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

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Abstract

Product standards are omnipresent in industrialized societies. Though standardization can be beneficial for *domestic* producers, divergent product standards have been categorized as a major obstacle to international trade. This paper quantifies the effect of standard harmonization on trade flows and characterizes the extent to which it changes the cost and demand structure of exporting. Using a novel and comprehensive database on cross-country standard equivalences, we identify standard harmonization events at the document level. Our results show that the introduction of harmonized standards increases trade through entry (extensive margin) and a larger sales volume of existing exporters (intensive margin). These findings are consistent with a multi-country heterogeneous firm model featuring endogenous standard adoption. Thanks to additional demand, standard harmonization raises firms' incentives to produce varieties in accordance with the standard despite high sunk investment costs. As a result, entry in foreign markets is encouraged and export sales of firms expand.

JEL-Classification: F13, F14, F15, L15

Keywords: Non-tariff barriers, international trade, standardization, harmonization

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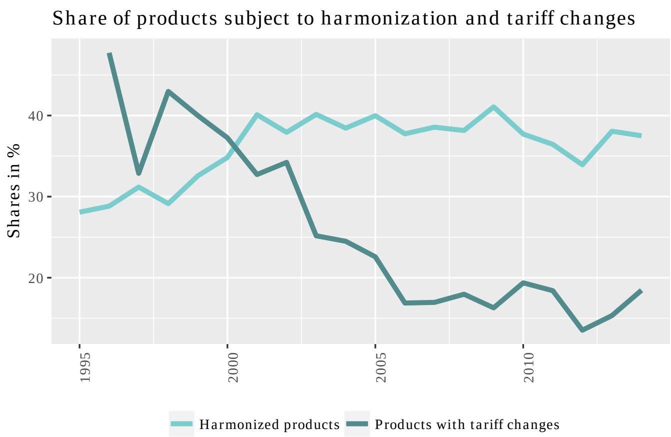
1 Introduction

Product standards are a defining feature of industrial processes and citizens' everyday life. From environmental or safety standards to technological standards that ensure the compatibility of different devices and inputs, standardization is widespread and affects production processes in virtually all industries (ISO, 2016). While standards assure a better synergy between inputs and products in a *domestic* context, they may constitute an obstacle for producers from countries that are not subject to the same standards.[1] Not surprisingly, product standards are therefore among the first to be listed as barriers to trade. Cross-country standard harmonization can be an effective trade policy tool to reduce these non-tariff barriers. However, such policies are subject to controversial debate, both in policy circles and among citizens.[2]

The empirical literature offers little guidance on the economic effects of standard harmonization. This is both due to data limitations and to econometric challenges (Goldberg and Pavcnik, 2016). To fill this gap, we track the accreditation of foreign and international standards by domestic standard setting organizations at the document level and construct a novel bilateral product-level database of standard harmonization capturing 82% of world trade. As figure 1 shows, *harmonized* standard releases are omnipresent and actually affect more products than traditional barriers to trade. In this paper, we provide new evidence on what this implies for international trade, both by quantifying the effect of standard harmonization on trade flows and by shedding light on the underlying economic channels.

Figure 1: Harmonizations vs. tariffs, 1995–2014



Notes: The figure displays the share of bilateral trade flows measured at the HS 4-digit level that are subject to standard harmonization or subject to tariff changes.

[1] See, for example, Fontagné *et al.* (2015) and Fernandes *et al.* (2017).

[2] The public protests against recent US-European free trade negotiations are one example of citizens' mobilization against policy efforts that concern product standards. For instance, 180,000–320,000 people protested against TTIP and CETA in Germany in September 2016.

To measure the impact of standard harmonization on international trade flows, we compare trade values of harmonized versus non-harmonized products following a difference-in-difference approach. Our results show that, on average, standard harmonization increases product-level trade flows by 0.67, which corresponds to a reduction of 2.1 percentage points in ad-valorem equivalents of tariffs. This marginal effect is amplified by the fact that close to 40% of bilateral product-level trade flows are subject to standard harmonization every year. Overall, we estimate the average increase in trade to be 0.26% per year, more than five times larger than the contribution of changes in tariffs.

How does the harmonized release of a standard affect trade flows? Do we see more trade because of a larger number of varieties traded (extensive margin), or because the sales of already exported product varieties increases (intensive margin)? Our results show that the change in trade flows is mainly driven by an increase in sales of existing varieties (74 percent), while the positive contribution of more entry is minor (26 percent). Decomposing the intensive margin into a price (unit value) and quantity component shows that the increase is mainly a result of more quantities being sold rather than a change in unit values.

To shed light on the underlying economic channels, we build a multi-country model of international trade with heterogeneous firms and allow for endogenous standard adoption, i.e. firms decide to produce a standardized or a non-standardized variety of a differentiated product. Product standards reduce information asymmetries and ensure the compatibility of inputs and devices, which increases consumers' demand. Producing the standardized variety requires sunk investment costs and higher marginal costs, which both increase in the severity of the standard.[3] The presence of sunk costs implies a selection effect where only high-productivity firms are able to produce in accordance with the standard while low-productivity firms choose to produce the non-standardized variety. The harmonization of a newly released standard increases the incentives for firms to adopt the standard, mainly by generating additional demand. Overall, the positive demand effect dominates the negative cost effect and more firms enter (higher extensive margin). Due to sunk investment costs, these firms need to produce at a larger scale implying that average sales per firms increase (higher intensive margin).[4]

In our model, standard harmonization essentially acts as a demand shifter. While standardization reduces negative externalities (see for example Costinot, 2008), there are additional demand effects when the standards in question are harmonized due to the reduction of information asymmetries or the creation of positive externalities such as network effects. To provide empirical support for this view, we corroborate

[3]These features are consistent with recent models on product standards, such as Mei (2017), as well as empirical evidence by Fontagné *et al.* (2015), Fernandes *et al.* (2017) and Macedoni and Weinberger (2018).

[4]These conclusions also hold in a model with regulatory standards, which obliges firms to produce a minimum level of product quality. Details of this version of the model are in the appendix.

our analysis with French firm-level data. While bilateral product-level data allow us to simultaneously control for sector-specific demand and supply effects, the interpretation of our results could be flawed by composition effects between firm and product entry within a sector. Running our baseline specification with the corresponding decomposition at the firm-level confirms our previous results. Firm-level sales increase, mainly through more quantities being sold. The increase in quantities despite a small increase in firm-level prices (unit values) supports our interpretation that the trade-inducing effect of standard harmonization stems mainly from increasing demand for the harmonized product (for example by reducing information asymmetries) rather than a reduction in variable trade cost (for example by facilitating border processing).

Concerning the robustness of our results, we first want to point out that trade policies almost always concern product standards, but not all product standards are formulated with a trade objective in mind. The standards in our database are released for a variety of reasons (such as to ensure the compatibility of technological devices or to address health concerns) and do not necessarily target exporters or importers. Hence, ex ante it is not clear that harmonization has a positive effect on trade flows. Still, our estimated results are subject to endogeneity concerns. We address these concerns in a number of robustness checks. First, we show that our difference-in-difference estimator does not pick up different pre-trends between harmonized and non-harmonized products. Second, we present evidence that our results are not driven by the fact that harmonization may primarily happen in product categories with larger trade flows. Lastly, we instrument country-specific harmonization events by accreditations of neighboring countries and take advantage of mandatory harmonization of supranational standards to mitigate the concern that special interest groups drive the results.

Standards can be found everywhere and are pivotal to the functioning of industrialized societies. As such it is not surprising that there is considerable debate over the degree of international cooperation in standardization (Bagwell and Staiger, 2001). On the one hand, this is due to fears over protectionism (Staiger and Sykes, 2011), be it murky or not (Baldwin and Evenett, 2011); on the other hand, country-specific preferences might be jeopardized for the sake of global economic efficiency (see Bown and Crowley, 2016, or Loeper, 2011, for a discussion). Yet, empirical evidence and theoretical contributions are scarce (Goldberg and Pavcnik, 2016; Ederington and Ruta, 2016).

This paper contributes to the literature on non-tariff barriers to trade by creating an extensive standard harmonization database covering every traded sector across 25 major economies. Current papers in the literature concentrate only on specific sectors, like Fontagné *et al.* (2015) who focus on Sanitary and Phyto-Sanitary (SPS) measures, Fernandes *et al.* (2017) who cover pesticide standards for agricultural and food products, Moenius (2006) who analyzes agricultural products or Reyes (2011) who looks at the harmonization of European product standards in the electronics sector. Exploiting a novel datatset, we are able to trace the complete history of a standard document and identify the respective product with a newly developed concordance table. The information for the concordance comes from the WTO notification of Technical Barriers to Trade (TBT) database, which we supplement using a keyword matching algorithm based on product and standard descriptions. The resulting comprehensive database on standard equivalences matched to bilateral product-level trade data allows us not only to improve in terms of coverage but also in terms of the identification strategy.

In general, the literature on standards as a non-tariff barrier to trade focuses on the economic effect of the *introduction* of standards on trade flows, see Swann *et al.* (1996) for the seminal contribution and Swann (2010) for a literature review. More recently, Fontagné *et al.* (2015) and Fernandes *et al.* (2017) analyze firm dynamics and show that restrictive regulatory standards have a detrimental impact on trade flows, but less so for larger (and presumably more productive) firms.

While it is not necessarily the severity of the standard that presents an obstacle to trade, it is actually the multiplicity of standards that impede trade (see the discussion in Ederington and Ruta, 2016). In addition, many provisions in product standards are of qualitative nature, thus making comparisons very difficult. In the empirical literature, there are a few notable exceptions that specifically analyze the effect of cross-country standard *harmonization* on trade flows. Chen and Mattoo (2008) use information on EU/EFTA harmonization and mutual recognition agreements and 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 and point out the trade-deflecting effect on South-South trade. Another study 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.

