1: Means of accreditation: bilateral vs. international SSOs

Number of standards in subset	586646	in %
of which: original national standards	8154	1.4
of which: accreditations of national standards	42954	7.3
by national SSOs	37178	6.3
by international SSOs	5776	1.0
of which: original international standards	84101	14.3
of which: accreditations of international standards	451437	77.0

We thus retain that standard harmonization is largely achieved via international SSOs. A large amount of this international dimension of standard harmonization is due to the European integration process and the accompanying dominance of European SSOs among international SSOs. Table 2 lists the largest international SSOs (in terms of original standards). As their names reveal, many of these SSOs are European ones. However, it should be noted that many of these SSOs were founded as part of the European integration process, but also produce international standards and are comprised of non-European members (one such example is ETSI).

Table 2: Top ten international SSOs (release of original standards)

SSO	Number	%
CEN – European Committee for Standardization	33109	32.2
ISO – International Organization for Standardization	30308	29.5
IEC – International Electrotechnical Commission	19111	18.6
CENELEC – European Committee for Electrotechnical Standardization	11636	11.3
ETSI – European Telecommunications Standards Institute	5345	5.2
ASD – AeroSpace and Defence Industries Association of Europe	1762	1.7
ITU – International Telecommunication Union	405	0.4
ECMA – European Asso. for Standardizing Info. and Comm. Systems	251	0.2
EC – European Communities/European Union	134	0.1
Other	848	0.8
Sum	102909	100

Notes: The table displays the number of original standards of international SSOs, broken down by SSO. A standard can be released by more than one SSO per year and can thus be counted several times. The data are summed over the years 1960–2015 and all ICS classes.

3 Expected effects and theoretical export equation

The introduction of a standard can have various effects which are often related to their underlying different purposes. The literature acknowledges that the introduction of standards can have both a trade-restricting effect, i.e. when the need to comply with quality or safety standards raises additive per-unit or fixed costs, and a trade-promoting effect, i.e. when information asymmetries are lowered and thus additive or iceberg costs are reduced. Though a direct mapping is clearly infeasible, table 3 summarizes the different economic effects that standardization can have for production, market transactions and users of standardized products.[1]

Standards are widely used in technological applications to ensure the compatibility of different devices. The positive externatilities associated with this interoperability should increase the demand for such products as additive trade costs are reduced, thus increasing both the intensive and extensive margin of trade. In a similar vein, standardization can lead to economies of scale and scope when complementary intermediate goods are used for a large variety of final products. One could thus also expect that supply chains become more detailed and complex and markets more integrated. The standardization of intermediate goods, and in particular the harmonization of these standards across trade partners, could then be associated with an increase of both the extensive and intensive margin of trade. One of the most basic purposes of standardization is the use of common definitions. This reduces information asymmetries and lowers transaction costs between producers and buyers of a product. One would thus expect the release of such standards to be associated with a higher extensive margin as fixed costs of exporting are lowered. However, to the extent that the use of common definitions reduces variety, the overall effect of the use of common definitions on the extensive margin is ambiguous.

The conventional understanding of standards is centered around them representing non-tarrif barriers to trade. While an increase in product quality could potentially increase trade flows, the detrimental impact of the need to comply with quality standards is fueling the idea that standards impede trade. While quality or saftey standards can certainly represent a barrier to trade, their harmonization across countries should be associated with an increase in the extensive margin of trade. The last item in table 3 concerns the positive impact of codifying knowledge on technologies, procedures and products via standardization. Both an idiosyncratic release of a standard as well as harmonization across countries should have a positive impact on trade flows, presumably via the extensive margin. To summarize, the impact of standard harmonization on the different margins of trade depends ultimately

[1] See also Baron and Schmidt (2014) and Baron and Spulber (2015) for a general discussion on the economic impact of standardization.

Table 3: Economic effects of standardization

Purpose of standard	**Potential economic effects**
Compatibility	Network effects (increasing number of users)
Complementary	Economies of scale and scope
intermediate goods	Decentralization of supply chains
Common definitions	Lower transaction costs between producer and user/buyer
	Variety reduction
	Reduction of information asymmetries
Quality and safety	Rise in quality/safety requirements
	Need to certify compliance with standard
Knowledge diffusion	Lower production/development costs

on the extent to which it alters fixed and additive (per unit) trade costs. It is thus essentially an empirical question which we will tackle in this section.

To derive or testable empirical predictions, we start by describing the sector-level demand system. We base ourselves on a Two-Tier CES demand system, where in each sector p of country j, consumers demand a continuum of varieties indexed by i, which may be imported or not.

$$X_{jkt} = \left[\sum_{i \in I} C_{ijk}^{\frac{\sigma_k - 1}{\sigma_k}} \right]^{\frac{\sigma_k}{\sigma_k - 1}} \tag{1}$$

where $i \in I$ indexes varieties, or equivalently producing countries, including the varieties produced in home country j. The representative consumer chooses her optimal consumption by minimizing the expenditure across all varieties. The resulting demand for variety i in each sector k is given by:

$$X_{ijk} = \left(\frac{P_{ijk}}{P_{jk}} \right)^{-\sigma_k} X_{jk} \tag{2}$$

with the corresponding CES price index:

$$P_{jkt} = \left[\sum_{i \in I} P_{ijk}^{1-\sigma_k - 1} \right]^{\frac{1}{1-\sigma_k}} \tag{3}$$

We now suppose that each variety i of product k is potentially supplied by a continuum of heterogeneous monopolistic competitive firms. We base ourselves on a Melitz (2003) type of theoretical framework with heterogeneous firms facing the

CES demand elasticity, σ_k, and bilateral product specific iceberg trade costs τ_{ijp}. In this setup, firm-level export sales, x_{ijk}, of country i to country j depend upon the firm-specific productivity (α), unit labor costs, i.e. wages (w), trade costs and total demand for variety i of product k in destination j, X_{ijk}, as well as the ideal CES price index P_{ijk}. Hence, we can write exports of firm α in country i to country j as:

$$x_{ijk}(\alpha) = \left(\frac{\sigma_k}{\sigma_k - 1}\right)^{1-\sigma_k} \left[\frac{w_{ik}\tau_{ijk}}{\alpha}\right]^{1-\sigma_k} \frac{X_{ijk}}{P_{ijk}^{1-\sigma_k}} \tag{4}$$

Note that there are two types of trade costs associated with reaching market j: the fixed cost f_{ijk} and the marginal (ice berg) trade cost (τ_{ijk}). Because firms are heterogeneous in their productivities, there exists a marginal firm that is just able to cover the fixed cost, i.e. her export revenues must equal the fixed costs. The zero profit condition of that firm implies.

$$x_{ijk}(\bar{\alpha}_{ijk}) = \left(\frac{\sigma_k}{\sigma_k - 1}\right)^{1-\sigma_k} \left[\frac{w_{ik}\tau_{ijk}}{\bar{\alpha}_{ijk}}\right]^{1-\sigma_k} \frac{X_{ijk}}{P_{ijk}^{1-\sigma_k}} = f_{jk} \tag{5}$$

and defines the productivity cut-off denoted by ($\bar{\alpha}_{ijk}$). Firms with an idiosyncratic productivity higher than ($\bar{\alpha}_{ijp}$) enter export markets, while firms with a lower productivity don't. To calculate the total value of exports from country i to country j, we simply sum over all firms capable of paying the fixed cost to enter:

$$X_{ijk} = \int_{\bar{\alpha}_{ijk}}^{\infty} x_{ijk}(\alpha)\phi(\alpha)d\alpha \tag{6}$$

where $\phi(\alpha)$ is the cumulative density function of firm productivities. The corresponding price index is given by

$$P_{ijk} = \left(\int_{\bar{\alpha}_{ijk}}^{\infty} p_{ijk}^{1-\sigma_k}(\alpha)\phi(\alpha)d\alpha\right)^{\frac{1}{1-\sigma_k}} \tag{7}$$

We think that product specific standards, s_{ijk}, are part of the fixed costs, i.e. $f_{ijk}(s_{ijk})$. To assess the implications of standard harmonization, we suppose that if countries harmonize their standards bilaterally, the fixed cost of exporting decreases, i.e. $f_{ijk}(s'_{ijk}) < f_{ijk}(s_{ijk})$. As a result, the productivity cut-off $\bar{\alpha}_{ijk}$ in equation 5 will go down and more firms will start to export, i.e. we should observe a positive effect on the extensive margin and net entry is going up. An increase in firm entry

will reduce the price index of that firms from country i charge to country j P_{ijk} and increase its export sales X_{ijk}.