Finally, we contribute to the broad literature on quantifying the impact of non-tariff measures (NTMs) on international trade. International standards are an important component of non-tariff measures to trade, which have become the center of attention in the international trade policy discussion, see, for example, OECD (2005) and WTO (2012). With an average tariff of 1.5 percent on goods imported by developed countries in 2016 (see UNCTAD, 2016), estimates from recent studies (Kee *et al.*, 2009) suggest that NTMs are now the main trade barrier between countries. However, little is known about the economic channels of lowering these barriers. One example is Arkolakis *et al.* (2016), who use a structural micro-founded general-equilibrium model of multi-product firms to generate counter-factual predictions for how a reduction in market access costs (NTMs) affect trade patterns. Gandal and Shy (2001) study standardization policy and, similar to some of the economic effects we consider in this paper, take into account how governments' incentives are affected by "conversion costs" and network effects.[5] Mei (2017) studies the welfare implications of the introduction of product standards in a general-equilibrium framework and shows that international cooperation in standard-setting (i.e. harmonization) can improve welfare substantially. Similarly, Macedoni and Weinberger (2018) show that tighter product market regulation shifts production towards higher-quality firms, thus improving overall welfare. In this paper, we quantify the implied cost reduction of standard harmonization by computing industry-specific ad-valorem tariff equivalents. Our empirical estimates suggest that one harmonization event reduces market access costs equivalent to a 2.1 percentage point reduction in tariffs.

The rest of the paper is organized as follows. Section 2 explains the data and stylized facts on cross-country standard harmonization. Section 3 describes the correspondence table, while Section 4 discusses our empirical strategy and presents the main results. In section 5, we present a theoretical framework that we use to interpret the results and discuss the different expected effects of standard harmonization on trade. In section 6, we further investigate these economic channels while section 7 provides robustness checks. The last section concludes.

2 Cross-country standard harmonization and data

The conventional understanding of product standards in the literature on non-tariff measures considers these to be regulatory measures that are the result of government initiatives. However, standardization is not exclusively in the hands of regulators. On the contrary, industries and private firms organize themselves in standard-setting organizations (SSOs). Examples of such SSOs are ISO (International Organization for Standardization), IEEE (Institute of Electrical and Electronics Engineers) or DIN (Deutsches Institut für Normung – German Institute for Standardization). Many of those SSOs are non-profit, non-governmental organizations. SSO elaborate standards in working groups and technical committees which are composed of industry experts. For example, in ISO, there are technical committees on a variety of issues such as screw threads (ISO/TC 1), cosmetics (ISO/TC 217) or blockchain technologies (ISO/TC 307). The experts in those committees participate on behalf of private firms, non-governmental and governmental agencies. A SSO can release a standard developed by its own technical committee, but can also release a standard developed by another SSO. This is for example the case when a standard released by an international SSO such as the International Organization for Standardization (ISO) is published by a national SSO such as the British Standards Institution (BSI).

By definition, SSOs produce voluntary standards. These can become *de jure* binding when a governmental regulation references a standard. For example, the IEC (International Electrotechnical Commission) standard IEC 331:1970 that deals with

[5] We refer to "conversion costs" as sunk investment costs and summarize "network effects" under demand effects.

fire-resisting characteristics of electrical cables has been incorporated by reference into the U.S. Code of Federal Regulations. In addition, a large number of standards are *de facto* binding as market forces constrain firms in the production of goods. For example, consumers expect a printer to be compatible with A4 paper size (ISO 216:2007) or letter size (ANSI/ASME Y14.1) despite there being no official law on paper dimensions for printers.

We use the Searle Center Database for the construction of our database on standard releases and harmonization. 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 International Classification for Standards (ICS) category, the nationality of the SSO as well as the duplicate versions in other SSOs are known ("equivalences" with other standards). These equivalences constitute the core of our analysis. We define cross-country harmonization events as equivalent standards released by SSOs of different nationalities.[6] The nationality of an SSO can either be a country ("national") or an international SSO ("international").

In order to identify relevant harmonization events, we restrict the sample to those standards that constitute the first publication ("original") across all SSOs/nationalities as well as the accreditation of these original standards by another country (technically speaking, by a SSO of a nationality other than the one of the SSO that released the original standard). More details on the database construction can be found in appendix I.

Figure 2: Terminology

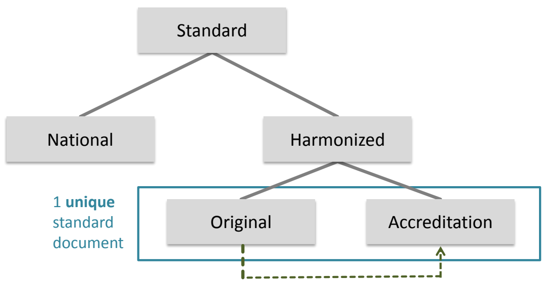


Figure 2 exemplifies the different types of standards and the terminology we use in the remainder of this paper to designate them. A standard document can either be a national standard, meaning that it was released by a national SSO and never accredited by a SSO of another nationality, or a harmonized standard, meaning that at least two versions of the same unique standard document have been released by at least two SSOs of different nationality. Over the time period we consider in

[6]In the data, we code harmonization as follows: a SSO of the importing country releases a standard that was also released by a SSO of the exporting country (either in the same year or before). See appendix IV.

the empirical part of this paper (1995–2014), there were a total of 566084 national standard releases and 530645 releases of a harmonized standard. Thus, we first note that a considerable amount of a country's product standards is harmonized.

In terms of cross-country differences, we distinguish between the issuer of an original standard release and the accreditor of an existing standard release. 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 an "accreditation". As such, a standard can be accredited by more than one SSO of different nationalities. Indeed, on average, a harmonized standard is accredited by 6.4 countries. There are two means via which product standards are harmonized across countries. Either a SSO decides to accredit the standard of a SSO of another nationality ("bilateral standard harmonization") or two SSOs of different nationality accredit a standard originating in an international SSO ("international standard harmonization").

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. 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 1: Means of accreditation: bilateral vs. international

Number of standards in subset	695724	in %
of which: original bilateral standards	10541	1.5
of which: accreditations of bilateral standards	45493	6.5
of which: by national SSOs	39885	5.7
of which: by international SSOs	5608	0.8
of which: original international standards	98987	14.2
of which: accreditations of international standards	540703	77.7

The International Classification for Standards (ICS) allows us to categorize each standard to a specific class.[7] Table 2 shows that cross-country standard harmonization is very prevalent in materials technologies, electronics and ICT as well as engineering technologies. We note that standardization is common in all types of industries and, compared to the primary concern of the trade literature on NTMs, extends beyond

[7]See the table in the appendix for the first level of disaggregation of the ICS.

health, safety and environmental concerns. SSOs constantly update their standards in order to reflect state-of-the-art technology. Many standards are released in bundles whenever they concern interrelated issues and are often categorized in several ICS classes. As a result, thousands of standards are released each year. For example, in 2017, ISO alone released over 1500 standards.

Standards have a large range of economic effects, however, there exists no official categorization of the different standard types.[8] The literature usually distinguishes between quality standards (where quality is defined in a large sense and also comprises product attributes such as safety aspects or environmental concerns), compatibility standards (which ensure the interoperability of devices and compatibility of inputs), conformity assessment or testing standards (which describe the procedures by which producers must prove that their product complies with regulatory provisions), standards whose aim it is to reduce variety (to allow for economies of scale) and standards whose basic goal it is to provide information and technical details. Of course, a certain standard can be categorized into more than one of these types and the standards in our database actually often fulfill several of these purposes.

Table 2: Releases of harmonized standards, by major ICS categories

Field	Number	in %
Agriculture and food technologies	34818	3.3
Construction	99263	9.4
Electronics, information technology and telecommunications	172479	16.3
Engineering technologies	188497	17.8
Generalities, infrastructures and sciences	121210	11.4
Health, safety and environment	115374	10.9
Materials technologies	178873	16.9
Special technologies	37212	3.5
Transport and distribution of goods	111945	10.6
Total	1059671	100

Notes: The Table displays the number of standard releases, 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, infrastructures 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]. A number of standards belongs to more than one ICS class (disaggregated at the 5-digit level). The data are summed over the years 1960–2018 and all SSOs.

After merging the data on harmonization with data on trade flows, we obtain our final dataset which varies by exporter, importer, product (HS 4-digit level) and year. We observe that 36% of all exporter-importer-product-year observations are subject to harmonization. Restricting to those trade flows that are strictly positive, this fraction increases to 45%. For the empirical exercise, we do not exploit whether a product traded between exporter and importer is subject to the harmonization

[8] See for example the discussion in Swann (2000).

of one standard or several standards at once. To keep things simple, we define a harmonization event as the situation where at least one standard that applies to a HS 4-digit-level product was harmonized between the exporter and the importer. However, as standards are often released in bundles (especially when they concern interconnected technologies), the actual median number of harmonized documents per harmonization event is 3 (the distribution is highly skewed, displaying a mean of 12). 88% of all harmonization events comprise at least one harmonization of an international standard whereas 44% concern at least one standard that originally originated in a national SSO.

Regarding trade policy efforts, a reduction in non-tariff barriers due to diverging product standards can mainly be brought about by standard harmonization or mutual recognition. While some of the harmonization events in our database are the result of explicit trade policies aiming to reduce non-tariff barriers to trade, many are simply the result of the international dimension of standardization where industries, both through government initiatives and privately, organize themselves beyond national borders. Mutual recognition, on the contrary, is always explicitly put in place in order to facilitate trade. We are not able to identify mutual recognition events in the data. As described in Maur and Shepherd (2011), mutual recognition largely concerns conformity assessment procedures (for health, safety or environmental concerns); the standard harmonizations in our database address every possible aspect of product market regulations, thus also treating aspects that are not of regulatory nature. Most importantly, however, mutual recognition does not address the reduction of negative externalities, for example when goods are not compatible with each other or information asymmetries about the specifics of the exported goods are high. Indeed, Costinot (2008) shows that mutual recognition can result in too little standardization whenever there are important negative externalities. Harmonization specifically addresses the multiplicity of standards and therefore results in different costs and consumer utility (demand effects) than mutual recognition.

3 Concordance table

Before presenting the empirical framework, we want to point out that as key identification issue in quantifying the impact of standard harmonization on international trade is linking the standard documents to their corresponding products. The International Standard Classification (ICS) system groups standards according to economic sector, the underlying technology or activity such as environmental protection, safety assurance or protection of public health. On the other hand, products in international trade data are categorized according to the Harmonized System (HS) established by the World Customs Organization (WCO).

The HS nomenclature follows trade policy concerns such as tariffs and not necessarily the production characteristics of the product. The non-existence of a concordance is one of the main reasons why previous paper in the literature cover only certain industries, see Moenius (2006), Reyes (2011) or Fontagné *et al.* (2015). This paper tackles the concordance issue in two ways. First, we use a newly developed concordance table from the World Trade Organization (WTO) with the drawback that some links between key standard categories and products are missing. As a second step, we develop an alternative all-industry concordance table using keyword matching techniques. We briefly describe both approaches below.

3.1 Concordance table based on WTO's TBT IMS database

The WTO concordance 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.[9] 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 4-digit HS code (in some instances the 2-digit or the 6-digit codes) of the products on which the measure is applied.

All the notified relationships between HS and ICS classes for the period 2000 to 2016 amount to 3775 notifications, of which several mention one or more HS and ICS classes. There are a total of 2391 links between HS and ICS and these make up 0.5% of all possible links. 32% of the identified relationships cover multiple relationships and lead to a many-to-many concordance. One of the drawbacks of this concordance table is potential underreporting because there will only be links for those HS-ICS relationships for which there was actually a notification at the WTO. In addition, there might be biased reporting as WTO members have different incentives to report to the WTO depending on the importance of the export and import flows pertaining to a particular product.

3.2 Concordance table based on keyword matching

Although the inclusion of fixed effects will alleviate part of these concerns, identification concerns of neglecting key standard-product links remain. To mitigate this concern, we construct another concordance table based on keyword matching techniques described in a companion paper (Han *et al.*, 2017). The main idea is to use keywords describing individual standards (obtained from the German Institute for Standardisation DIN, Deutsches Institut für Normung e.V.) and match them with keywords extracted from the descriptions of the product categories in the Harmonized System.

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

The first step reduces the set of keywords via a stemming algorithm. We consider only the present tense of a verb and the singular of a noun. After having unified each word, a keyword algorithm extracts all the keywords from the HS and ICS classification and attaches an importance weight to each of them. The importance weight is defined by the combination of the inverse-document frequency (how distinctive is the word in the overall classification scheme) and the term-frequency (how distinctive is the word in the respective standard or product category). The list of all links between the two classification systems consists of standard-product category pairs that have at least one keyword in common and pass a threshold value of the importance weights.

We obtain a concordance table with 61062 links between ICS and HS (12% of all possible links) and replicate 66% of the links identified via the WTO notifications data. Given that the quality of the match is not as good as the one by the WTO (which is based on human knowledge), we use this table as a robustness check. The advantage of the keyword matching algorithm is that it is unbiased and comprehensive.

Both concordance tables create links between the 5-digit ICS standard categories and 4-digit HS product categories. We link the standard harmonization events at the country-pair level to the corresponding product and sum all harmonization within a 4-digit HS product. The empirical results in the following section are all based on this level of aggregation.

4 Empirical results

The international trade data used in our empirical regressions is the BACI database developed by the CEPII, see Gaulier and Zignago (2010). BACI reconciles export and import declarations of values and volumes in the United Nations COMTRADE database by giving precedence to countries with more reliable trade statistics. The data cover the years 1995 to 2014 and include 5,000 HS 6-digit product categories for more than 160 countries. In our analysis we work on the HS 4-digit level (1250 different categories) and use the disaggregate HS 6-digit level to measure product entry (extensive margin) and average sales (intensive margin) within a HS 4-digit sector. The total sample size consists of all bilateral industry linkages between the 26 countries for the period 1995-2014 and results in 6.7 million observations with a positive trade flow.

4.1 Econometric specification and definitions

The model introduced in section 5 derives the following reduced-form regression equation to estimate the effect of standard harmonization on international trade:

$$\log(X_{ijkt}) = \beta h_{ijkt} + f_{ikt} + f_{jkt} + f_{ijt} + f_{ijk} + \varepsilon_{ijkt} \tag{1}$$

Bilateral trade flows (exports of products in industry k from country i to country j at time t), X_{ijkt}, are a log-linear function of standard harmonization, h_{ijkt}, as well as a number of fixed effects. In particular, we include product-specific supply effects, f_{ikt}, and product-specific demand effects, f_{jkt}, time-invariant exporter-importer-product effects, f_{ijk} as well as time-varying shocks that affect both importer and exporter, f_{ijt}. This set of fixed effects ensures that the identification in equation 1 is entirely coming from within-bilateral-product variation and unrelated to product-specific supply and demand shocks. In all regression specifications, standard errors are clustered at the exporter-product-level.

The identification of the impact of standard harmonization on trade relies on a difference-in-difference approach with multiple treatment. h_{ijkt} is a dummy variable which equals one whenever there is at least one standard that the importing country j harmonizes with the exporting country i in product k at time t. The dummy remains one until the end of the sample period, except if there is an additional harmonization event in the same product category between the same countries. In this case, the dummy takes the value two from the year the second harmonization event took place. In the possible case where a product is harmonized every period the dummy variable h_{ijkt} takes the value 20 in the last sample period.

Next, we decompose the bilateral trade flow into the product of the extensive and intensive margin. The decomposition sheds light on the underlying channel through which standard harmonization affects bilateral trade. According to our theoretical framework (see summary in table 9), changes in the average sales per product (intensive margin), which we define as the average trade value per 6-digit HS product ($\bar{x}_{ijkt} = X_{ijkt}/N_{ijkt}$), are informative about the presence of fixed costs of exporting or sunk investment costs. Correspondingly, changes in product entry (extensive margin), defined as the number of unique 6-digit HS products (N_{ijkt}), also pick up changes in bilateral product demand or changes in variable trade costs. In line with section 5, we further decompose the intensive margin into the average price per HS6-product ($\tilde{p}_{ijkt}$) within one HS4-industry and a quantity ($\tilde{q}_{ijkt}$) component.[10] Given these definitions, the complete decomposition equals:

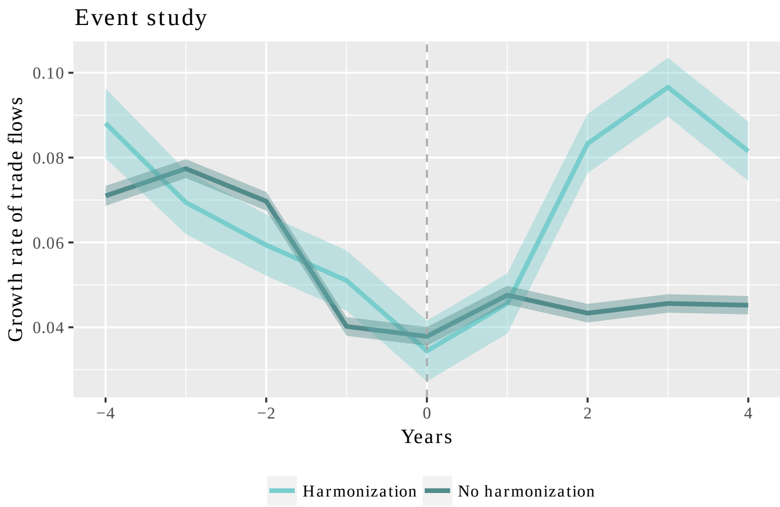
$$X_{ijkt} = N_{ijkt}\bar{x}_{ijkt} = N_{ijkt}\tilde{p}_{ijkt}\tilde{q}_{ijkt} \tag{2}$$

All dependent variables are included in logs.

Before discussing the empirical results, we want to stress that even though the Searle Center Database is a comprehensive database covering the most important industrialized countries we cannot exclude underreporting for specific countries and Standard Setting Organizations (SSOs). In the regression analysis, we therefore consistently use fixed effects to minimize the risks from underreporting. With regards to trade integration, we hypothesize that the explicit release of another country's

[10]We use information on kilograms to compute quantities.

Figure 3: Growth of trade flows around harmonizations



Notes: This figure plots the mean growth rate before and after a harmonization event for harmonized trade flows (treatment group) and non-harmonized trade flows (control group). Only the first harmonization event for each exporter-importer-product-combination is considered. The control group only comprises exporter-importer-product-combinations that were never harmonized. The point 0 denotes the timing of the event. The sample covers the years 1999–2010 and has been restricted to only include observations with positive trade flows in the preceding four years. Growth rates below the 2.5th and above the 97.5th percentiles are excluded from the calculations.

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. Our results should thus be interpreted as pertaining explicitly to *formal* harmonization.

4.2 Baseline results

Standard harmonization is generally associated with a positive overall impact on trade flows. A first glance at the data confirms this intuition. We plot the average growth rate of trade flows before and after an harmonization event in figure 3 and compare this growth rate to trade flows that were never subject to standard harmonization. One notices a significantly higher growth rate for bilateral exports after the importer accredited a standard from an exporter. Before the harmonization event, we do not obverse any significant differences in the growth rates between the treatment ("Harmonization") and the control group ("Non-harmonization").