Until now we implicitly assumed that countries harmonize standards in order to simplify the import requirements into their countries. However, this does not necessary have to be the case. It is conceivable that the new standard harmonization imposes additional import requirements if the specific product in question was previously not subject to a standard regulation. As a consequence, this would imply an increase of the fixed cost of exporting and therefore a reduction in trade flows.

Alternatively, part of the fixed cost to export might be related to design or adaption costs aimed at the importing countries consumers taste. A benefit of these consumer specific investment is to charge a markup. If the new product standard imposed by the harmonization requires now all products to use the same specifications, the previously gained competitive advantage might be lost and may even reduce firms' exports. A concrete example would be a computer power plug. For the moment, each computer manufacture can create its' own design for the power plug making it incompatible with other manufactures. This obliges the consumer to buy the power plug from the same computer manufacture. However, if countries agree on a common standard of computer power plugs, then each manufacturer looses his previous monopoly on the power plug and markups as well as trade volume may decline.

Overall, we would like to stress that it is not clear whether we should observe an increase in the total export values after a harmonization. The empirical analysis will shed light on this question and measure the *average* impact of standard harmonization on trade flows. In the following, we decompose the overall trade flows into a measurement for the extensive and intensive margin. Broadly speaking, the extensive margin captures the number of products exported, while the intensive margin captures the average value of products exported.

4 Correspondence table

In this section we describe correspondences between the Harmonized System (HS) categories used to classify products in international trade data and the International Standard Classification (ICS) system used to characterize international product standards. The correspondence tables links the 4 digit HS codes to the 5 digit ICS codes. The key advantage of this correspondence table is that it includes all sectors, previous correspondence used in the literature cover only certain industries, see Moenius (2006), Reyes (2011) and Fontagne, Orefice, Piermartini and Rocha (2013).

Before we describe the correspondence in detail, we include a short overview of the ICS and the HS classification system. The International Classification for Standards (ICS) is an international classification system for formal standards. It

is developed and maintained by the International Organization for Standardization (ISO) and designed to cover every economic sector. Standards can be classified by a 7-digit code (i.e. 33.060.30) where the first two digits describe the overall sector (i.e. 33 — Telecommunications. Audio and video engineering). The next three to five digits are sub-group headings indented to refine the description of the sector (i.e. 33.060 — Radiocommunications and 33.060.30 — Radio relay and fixed satellite communications systems). International trade data codes are based on the Harmonized System established by the World Customs Organization (WCO). The WCO assigns 6-digit codes for general categories and countries adopting the HS are required to assign one of these 6-digit codes to any product they are trading internationally. These 6-digit codes are the same across countries.[2]

The core of the correspondence table is based on the Technical Barriers to Trade Information Management System (TBT IMS) database of the WTO. The Technical Barriers to Trade Information Management System (TBT IMS) is a publicly available database of transparency information provided by WTO Members in relation to technical regulations, conformity assessment procedures and standards.[3] A typical notification of a member country consists of an explanation on why it imposes a technical barrier to trade, which partner country is affected, the ICS classification of the TBT and, in some instances, it also includes the 6 digit HS code (in some instances the 2 digit or the 4 digit codes) of the products on which the measure is applied.

The first step consists of gathering all the notified relationships between HS and ICS classes for the period 2000 to 2016, which accounts for 3775 notifications. However, 32 percent of the identified relationships cover multiple relationships and lead to a many-to-many correspondence. Thus, in a second step, we refine the obtained correspondences via a keyword matching algorithm. To this end, we first extract for each 6 digit HS and 7 digit ICS class their keywords and the associated importance weight using the Rapid Automatic Keyword Extraction (RAKE) algorithm as described in Rose *et al.* (2010). Next, we match the keywords from the ICS and HS relationships we find in the WTO notification database and keep only those relationships, where any keyword match occurs. This algorithm reduces the number of links to 946 relationships between 5 digit ICS codes and 4 digit HS codes.

Based on the correspondence table, we link the standard harmonizations by country pair to the product level trade data and sum all harmonizations within a 4 digit HS product. The baseline regressions are all run on this level of aggregation.