To provide more formal evidence on the relationship plotted in figure 3, we start by running regression equation 1 without fixed effects and then progressively add fixed effects that control for time-varying exporter-importer fixed effects as well as time-varying product-specific supply and demand factors. Column (1) in table 3 presents the results from the baseline regression without fixed effects, column (2) the results with three-way fixed effects with the exception of exporter-importer-product

Table 3: Regression results / Adding fixed effects

	(1) Total	(2) Total	(3) Total
Harm.	0.09713***	0.02852***	0.00667***
	[0.000]	[0.000]	[0.000]
Observations	5919911	5887705	5848622
R^2	0.02	0.76	0.88
Adjusted R^2	0.02	0.72	0.85
ijk-FE	No	No	Yes
ikt-FE	No	Yes	Yes
jkt-FE	No	Yes	Yes
ijt-FE	No	Yes	Yes

Notes: Regression of log total trade flows on harmonization indicator. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

fixed effects as well as the full battery of fixed effects shown in column (3). The dependent variable is total trade flows.

Table 3 confirms the suggested positive effect of harmonization on trade flows in figure 3. The harmonization coefficient is positive and significant in all specifications, although the magnitude of the coefficients decreases when adding fixed effects. Controlling for product-specific demand and supply factors reduces the coefficient by a fourth compared to the specification without fixed effects ((1) vs. column (2)). Including exporter-importer-product fixed effects are equally important and reduce the coefficient further from 0.028 in column (2) to 0.0067 in column (3). Still, the estimated coefficient is significant at the 1 percent level and suggests that, on average, a harmonization event increases trade flows by 0.67%.

Table 4: Regression results / Baseline specification

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00667***	0.00176***	0.00491***	-0.00407***	0.00898***
	[0.000]	[0.000]	[0.002]	[0.000]	[0.000]
Observations	5848622	5848622	5848622	5848624	5848624
R^2	0.88	0.90	0.86	0.85	0.86
Adjusted R^2	0.85	0.87	0.82	0.81	0.83

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

Table 4 decomposes the overall trade flows into the extensive (column (2)) and the intensive margin (column (3)). The latter is then further decomposed into price (column (4)) and quantity (column (5)) contributions. The results suggest that the overall effect is entirely driven by the intensive margin, which itself is driven by an increase in quantities, which outnumbers the decrease in prices. The response of the extensive margin is positive, but considerably smaller in magnitude than the response of the intensive margin. In light of the discussion in section 5, the increase in the intensive margin is associated with an increase in sunk investment costs. Firms have to produce on a larger scale in order to cover sunk investment costs that arise in response to the new regulation. At the same time, the increase of the extensive margin indicates a simultaneous reduction in variable costs or higher product demand that counteract the detrimental effect of this higher entry barrier.

4.3 Ad-valorem equivalents

The results from our baseline regression suggest that a harmonization event increases trade flows, on average, by 0.67%. But how does this increase in trade flows compare to observable changes in trade costs? To answer this question, we calculate the average ad-valorem equivalent (AVE) of tariffs following Kee and Nicita (2016). They define the ad-valorem equivalent (AVE) in non-tariff measures (in our case standard harmonization) as the equivalent of the ad-valorem tariff that induces the same proportionate change in the quantity traded

$$AVE = \frac{(\exp(\beta_2) - 1)}{(\exp(\beta_1) - 1)} \tag{3}$$

where β_1 and β_2 are the estimated coefficients from a quantity regression that includes the average tariff rate (t_{ijkt}) at the 4-digit HS level as a control variable. The advantage of this definition of AVE is that we do not need to know the sector specific import demand elasticity (σ_k).[11] Including the full set of fixed effects, the corresponding estimation equation is written as:

$$\log(q_{ijkt}) = \beta_1 \log(1 + t_{ijkt}) + \beta_2 h_{ijkt} + f_{ikt} + f_{jkt} + f_{ijt} + f_{ijk} + \varepsilon_{ijkt}. \tag{4}$$

We use these regression coefficients in combination with the "delta method" to compute the point estimate of the AVE together with the standard errors. Table 5 shows the regression output. Note that the number of observations compared to the baseline regression drops because of missing information on tariff rates for some data points. The estimated coefficients change only slightly but are not significantly different from the baseline.

[11] As Kee and Nicita (2016) note, there are other ways of to define AVEs, such as the equivalent tariff that induces the same change in quantities imported, or the equivalent tariff that induces the same rate ratio change in quantities imported. Kee *et al.* (2009) define the corresponding AVE for those cases as follows:

$$AVE_k = \frac{(\exp(\beta_2) - 1)}{\sigma_k}$$

where β_2 is the estimated coefficient of the standard harmonization variable and σ_k the sector specific import demand elasticity.

Table 5: Regression results / Controlling for tariffs

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00491***	0.00121***	0.00371**	-0.00406***	0.00777***
	[0.008]	[0.002]	[0.033]	[0.001]	[0.000]
Ln(1+tariff)	-0.66319***	-0.04247**	-0.62072***	-0.15388***	-0.46684***
	[0.000]	[0.014]	[0.000]	[0.002]	[0.000]
Observations	4692971	4692971	4692971	4692973	4692973
R^2	0.89	0.91	0.87	0.87	0.88
Adjusted R^2	0.86	0.88	0.83	0.83	0.84

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator and tariffs. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

Table 6: AVEs

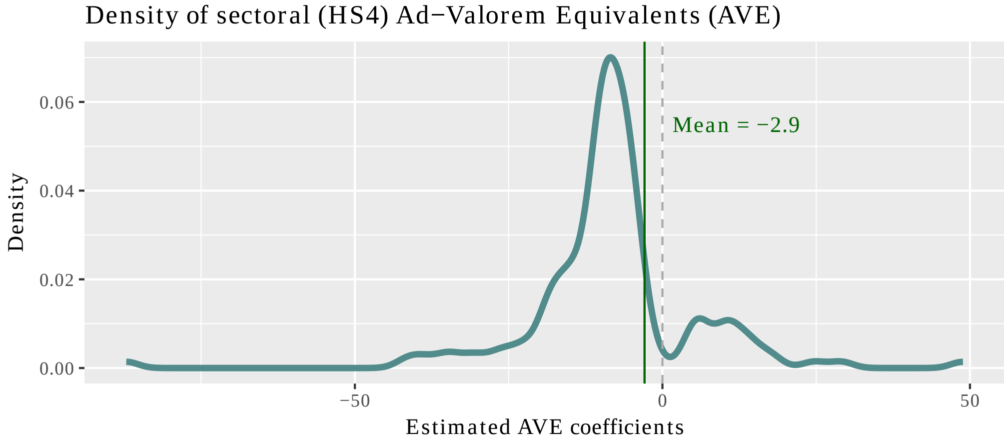
	(1) Quantity
Harm.	0.00777***
	[0.000]
Ln(1+tariff)	-0.46684***
	[0.000]
Observations	4692973
R^2	0.88
Adjusted R^2	0.84
Ad-valorem equivalent tariff	-2.090***
	[0.002]

Notes: Regression of log quantities on harmonization indicator and tariffs. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels. The AVE tariff is calculated according to Kee and Nicita (2016).

What is the hypothetical percentage change in the tariff rate that would yield the same effect as a harmonization event? In the bottom line of table 6, we present the ad-valorem equivalent from the quantity regression. The increase in traded quantities after a standard harmonization event can be associated with an equivalent tariff reduction of 2.09 percentage points.

The AVE estimate in table 6 is an average and masks significant heterogeneity across the 1250 different 4-digit HS products. For this reason, we first estimate equation 4 on the level of each individual HS 4-digit product and include exporter, importer and time fixed effects. Second, we substitute the obtained product-specific coefficients for tariffs and the harmonization dummy into equation 3 and compute the corresponding AVE.

Figure 4: Ad-Valorem Equivalents (AVE)



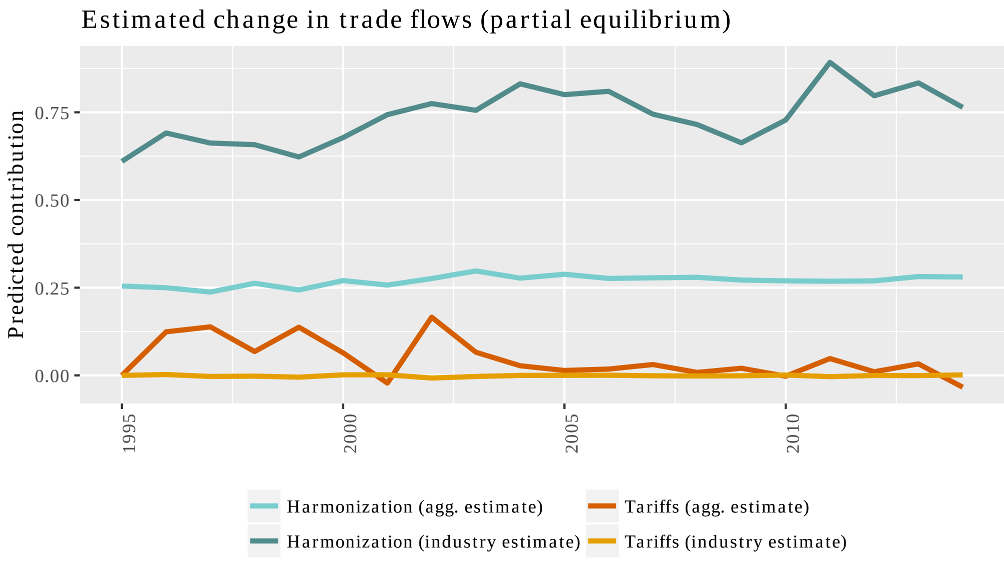
Notes: This figure plots the kernel density estimate of the product-specific AVE estimates at the HS 4-digit level. Only statistically significant AVE estimates are included in the plot. The vertical line displays the mean AVE estimate (taking into account both statistically significant and not significant AVE estimates).