[2]HS codes that have more than 6 digits are country-specific codes, with the first 6 digits being common across countries and the last 2 digits being country-specific.

[3] The table is available at: https://i-tip.wto.org/goods/Forms/Methodology.aspx

5 Empirics

5.1 Data

The analysis in this paper is based on the BACI database developed by the CEPII, see Gaulier and Zignago (2009), which is based on the United Nations COMTRADE database. The data are harmonized in order to reconcile export and import declaration of values and volumes across countries, where precedence is given to countries with more reliable trade statistics. The main advantage of this database is that it has an extensive country coverage at a high level of disaggregation for many years. The data spans from 1995 to 2014 and includes 5,000 HS6 product categories for more than 160 countries.

In our analysis we will work on the HS4 digit industry level. This level of aggregation allows merging the trade data to the standard data using the correspondence table described above. In total we have standard data from 26 countries. We consider their bilateral linkages. So in total, we have 1250 different HS4 codes for 26 countries, covering the period of 1995–2014.

5.2 Regression analysis

5.2.1 Baseline specification

We model trade flows (exports of products in industry k from country i to country j at time t), Y_{ijkt}, as a function of standard harmonization, h_{ijkt}, as well as a number of fixed effects:

$$Y_{ijkt} = \beta h_{ijkt} + f_{ikt} + f_{jkt} + f_{ijt} + f_{ijk} + \varepsilon_{ijkt}$$

The inclusion of product-specific supply effects, f_{ikt}, and product-specific demand effects, f_{jkt}, as well as the inclusion of time-varying shocks that affect both importer and exporter, f_{ijt}, ensures that all other fixed effects (f_i, f_j, f_k, f_t, f_{it}, f_{jt}, f_{kt}, f_{ij}, f_{ik}, f_{jk}) are taken care of. Such a rich specification allows to take into account all other factors apart from those that affect fixed costs varying at the exporter-importer-industry-time-level. It is thus compatible with the theoretical export equation presented above.

We use the following measure for h_{ijkt}. We define a dummy variable which equals one whenever there is at least one standard that was harmonized in t. We do so as the number of standard harmonizations per ICS class (industry) between i and j might not be very informative and thus only distinguish between the event of a standard harmonization and no harmonization. Therefore, the variable h_{ijkt} can be thought of as a dummy variable measuring the treatment effect of a harmonization event.

We are interested in the different margins of trade, the intensive and extensive margin, as well as the effect of standard harmonization on unit values. In order to capture the extensive margin, we define a dummy indicator equal to one whenever trade flows between an exporter or importer are non-zero. We estimate model the with ordinary least squares to avoid the incidental parameter problem. For the intensive margin, the dependent variable, Y_{ijkt}, is the change in log export flows from country i to country j in industry k at time t. We are also interested in price effects and investigate the impact of standard harmonization on unit values.

For the intensive margin and unit values, the identification comes from restricting observations to those where a country exports a product to at least two countries in the same year. In addition, we restrict observations per exporter, product and year to include at least one harmonization event (the treatment group: $h_{ijkt} = 1$) and one non-harmonization event (the control group: $h_{ijkt} = 0$) among its importers in order to measure the differential impact of a standard harmonization by exploiting the cross-sectional difference. Note that this approach is similar to Khwaja and Mian (2008) as well as Bas *et al.* (2015) in controlling for demand and supply effects. Standard errors are clustered on the industry-level in all specifications.

We interpret each equivalence of standards released by two or more SSOs of different nationalities as a harmonization event and consider the incidence of those harmonizations as an indicator of trade integration. Though Perinorm is a comprehensive database covering the most important industrialized countries, we cannot exclude underreporting for specific countries and SSOs. In the regression analysis, we therefore consistently use fixed effects to minimize the risks from underreporting. Relatedly, a country's membership in an international SSO might automatically imply that the standards released by the international SSO in question are applied in the respective country. Once again, fixed effects tackle this issue. With regards to trade integration, we hypothesize that the explicit release of another country's standard will lead to higher trade flows. However, manufacturers of a certain product have access to foreign SSOs' standards and might produce according to these foreign standards independently of whether their home SSOs explicitly accredit a foreign standard or not. This caveat, however, does not prevent us from measuring the gains from explicit cross-country standard harmonization/accreditation as for example discussed in the framework of FTA negotiations.

The regression results are displayed in table 4. Standard harmonizations between an exporter and an importer are clearly associated with both a higher extensive as well as intensive margin. Unit values (prices) decrease in response to standard harmonization.

Table 4: Regression results: Explanatory variables in levels

	(1) Ext. margin	(2) Int. margin	(3) Price
Harm.	0.00050*	0.00829***	-0.00278**
	[0.063]	[0.000]	[0.046]
Observations	10304800	4964875	4964875
R^2	0.74	0.90	0.87
Adjusted R^2	0.70	0.87	0.83

Notes: In brackets: p-values.

One could argue that the results in table 4 are driven by endogeneity, i.e. that standard harmonizations are primarily done in sectors where exporters are present (a positive extensive margin) and where trade volumes are very high (a high intensive margin). It is for this reason, that we specify our baseline regression in terms of first differences, i.e.:

$$\Delta Y_{ijkt} = \beta \Delta h_{ijkt} + f_{ikt} + f_{jkt} + f_{ijt} + \varepsilon_{ijkt}$$

While we do not exclude the possibility that a positive extensive margin and a high intensive margin influence the probability that two countries harmonize standards, we can exclude that this is the case for the change in the extensive margin as well as the growth rate of the intensive margin (log changes of non-zero trade flows). The variable of interest, Δh_{ijkt}, is therefore a binary indicator of whether there was a standard harmonization or not.

We further decompose the change in the extensive margin into entry and exit: the former is defined as a dummy indicator equal to one if trade flows are positive in period t and zero in period $t-1$ while the latter is defined as a dummy indicator equal to one if trade flows are zero in period t and positive in period $t-1$. The linear combination of entry and exit therefore give the change in the extensive margin:

$$\Delta Y_{ijkt}^{\text{ext.m.}} = Y_{ijkt}^{\text{entry}} - Y_{ijkt}^{\text{exit}}$$

Results are displayed in 5. One can see that standard harmonization leads to a 0.5 percent decrease in the probability of entry of a new product. This has a negative impact on the change in the extensive margin. However, this partial effect is offset by the effect on the probability to exit which is of the same order of magnitude as the reduction in entry. It is for this reason that the overall change in the extensive margin is nil. We interpret this finding as indicative of the idea that incumbents push for the harmonization of standards (that's why we observe the positive coefficient for the extensive margin in column (1) of table 4); these harmonizations respresent an impediment to entry for other products (as every harmonization also represents the

introduction of a new standard) whereas incumbents remain longer in place than they would have in the absence of harmonization. Column (4) of table 5 shows that the growth rate of non-zero trade flows does not change significantly. We also observe that there are no significant changes in prices as unit values remain unaffected as shown in column (5) of table 5.

Table 5: Regression results: Explanatory variables in first differences

	(1) Δ Ext. margin	(2) Entry	(3) Exit	(4) Δ Int. margin	(5) Δ Price
Harm.	-0.00010	-0.00096***	-0.00086***	0.00275	0.00122
	[0.835]	[0.006]	[0.009]	[0.267]	[0.598]
Observations	9789560	9789560	9789560	4567388	4567388
R^2	0.11	0.14	0.13	0.22	0.23
Adjusted R^2	0.02	0.05	0.04	0.08	0.09

Notes: In brackets: p-values.

5.2.2 Medium-term impact

The results in table 5 only show the contemporaneous impact on trade flows. However, it could take time for the effects to materialize. In order to measure the medium-term impact of standard harmonization, we regress the difference of the 5-year-mean of extensive margin, intensive margin and price before and after a standardization event. In particular, we run the following econometric specification:

$$\left(\frac{1}{5}\sum_{s=1}^{5} y_{i,j,k,t+s} - \frac{1}{5}\sum_{s=1}^{5} y_{i,j,k,t-s}\right) = \Delta h_{ijkt} + f_{ijt} + f_{ikt} + f_{jkt}\varepsilon_{ijkt}$$