Figure 4 shows that for the majority of industries a standard harmonization is equivalent to a reduction in tariffs (observations with a negative AVE coefficient). However, for 46% of the industries we find that a standard harmonization is associated with an increase in tariffs, however, of these, only 6% are statistically significant. For the 54% of industries where standard harmonization corresponds to a tariff reduction, 25% are statistically significant. Overall, the cross-industry average AVE is -2.9% and slightly higher in magnitude compared to our average estimate from the full sample.[12]

Next, we use the point estimates of the harmonization indicator to calculate the implied increase in trade flows among the countries in our sample which is due to harmonization. We simply multiply the harmonization dummy with either (1) the point estimate in column (1) of table 4 or (2) the sectoral point estimates used to construct figure 4 and calculate the trade-weighted average increase in trade flows between the countries in our sample. Figure 5 plots the resulting estimated increase due to standard harmonization for both set of estimates. Based on the aggregate coefficient ("agg. estimate"), the implied increase is 0.27%, while the sectoral coefficients imply an increase of 0.74% of trade flows ("industry estimate"). Given that the average growth rate of trade in our sample is 5.9%, these estimates suggest that up to 12.5% of this increase is due to standard harmonization. The reason for this considerable change in trade despite the low point estimates is that 44% of our products are harmonized within a given year. For comparison, we also include the implied change in trade flows due to tariff changes. The implied increase in trade flows is smaller, amounting to only 0.05% ("agg. estimate"). Overall, these

[12] The detailed list with industry-specific AVEs and their confidence intervals can be downloaded from the authors' websites.

Figure 5: Increase in trade flows due to standard harmonization



Notes: This figure plots the contribution of standard harmonization and tariff changes to the growth rate of trade flows among the countries in our sample. The estimates are based on a regression of total trade flows on standard harmonization and tariffs.

estimates reveal that standard harmonization among the industrialized countries in our sample contributed significantly more to higher trade flows compared to trade barriers such as tariffs.

4.4 Multiple harmonization events

In contrast to most difference-in-difference setups, each exporter-importer-product-triplet can be subject to multiple treatments over the time period in question. The baseline specification estimates the marginal effect of a standard harmonization on trade flows relative to non-harmonized flows assuming that this effect is constant. However, the positive effects of standard harmonization might take time to materialize. For this reason, we consider a non-parametric specification, where we allow the marginal effect to depend on the number of times a product experienced a harmonization event. The corresponding regression specification looks as follows, where the subscript n indexes the n-th harmonization:

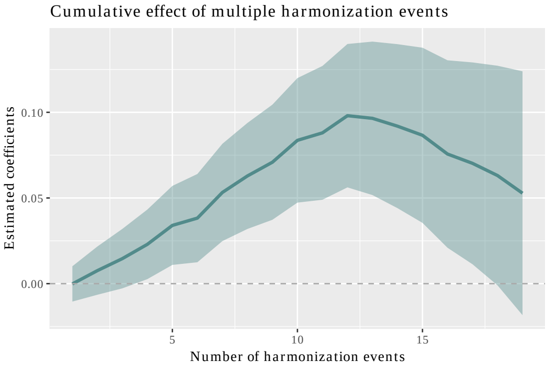
$$\log(X_{ijkt}) = \sum_{n}^{20} \beta_n h_{n,ijkt} + f_{ikt} + f_{jkt} + f_{ijt} + f_{ijk} + \varepsilon_{ijkt} \tag{5}$$

The dummy $h_{n,ijkt}$ equals 1 if a product was n times harmonized and zero otherwise. The variable measures the difference in the average trade flow of a product that was n times harmonized compared to a product that was never harmonized.

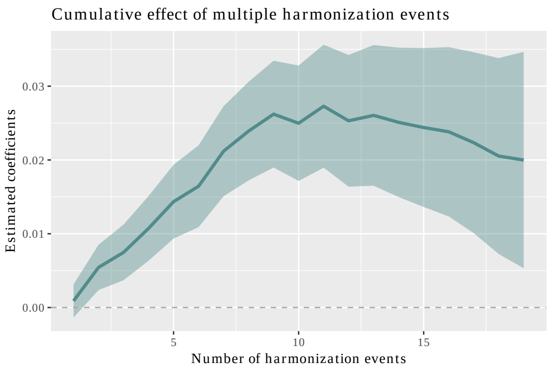
Figure 6 plots the coefficients β_n from the above specified regression set-up together with the 95 percent confidence interval. Panel a shows that the marginal

Figure 6: Cumulative effect of multiple harmonization events

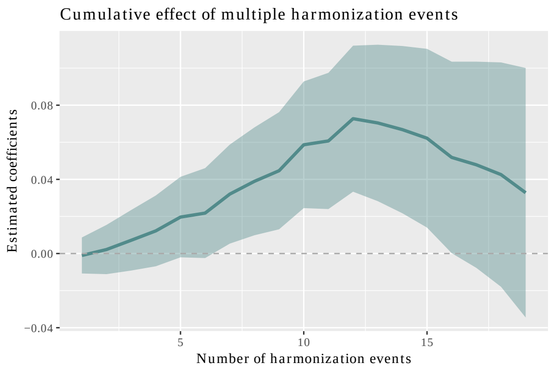
(a) Total flows



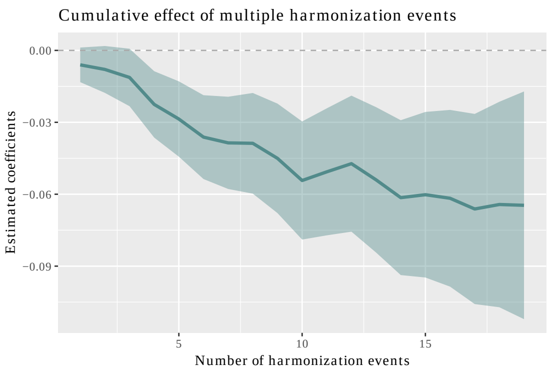
(b) Extensive margin



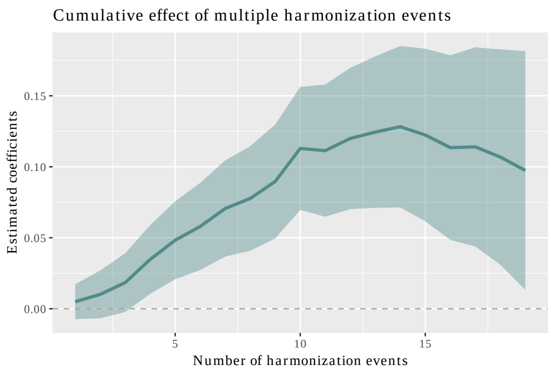
(c) Intensive margin



(d) Price



(e) Quantity



Notes: The figure display the coefficient estimates of a regression of the respective dependent variable (designated in figure subtitles) on dummies for each subsequent harmonization within an exporter-importer-product triplet (regression specification 5). Shaded regions represent 95% confidence intervals.

effect of standard harmonization on trade flows is more or less constant in the number of harmonization events (up to 12-13 events) with each subsequent harmonization contributing a similar positive amount to overall trade flows. Afterwards the additional effect declines slightly, but the overall effect remains positive. The effects for the extensive margin (panel b), the intensive margin (panel c) and quantities (panel e) mirror the baseline results. The price response shows a steadily negative response.

Taken together, our empirical results suggest that standard harmonization has a significant and positive effect on trade flows in terms of the number of harmonization events. The increase in trade flow operates mainly through higher average product sales (changes in the intensive margin) brought about by a larger trading volume (quantities) while prices decline. The effect of product entry (extensive margin) on overall trade flows is only minor. If we interpret these findings in light of our theoretical framework, the results suggest that standard harmonization leads to an increase in fixed costs due to higher sunk investment costs and, simultaneously, generates additional product demand and/or a reduction in variable trade costs. To shed more light on the contribution of the latter two, we turn to firm-level data and discuss the results in the next section.

5 Model

This section describes a theoretical framework that helps us shedding light on the underlying economic channels of standard harmonization. We start by modeling the impact of a standard introduction on firms' decisions and on the different margins of the gravity equation in line with recent empirical evidence. Within this framework, we then attribute changes in cost and demand parameters that reconcile the model with our empirical evidence in section 4 as suggestive evidence about the economic channels of standard harmonization.

5.1 Theoretical framework

Our theoretical framework is a modified version of the Melitz (2003) framework and borrows from Flach and Unger (2018). Heterogeneous firms face a sector k specific CES demand elasticity, fixed costs of exporting from country i to country j, as well as variable iceberg trade costs. There are three demand elasticities. The first one is the aggregate elasticity across industries which is equal to one. The second elasticity is γ_k and describes the elasticity of substitution across consumption baskets from different exporting countries and the third one, σ_k, denotes the elasticity of substitution between different industry-specific varieties. Quantities exported from country i to country j in sector k are denoted by c_{ijk}. (This includes domestically produced goods c_{ijk}.) Industry specific bilateral quantities are given by:[13]

$$\max_{c_{ijk}(\omega)} C_{ijk} = \left[\int_{\omega \in \Omega_{ijk}} \left(d^z_{ijk}(\omega) \right)^{\frac{1}{\sigma_k}} \left(z_{ijk}(\omega) c_{ijk}(\omega) \right)^{\frac{\sigma_k - 1}{\sigma_k}} d\omega \right]^{\frac{\sigma_k}{\sigma_k - 1}} \tag{6}$$

where z_{ijk} denotes the introduction of new product market regulation in the form of a product standard in sector k between countries i and j. It represents product attributes such as technical specifications, environmental regulation, health or safety requirements and is expressed in terms of demand equivalents. In this version of the model, the standard introduced by i and j concerning product k is not mandatory. Firms have the choice to produce freely (which is equal to the case $z_{ijk} = 1$) or to produce according to the new standard ($z_{ijk} > 1$).[14] Demand shocks d^z_{ijk} affect only the standardized varieties of a particular sector k and account for any potential positive externalities that the introduction of standards can have on consumer demand, for example, through the reduction of information costs. Across exporting countries, quantities are aggregated via CES:

$$Q_{jk} = \left[\sum_{k=1}^{N} C_{ijk}^{\frac{\gamma_k - 1}{\gamma_k}} \right]^{\frac{\gamma_k}{\gamma_k - 1}} \tag{7}$$

where γ_k is the elasticity of substitution across countries. We assume that demand for goods produced in different sectors k is determined by the following utility function:

$$U_j = \sum_{k=0}^{K} \beta_k \log Q_{jk} \quad , \qquad \sum_{k=0}^{K} \beta_k = 1 \ , \quad \beta_k > 0 \tag{8}$$

Consumers in country j maximize their utility to obtain: (1) industry-specific demand (C_{jk}), (2) bilateral demand for products from exporter i in industry k (C_{ijk}) and, finally, (3) demand for variety specific exports from country i to country j in sector k given by:

$$c_{ijk}(\omega) = A_{ijk} z_{ijk}^{\sigma_k - 1}(\omega) p_{ijk}^{-\sigma_k}(\omega) \tag{9}$$

where $X_{ijk} P_{ijk}^{\sigma_k - 1} = P_{ijk}^{\sigma_k - \gamma_k} A_{jk}$ summarizes destination specific industry demand and

[13] With respect to the empirical exercise, we think of a sector k as a HS 4-digit category in the trade data.

[14] In the appendix, we assume that the implementation is mandatory and show that the main messages of the model hold in a model where firms can choose their optimal level of the product attribute but have to produce at least the level z_{ijk}.

the corresponding price index, which is defined as follows:

$$P_{ijk} = \left(\int_{\omega \in \Omega_{ij}} d^z_{ijk}(\omega) \left(\frac{p_{ijk}(\omega)}{z_{ijk}} \right)^{1-\sigma_k} d\omega \right)^{\frac{1}{1-\sigma_k}} \quad (10)$$

Firms maximize profits by choosing prices given the product regulation z_{ijk}. Firm costs are affected by z_{ijk} in two ways. First, the implementation of a new product standard z_{ijk} necessitates sunk investment costs $z^{a_k}_{ijk}$. These capture the idea that a new product standard requires firms to change existing production structures to adapt to the new regulation (Shepherd, 2007). Second, marginal production costs $z^{t_k}_{ijk}$ also depend on the stringency of the product attribute. Note that the choice of functional forms for sunk investment costs and marginal productions costs are similar to Flach and Unger (2018). However, the model is flexible and its predictions do not depend on these specific choices.[15] Firms differ in their productivity φ to produce their respective variety. They face variable iceberg costs of exporting τ_{ijk} as well as fixed costs of exporting f_{ijk}. The superscript z denotes costs for firms producing a standardized variety, while the cost parameters without superscript designate firms that produce the non-standardized variety. Firms' profit maximization problem is as follows:[16]

$$\max_{p_{ijk}} \pi^z_{ik}(\varphi) = \sum_{j=1}^{I} p_{ijk} c_{ijk} - \frac{\tau^z_{ijk} z^{t_k}_{ijk}}{\varphi} c_{ijk} - f^z_{ijk} - z^{a_k}_{ijk} \quad (11)$$

The parameter t_k captures the elasticity of marginal costs with respect to the standard. Firms then choose their optimal price given the product standard, demand and their idiosyncratic productivity:

$$p^z_{ijk}(\varphi) = \frac{\sigma_k}{\sigma_k - 1} \frac{\tau^z_{ijk} z^{t_k}_{ijk}}{\varphi} \quad (12)$$

Substituting for product demand and the optimal price, we obtain firm sales:

$$x^z_{ijk}(\varphi) = d^z_{ijk} P^{\sigma_k - \gamma_k}_{ijk} A_{jk} \left(\frac{\sigma_k}{\sigma_k - 1} \frac{\tau^z_{ijk}}{\varphi} \right)^{1-\sigma_k} z^{(\sigma_k - 1)(1-t_k)}_{ijk} \quad (13)$$

Substituting back into the profit function, we can write profits of firm φ selling to market j, $\pi^z_{ijk}(\varphi)$, as follows:

$$\pi^z_{ijk}(\varphi) = \frac{x^z_{ijk}(\varphi)}{\sigma_k} - f^z_{ijk} - z^{a_k}_{ijk} \quad (14)$$

[15] Given that marginal costs (and hence the price) depend on the product attribute, our main framework considers the case of vertical product differentiation (i.e. quality). However, the model captures the case of horizontal product differentiation simply by setting the parameter t_k to zero.

[16] Without loss of generality, we normalize the industry specific factor price of labor input to one.

When maximizing profits, firms have to take another component into account, namely whether to produce according to the standard ($z_{ijk} > 1$) or to produce freely ($z_{ijk} = 1$). In the latter case, firms do not incur the sunk investment cost (i.e. $z_{ijk}^{a_k} = 0$) and their total sales are given by the following equation:

$$x_{ijk}(\varphi) = P_{ijk}^{\sigma_k - \gamma_k} A_{jk} \left(\frac{\sigma_k}{\sigma_k - 1} \frac{\tau_{ijk}}{\varphi} \right)^{1-\sigma_k} \tag{15}$$

The corresponding profit function equals:

$$\pi_{ijk}(\varphi) = \frac{x_{ijk}(\varphi)}{\sigma_k} - f_{ijk} \tag{16}$$

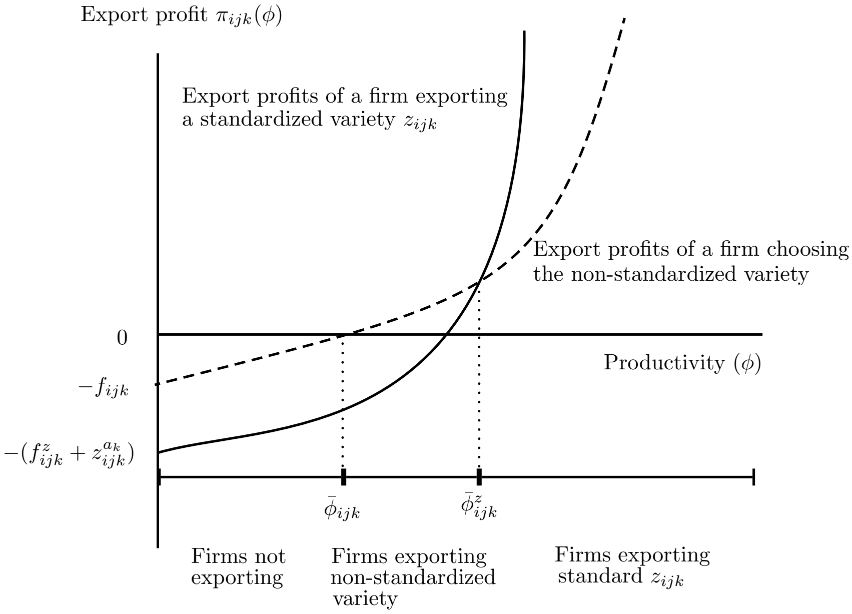
Firms that do not produce in accordance with the standard save on the sunk investment costs, but forego additional demand effects since consumers value the standardized variety more. To ensure that both types of varieties are produced, we assume that not all firms are able to pay the sunk investment costs. For this reason, some (the ones with low productivity) choose to produce freely whereas others (high productivity firms) choose to produce according to the standard. There are two productivity cut-offs: a zero-profit condition for the first firm that enters the export market and produces freely (denoted by $\bar{\varphi}_{ijk}$) and a condition for the first firm that is indifferent between producing freely or according to the standard (denoted by $\bar{\varphi}_{ijk}^{z}$). These cut-offs are respectively:

$$\bar{\varphi}_{ijk} = \frac{\sigma_k}{\sigma_k - 1} \tau_{ijk} \left(\frac{\sigma_k f_{ijk}}{P_{ijk}^{\sigma_k - \gamma_k} A_{jk}} \right)^{\frac{1}{(\sigma_k - 1)}} \tag{17}$$

$$\bar{\varphi}_{ijk}^{z} = \frac{\sigma_k}{\sigma_k - 1} \tau_{ijk} \left(\frac{\sigma_k \left(f_{ijk}^{z} - f_{ijk} + z_{ijk}^{a_k} \right)}{d_{ijk}^{z} P_{ijk}^{\sigma_k - \gamma_k} A_{jk} \left(\frac{\tau_{ijk}^{z}}{\tau_{ijk}} \right)^{1-\sigma_k} \left(z_{ijk}^{(\sigma_k - 1)(1-t_k)} - 1 \right)} \right)^{\frac{1}{(\sigma_k - 1)}} \tag{18}$$

Figure 7 shows the corresponding productivity cut-offs and the implied relationship with export profits and export status. Given $z_{ijk} > 1$, the cut-off for the non-standardized good is smaller than the cut-off for the standardized good,$\bar{\varphi}_{ijk} < \bar{\varphi}_{ijk}^{z}$. The extensive margin of exports is defined by the marginal firm that is indifferent between exporting and non-exporting in equation 17. Assuming a Pareto distribution $g(\phi) = \xi_k \phi^{-\xi_k - 1}$ with support $[1, \infty]$, we can derive analytical expressions for total sales (X_{ijk}), the extensive (M_{ijk}) and the intensive margin ($\bar{x}_{ijk}$) at the bilateral