The fixed effects f_{ijk} are not included as the above regression set-up is essentially a difference specification (time-invariant factors thus drop out). The variable y is either the extensive margin, intensive margin or the price. Similarly, we also define dummy indicators for entry and exit which are defined as:

$$Y^{en} = \begin{cases} 1 & \text{if} \quad \sum_{s=1}^{5} y_{i,j,k,t-s} = 0 \ \text{ and } \ \sum_{s=1}^{5} y_{i,j,k,t+s} > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$Y^{ex} = \begin{cases} 1 & \text{if} \quad \sum_{s=1}^{5} y_{i,j,k,t-s} > 0 \ \text{ and } \ \sum_{s=1}^{5} y_{i,j,k,t+s} = 0 \\ 0 & \text{otherwise} \end{cases}$$

The results of these regressions are displayed in table 6. Panel (a) shows the results for all types of harmonization events whereas panel (b) focuses on contemporaneous ones and panel (c) on subsequent ones. We observe a positive impact on the extensive margin (net entry) which is driven by a reduction in exit rates which outnumbers the

reduction in entry rates. The intensive margin reacts positively to a harmonization event: on average, the mean growth rate is 1.1% higher in the five years following a harmonization event than in the five preceding years. Interesting results can be noted when differentiating between contemporaneous and subsequent harmonization events. In the case of the former, both producers in the exporting country as well as the importing country have to cope with a new regulation. A harmonization may therefore constitute a relative increase in barriers to trade. On the other hand, in the case of the subsequent harmonization, producers in the exporting country are already used to the standard and harmonization potentially allows them to profit from economies of scale or a reduction in information asymmetries, thus being equivalent to a reduction in trade costs. The results in panels b and c of table 6 confirm this line of interpretation: contemporaneous standardization leads to a reduction in the extensive margin (which is mainly driven by reductions in entry) whereas the intensive margin does not change significantly. However, in the case of subsequent harmonization, we observe an increase of the extensive margin (which is driven by higher entry) and increase of the intensive magi by 4.5%.

Table 6: Regression results: medium-term impact

(a) All harmonization events

	(1) Ext. margin	(2) Entry	(3) Exit	(4) Int. margin	(5) Price
Harm.	0.00085**	-0.00163***	-0.00221***	0.01097***	-0.00031
	[0.038]	[0.000]	[0.000]	[0.000]	[0.896]
Observations	9274320	10304800	10304800	5068766	5068766
R^2	0.22	0.30	0.30	0.31	0.30
Adjusted R^2	0.15	0.23	0.23	0.20	0.19

(b) Contemporaneous harmonization events

	(1) Ext. margin	(2) Entry	(3) Exit	(4) Int. margin	(5) Price
Harm.	-0.00170***	-0.00316***	-0.00079*	0.00022	-0.00227
	[0.000]	[0.000]	[0.050]	[0.947]	[0.360]
Observations	9274320	10304800	10304800	3941737	3941737
R^2	0.22	0.30	0.30	0.33	0.32
Adjusted R^2	0.15	0.23	0.23	0.22	0.20

(c) Subsequent harmonization events

	(1) Ext. margin	(2) Entry	(3) Exit	(4) Int. margin	(5) Price
Harm.	0.00090**	0.00158***	0.00031	0.00445*	0.00044
	[0.014]	[0.000]	[0.345]	[0.079]	[0.822]
Observations	9274320	10304800	10304800	4955806	4955806
R^2	0.22	0.30	0.30	0.31	0.30
Adjusted R^2	0.15	0.23	0.23	0.20	0.19

Notes: In brackets: p-values.

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Appendix

Table 7: International classification of standards (ICS)

ICS class	Description
1	Generalities. Terminology. Standardization. Documentation.
3	Services. Company organization, management and quality. Administration. Transport. Sociology.
7	Mathematics. Natural sciences.
11	Health care technology.
13	Environment. Health protection. Safety.
17	Metrology and measurement. Physical phenomena.
19	Testing.
21	Mechanical systems and components for general use.
23	Fluid systems and components for general use.
25	Manufacturing engineering.
27	Energy and heat transfer engineering.
29	Electrical engineering.
31	Electronics.
33	Telecommunications. Audio and video engineering.
35	Information technology. Office machines.
37	Image technology.
39	Precision mechanics. Jewelry.
43	Road vehicles engineering.
45	Railway engineering.
47	Shipbuilding and marine structures.
49	Aircraft and space vehicle engineering.
53	Materials handling equipment.
55	Packaging and distribution of goods.
59	Textile and leather technology.
61	Clothing industry.
65	Agriculture.
67	Food technology.
71	Chemical technology.
73	Mining and minerals.
75	Petroleum and related technologies.
77	Metallurgy.
79	Wood technology.
81	Glass and ceramics industries.
83	Rubber and plastic industries.
85	Paper technology.
87	Paint and colour industries.
91	Construction materials and building.
93	Civil engineering.
95	Military engineering.
97	Domestic and commercial equipment. Entertainment. Sports.
99	(No title)