Figure 7: Firm level sales with voluntary product standard z_{ijk}



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sector level

$$X_{ijk} = \underbrace{\left(\frac{\sigma_k}{\sigma_k - 1}\tau_{ijk}\left(\frac{\sigma_k f_{ijk}}{P_{ijk}^{\sigma_k - \gamma_k} A_{jk}}\right)^{\frac{1}{\sigma_k - 1}}\right)^{-\xi_k} M_{ik}}_{\text{Extensive margin}}$$

$$\underbrace{\Gamma_{1k} f_{ijk}\left(1 - w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} + w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} d^z_{ijk}\left(\frac{\tau^z_{ijk}}{\tau_{ijk}}\right)^{1-\sigma_k} z_{ijk}^{(1-t_k)(\sigma_k - 1)}\right)}_{\text{Intensive Margin}} \tag{19}$$

where M_{ik} is the total number of exporters in industry k and $\Gamma_{1k} = \frac{\xi_k \sigma_k}{\xi_k - (\sigma_k - 1)}$ is a function of the parameters (a_k, t_k, σ_k) and the Pareto parameter (ξ_k). The intensive margin is a weighted average of the share of firms that sell the standardized and the non-standardized variety. w_{ijk} is equal to the share of firms that invest into the standard and is given by the following expression:

$$w_{ijk} = \frac{\left(1 - G(\bar{\varphi}^z_{ijk})\right) M_{ik}}{\left(1 - G(\bar{\varphi}_{ijk})\right) M_{ik}} = \left(\frac{\sigma_k\left(\frac{z^{a_k}_{ijk}}{f_{ijk}} + \frac{f^z_{ijk}}{f_{ijk}} - 1\right)}{d^z_{ijk} A_{ijk} f_{ijk}\left(\frac{\tau^z_{ijk}}{\tau_{ijk}}\right)^{1-\sigma_k}\left(z_{ijk}^{(\sigma_k - 1)(1-t_k)} - 1\right)}\right)^{\frac{-\xi_k}{\sigma_k - 1}} \tag{20}$$

In a similar vein, we can derive the corresponding expressions for the average quantity and price of firms:

$$
\begin{aligned}
\tilde{p}_{ijk} =& \Gamma_{2,k} \left(A_{ijk}\right)^{\frac{1}{\sigma_k - 1}} f_{ijk}^{\frac{1}{1-\sigma_k}} \\
& \left(1 - w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} + w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} d^z_{ijk} \left(\frac{\tau^z_{ijk}}{\tau_{ijk}} \right)^{1-\sigma_k} z_{ijk}^{(1-t_k)(\sigma_k - 1)} \right)^{\frac{1}{1-\sigma_k}} \qquad (21) \\
\tilde{c}_{ijk} =& \Gamma_{3,k} \left(A_{ijk}\right)^{\frac{1}{1-\sigma_k}} f_{ijk}^{\frac{\sigma_k}{\sigma_k - 1}} \\
& \left(1 - w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} + w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} d^z_{ijk} \left(\frac{\tau^z_{ijk}}{\tau_{ijk}} \right)^{1-\sigma_k} z_{ijk}^{(1-t_k)(\sigma_k - 1)} \right)^{\frac{\sigma_k}{\sigma_k - 1}} \qquad (22)
\end{aligned}
$$

where $\Gamma_{2,k}$ and $\Gamma_{3,k}$ are constants at the sectoral level.[17] The equivalents of the price $\tilde{p}_{ijk}$ and the quantity $\tilde{c}_{ijk}$ in the product-level data are the average price and quantity at the HS 4-digit level. We leave the detailed derivations of equations 19 to 22 for the appendix.

5.2 Introducing a product standard

The above model outlines the linkages between firm behavior and product standards and derives the corresponding gravity equation with a decomposition into an extensive and intensive margin. Table 7 summarizes the theoretical predictions on the various margin when the importing country j introduces a new product standard that increases the differences between standardized and non-standardized varieties ($z_{ijk} \uparrow$). The strengthening of a product standard increases product demand and, at the same time, entails marginal and sunk investment costs. Overall, the cost effect dominates and bilateral trade flows decrease. This effect is mainly driven on the extensive margin. High productivity firms opt to produce the standardized variety and reduce demand for the non-standardized variety and drives low productivity firms out of the export market. With respect to the intensive margin, see equation 19, the change on the average sales depends on two opposing effects. First, there exists a direct effect positive on the intensive margin because firms have to sell more in order to cover the higher sunk investment costs. The second effect is a negative composition effect. An increase in z_{ijk} reduces the share of firms that opt to produce the standard. Instead, these firms choose to produce the non-standardized variety, which require lower sales as they only need to cover the fixed costs to export. The combined effect depends on conditions on the parameters $(a_k, t_k, \sigma_k, \xi_k)$ that determine the relative strength of these opposing effects, which we derive in the appendix. The overall effect on the intensive margin also defines the response of average prices and quantities. The average price has a negative elasticity, see equation 21, while the average quantity has a positive elasticity, see equation 22.

[17] $\Gamma_{2,k} = \left(\frac{\xi_k \sigma_k}{\xi_k - (\sigma_k - 1)}\right)^{\frac{1}{1-\sigma_k}}$ and $\Gamma_{3,k} = \left(\frac{\xi_k \sigma_k}{\xi_k - (\sigma_k - 1)}\right)^{\frac{\sigma_k}{\sigma_k - 1}}$.

Table 7: Predicted effects when introducing a standard

	Bilateral sector-level data				
	∂X_{ijk} (1)	∂N_{ijk} (2)	$\partial X_{ijk}/N_{ijk}$ (3)	$\partial \tilde{c}_{ijk}$ (4)	$\partial \tilde{p}_{ijk}$ (5)
∂z_{ijk}	< 0	< 0	< 0	< 0	> 0

To guide the choice of our parameters, which will be relevant for the interpretation of our harmonization results, we use the parameters that are consistent with recent empirical evidence by Fontagné *et al.* (2015). Fontagné *et al.* (2015) find that following a standard introduction in a foreign market both the average sales of French exporters (intensive margin) and the number of French exporters (extensive margin) decrease. At the same time, the average prices increase and quantities exported decrease. Our framework reproduces these moments if we assume that the elasticity of substitution across countries is higher than the elasticity of substitution across varieties, i.e. ($\gamma_k > \sigma_k$). In other words, consumers care more about the differences between a standardized and non-standardized product than about the country of origin of a product.

5.3 Harmonizing a product standard

We outlined above the different channels via which standardization can affect the decision of firms to export. Next, we consider the harmonization of a standard between two trading partners. Generally, harmonization of standards is expected to reduce barriers to trade. Table 8 summarizes different economic effects that standardization harmonization can have for production, market transactions and users of standardized products.[18]

The first dimension concerns fixed costs to export from country i to country j. The harmonization of product standards may facilitate market access by reducing the need to change production structures in order to adapt the product to destination specific requirements of the export market (for example, certification, testing requirements or other compliance costs, see (Shepherd, 2007)). Similarly, firms can exploit cost complementarities that arise from synergies in the production of destination specific goods.

The second dimension can be summarized as demand effects. Standards are widely used in technological applications to ensure the compatibility of different devices. The positive externalities associated with this interoperability should increase the demand for such products. In a similar vein, standardization can lead to economies

[18] See also Baron and Schmidt (2014) and Baron and Spulber (2015) for a general discussion on the economic impact of standardization. Swann (2000) presents a broad overview of the economics of standardization and categorizes the economic effects in a similar way as presented in table 8.

Table 8: Economic effects of standard harmonization

Dimension	Parameter	Impact on firms	Potential economic effects
Trade effects due to harmonization	Fixed costs of exporting	Production structures (blueprints, machines)	Easier market access
		Compliance costs	Need to certify compliance with standard only once
	Demand	Compatibility	Network effects (larger number of users)
		Complementary goods	Economies of scale and scope
		Common definitions	Reduction of information costs
	Variable costs	Common definitions	Lower transaction costs between producer and user/buyer

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. While some of these demand effects pertain to standardization in general, the *harmonization* of standards across trade partners should raise demand for products from harmonizers relatively more compared to non-harmonizers.

One of the most basic purposes of standardization is the use of common definitions. While this most likely also raises demand, the reduction of information asymmetries lowers transaction costs between producers and buyers of a product (Swann *et al.*, 1996; Maur and Shepherd, 2011). This effect may also reflect lower variable costs of exporting from i to j (third dimension in table 8).