Source: ISO

Database construction

The original data set comprises individual standards for which the date of release, the ICS class, the nationality of the standard-setting organization (SSO) as well as the duplicate versions in other SSO are known ("links" to other standards). We denote these duplicates as "equivalences". The nationality of an SSO can either be a country ("national") or a European or international SSO ("international").

A Linking all equivalent standards to one another

The original Searle Center Database explicitly comprises a column where standard equivalences are listed; these essentially represent accreditations of a previously released standard by another SSO or the simultaneous release of a standard by more than one SSO. However, due to misreporting or chronological reporting, a single standard observation does not necessarily reveal all equivalences. In the case of chronological reporting, only equivalences known at the time of the release are listed and subsequent equivalences are only reported for newly released standards. For these reasons, one may for example encounter the following situation:

Table 8: Example of incomplete equivalences

Standard ID	Release date	Nationality of SSO	Equivalence
A	01/01/2000	FR	B
B	05/06/2005	DE	A, C
C	31/07/2012	FR	
D	04/08/2008	AT	B

All four standards A, B, C and D are equivalent, but this is not obvious when examining standards individually due to the incompleteness of the equivalence listings (which are most likely due to the fact that they were recorded in chronological order, i.e. when standard B was released, standard D did not yet exist, which is why it is not explicitly listed under its equivalences). For the purpose of identifying the originating country, we need to have the full information on these equivalences to determine which of the standards A, B, C or D was first released (standard A in the above example), and thus represents the original standard. All other standards B, C and D are then classified as accreditations of standard A.[4]

We use graph theory to identify all standards that belong to one group by assigning them the same group identifier.[5] In particular, we use the following

[4]The accreditation of standard A due to the release of standard C is irrelevant information for our research question as it concerns a within-country accreditation; we will thus drop the observation on standard C in the final dataset.

[5]We particularly thank François Farago for helping us out with this procedure.

breadth-first search algorithm (which we specifically adapt to the structure of the dataset) to connect all standards by exploring their equivalences:

1. Initialize the group identifier, equal to a standard's row number in the dataset, for each standard.
2. Starting with $n = 1$, store the group identifier of standard n in the database (i.e. A).
3. Add the group identifiers of the equivalent standards, i.e. B, to the vector of stored group identifiers.
4. Note the smallest element of the vector of stored group identifiers.
5. Modify the group identifiers of standard n and its equivalent standards by assigning them the value identified in step 4 (i.e. A and B will have the same group identifier).
6. Delete the stored group identifiers.
7. Go on to the next standard $n + 1$ and repeat from step 2 onwards.

In order to minimize the computing power needed to run the algorithm, we use a simple hash function to build a dictionary of all standards whose IDs, which are strings, are mapped one-to-one to numeric values.

B Identifying "originating country" and "accrediting country"

Once all equivalent standards have been grouped together, we identify the "originating country" by the nationality of the SSO who first released the standard. The nationalities of SSOs who released equivalent standards at a later date are used to classify the "accrediting countries". As such, a standard should have one originating country and one or several accrediting countries.

However, it is also possible that two or more SSOs release a standard at the same date.[6] If one of the originating countries is an international SSO, we classify the originating country as being uniquely "international" (as it is very likely that the national SSO simply is a member organization of the international SSO and simply accredits standards of the international SSO at the same date as the latter

[6]This situation arises most obviously when the date of the release is exactly the same. However, for some standards, only the year of the release is known and in this case, two standards with the same release year will also be considered to have been released at the same date despite the fact that we cannot rule out the possibility that they were released at different dates over the course of the same year.

one releases the standard). If two national SSOs are releasing a standard at the same time, both nationalities are registered as originating and accrediting countries; the observation is thus counted twice for the stylized facts. We create an identifier for these observations in order to treat them differently in robustness checks.

C Obtaining the relevant sub-sample

We eliminate the following standards to obtain the relevant subsample of all standard harmonizations:

1. Standards that exist by themselves and are not linked to any other standard, meaning there is no other equivalent standard in the database.
2. Standards that constitute pure within-country accreditations or accreditations of a foreign standard after it was already accredited by another SSO of the same nationality.
3. Standards that are only accredited by SSOs of the same nationality.
4. Duplicate standards that share the following characteristics: date, nationality, ICS, group

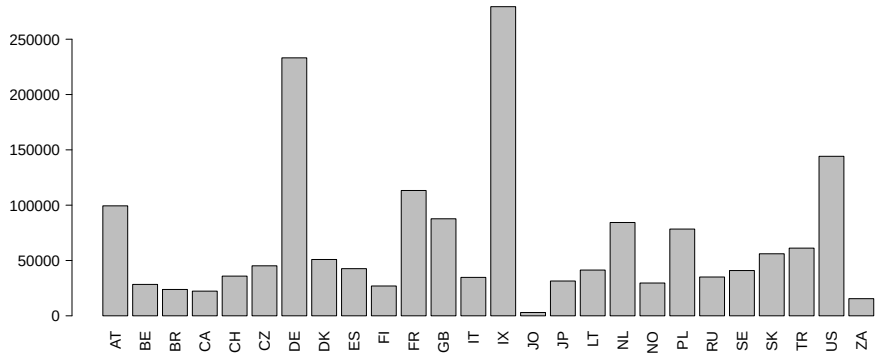
We also collect the number of purely national standards to compare cross-country accreditations against trends in national standard-setting. The appendix describes the dataset construction in more detail. The appendix also lists the country codes as well as the different industries ("ICS classes") which are organized according to the International Classification of Standards (ICS).

Table 9: Procedure to define subset of data

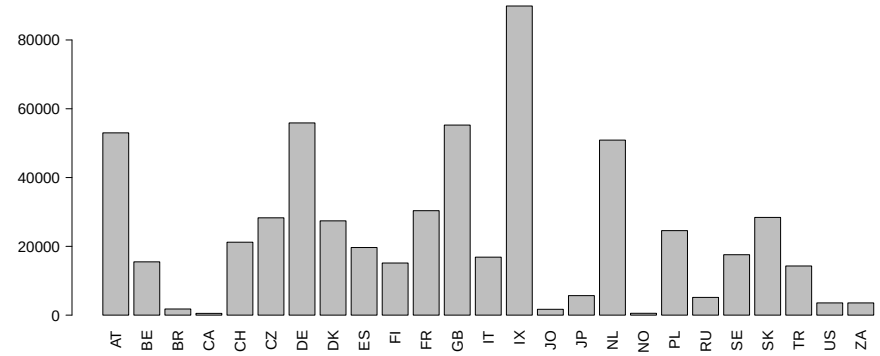
Initial number of standards	1744764
Standards that are not linked to other standards (step 1)	835152
Duplicate accreditations within one country (step 2)	229904
National original standards (step 3)	50382
Duplicate standards in terms of date, nationality, ICS, group (step 4)	42680
Remaining standards in database	586646
of which: original national standards	8154
of which: accreditations of national standards	42954
by national SSOs	37178
by international SSOs	5776
of which: original international standards	84101
of which: accreditations of international standards	451437

Figure 6: Country distribution before and after cleaning

(a) Raw data



(b) Relevant subset



Notes: The figure displays the number of standards, broken down by the nationality of the respective SSO. The data are summed over the years 1960–2015 and all ICS classes. Panel (a) displays the distribution based on the original dataset while panel (b) displays the distribution after the data have been cleaned according to the criteria described in this appendix.

Figure 6 (a) displays the country distribution of the raw data. We note the strong representation of Austrian, German and US standards. Besides the non-excludable possibility that these countries are very active in the standard-setting process, this could be due to more comprehensive reporting for the SSOs of these countries as well as the duplicate release of the same standard within one country due to institutional practices. Figure 6 (b) displays the country distribution of the relevant subset for our analysis and shows that the dominance of Austrian, German and US standards vanishes in the subsample.