To summarize, the impact of standard harmonization on the different margins of trade depends ultimately on the extent to which it alters fixed and variable trade costs as well as demand for or the quality of a product. To shed light on the relevance of the different economic effects described in Table 8 , we define wedges that allow us to reconcile the empirical findings on the various margins with our theoretical model. These wedges capture differences in costs and demand of firms producing the standardized variety relative to firms that produce freely. More precisely, we define the wedge in fixed costs to export ($\triangle^f_{ijk} = f^z_{ijk}/f_{ijk}$), the wedge in variable trade costs ($\triangle^\tau_{ijk} = \tau^z_{ijk}/\tau_{ijk}$) as well as demand wedge $\triangle^d_{ijk} = d^z_{ijk}/1$. Using these definitions, we can rewrite total exports as a function of $\triangle^{f}_{ijk}$, $\triangle^{\tau}_{ijk}$ and $\triangle^{d}_{ijk}$:

$$X_{ijk} = \underbrace{\left(\frac{\sigma_k}{\sigma_k - 1}\tau_{ijk}\left(\frac{\sigma_k f_{ijk}}{A_{ijk}}\right)^{\frac{1}{\sigma_k - 1}}\right)^{-\xi_k} M_{ik}}_{\text{Extensive margin}}$$
$$\underbrace{\Gamma_{1k} f_{ijk}\left(1 - w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} + w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} \triangle^{d}_{ijk}\left(\triangle^{\tau}_{ijk}\right)^{1-\sigma_k} z_{ijk}^{(\sigma_k - 1)(1-t_k)}\right)}_{\text{Intensive Margin}} \tag{23}$$

The share of firms producing the standardized variety is

$$w_{ijk} = \left(\frac{\sigma_k \sigma_k \left(\frac{z_{ijk}^{a_k}}{f_{ijk}} + \triangle^{f}_{ijk} - 1\right)}{\triangle^{d}_{ijk} A_{ijk}\left(\triangle^{\tau}_{ijk}\right)^{1-\sigma_k}\left(z_{ijk}^{(\sigma_k - 1)(1-t_k)} - 1\right)}\right)^{\frac{-\xi_k}{\sigma_k - 1}} \tag{24}$$

and the corresponding expressions for the average quantity and price of firms are:

$$\tilde{p}_{ijk} = \Gamma_{2,k}\left(P_{ijk}^{\sigma_k - \gamma_k} A_{ik}\right)^{\frac{1}{\sigma_k - 1}} f_{ijk}^{\frac{1}{1-\sigma_k}}$$
$$\left(1 - w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} + w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} \triangle^{d}_{ijk}\left(\triangle^{\tau}_{ijk}\right)^{1-\sigma_k} z_{ijk}^{(1-t_k)(\sigma_k - 1)}\right)^{\frac{1}{1-\sigma_k}} \tag{25}$$
$$\tilde{c}_{ijk} = \Gamma_{3,k}\left(P_{ijk}^{\sigma_k - \gamma_k} A_{ik}\right)^{\frac{1}{1-\sigma_k}} f_{ijk}^{\frac{\sigma_k}{\sigma_k - 1}}$$
$$\left(1 - w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} + w_{ijk}^{1-\frac{\sigma_k - 1}{\xi_k}} \triangle^{d}_{ijk}\left(\triangle^{\tau}_{ijk}\right)^{1-\sigma_k} z_{ijk}^{(1-t_k)(\sigma_k - 1)}\right)^{\frac{\sigma_k}{\sigma_k - 1}} \tag{26}$$

The aggregate changes in demand and supply, captured in changes in M_{ik} or A_{jk}, will be absorbed by product-specific time-varying importer and exporter fixed effects. Table 9 summarizes the marginal effect of these parameters on the various margin.

Table 9: Predicted effects

	(1)	(2)	(3)	(4)	(5)
			Bilateral sector-level data		
	∂X_{ijk}	∂N_{ijk}	$\partial X_{ijk}/N_{ijk}$	$\partial \tilde{c}_{ijk}$	$\partial \tilde{p}_{ijk}$
$\partial \triangle^{f}_{ijk}$	< 0	< 0	< 0	< 0	> 0
$\partial \triangle^{\tau}_{ijk}$	< 0	< 0	< 0	< 0	> 0
$\partial \triangle^{d}_{ijk}$	> 0	> 0	> 0	> 0	< 0
			Firm-level data		
	∂x_{ijk}			∂c_{ijk}	∂p_{ijk}
$\partial \triangle^{f}_{ijk}$	$= 0$			$= 0$	$= 0$
$\partial \triangle^{\tau}_{ijk}$	< 0			< 0	> 0
$\partial \triangle^{d}_{ijk}$	> 0			> 0	$= 0$

Column (2) in table 9 shows the changes in the extensive margin and column (3) on the intensive margin. Note that the signs of the differences in fixed and marginal costs are identical and the opposite of the demand effect. A reduction in fixed or marginal costs of (or higher demand for) firms producing the standardized variety increases overall trade through an increase on both the extensive and the intensive margin. Harmonization spurs investment into the standardized variety and increases the number of firms producing these varieties. As a result, the average price for standardized varieties (see column (4)) falls and the average quantity being sold increases, see column (5). Note that harmonization also decreases the sectoral price index, which determines the reaction on the extensive margin, see equation 17. Given that $\gamma_k > \sigma_k$, the fall in the price index implies that the substitution of demand from other countries towards the harmonized sector is stronger than the substitution away from the non-standardized variety towards the standardized variety. In other words, the net effect on demand for non-standardized varieties is positive and more firms enter the export market.

The model presented above serves as a means to shed light on the empirical results obtained in section 4. In section 6, we attempt to further test ssome of the predictions of the theoretical framework presented above. An important ingredient in our model is the sunk investment cost that firms have to pay when they adopt a standard. In section 6 below, we therefore specifically take into account the timing of harmonization as this allows us to evaluate the importance of these sunk investment costs.

Overall, the product level results in section 4 are consistent with the cost and demand effects described in table 8 but do not allow us to disentangle their relative importance. For this reason, we also run regressions using firm-level data in order to compare firm-level outcomes with our model predictions and to shed more light on the contribution of the described cost and demand channels.

To add support to the demand channel, we also exploit sectoral differences in the intensity of the harmonization effect. Matveenko (2017) provides micro-foundation for the demand shifter d_{ijk} in our CES utility function via a discrete choice model and rational inattentive consumers. In this model, consumers have to choose the optimal amount of time to search cost for products. The resulting demand for a product is defined by the ex-ante probability of searching for the good and the elasticity of substitution. According to the model, one should observe that changes in the probability of search increases demand more in low-elastic products compared to high-elasticity products. In section 6, we therefore specifically distinguish between differentiated and non-differentiated goods (the former have a low and the latter have a high elasticity of substitution) in order to test this dimension of our model.

6 Further investigations on economic channels

6.1 Timing of harmonization

An important determinant of the costs and benefits associated with standard harmonization may be the time period between the original introduction of the standard and the harmonization event. To illustrate the point, suppose a country introduces a new standard. Several years later, another country decides to accredit this particular standard. Firms operating in the standard-originating country have already adapted their production process to the standard and are likely to incur little additional costs when exporting to the country that accredits the standard. On the other hand, if both the exporting and the importing country introduce the same standard in the same year, exporters have to pay high sunk investment costs at the time of harmonization. In order to investigate the role of these investment costs, we therefore measure the time elapsed between the release of the standard by the exporter and the release of the same standard by the importer. This variable is denoted as the "time lag" of harmonization.

Table 10: Distribution of time lag

Time lag	Harmonization events	%
0	4369398	53.6
1	1348197	16.5
2	468078	5.7
3	320694	3.9
4	236094	2.9
>=5	1407316	17.3

Notes: The time lag is calculated as the mean number of years that have passed since the importing country accredited a standard already accredited by the exporting country. If both accredit a harmonized standard within the same year, this time lag is zero.

Table 10 shows the distribution of the time lag variable. The majority of harmonization events actually concern harmonizations where the standard is released by both countries at the same time. One should however keep in mind that, by construction, a harmonization event with a time lag equal to zero is counted twice in the dataset: once for the exports from A to B and once for the exports from B to A. For any harmonization event with a time lag strictly larger than zero, we consider the importer's accreditation of a standard already released by an exporter to represent a harmonization event but not vice versa.[19]

In table 11, we include the time lag of harmonization as an additional variable. We notice that a higher time lag is associated with a positive effect on the extensive

[19]See appendix IV for more details.

margin, thus implying more product entry. Though the model presented in section 5 is not a dynamic one, the positive response of the extensive margin to higher time lags can be interpreted within the stylized framework of the model: investment costs are sunk and thus hit exporters when first implemented. However, if exporters have already paid these sunk investment costs in the past (i.e. when the time lag is high), the effects of the accreditation of same the standard in the destination country lead to a decrease in fixed costs of exporting f_{ijk}, higher demand d_{ijk} and/or lower variable costs τ_{ijk} while sunk investment costs f^s_{jk} are nil.

Table 11: Regression results / Controlling for time lag

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00425**	0.00094**	0.00331*	-0.00359***	0.00690***
	[0.035]	[0.026]	[0.081]	[0.007]	[0.004]
Time lag	0.00007**	0.00002***	0.00005	-0.00001	0.00006*
	[0.022]	[0.000]	[0.109]	[0.471]	[0.093]
Observations	5848622	5848622	5848622	5848624	5848624
R^2	0.88	0.90	0.86	0.85	0.86
Adjusted R^2	0.85	0.87	0.82	0.81	0.83

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator and the time lag of harmonization. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

6.2 Firm-level evidence

All the results presented so far are based on bilateral product-level data and predictions implied by the model are based on interpreting a firm as a product. We therefore want to verify to what extent the above results can be confirmed at the firm-level. For this reason, we match our standard harmonization database at the HS 4-digit level with French firm-level data obtained from French custom declarations for the period 1995–2014. We have information on the euro value of exports by each firm and restrict the sample to the 25 importing countries in our standard database. In order to reduce any potential bias arising from the presence of occasional exporters, we follow Fontagné *et al.* (2015) and only include firm-product-importer combinations with at least 5 years of positive exports over the time period in question.

In section 5, we refer to sector k as a HS 4-digit category while varieties ω correspond to a firm producing a HS 6-digit product.[20] In line with the theoretical setup, we now consider the alternative interpretation with firms as the appropriate

[20]This assumption is quite realistic qiven the moments of French firm-level data: for a given combination of firm, HS4-category, destination country and year, 75% of firms export only one HS6 6-digit product.

unit of observation. The corresponding regression specification is:

$$Y_{fjnt} = \beta h_{jnt} + f_{fjn} + f_{fjt} + \varepsilon_{fjnt} \tag{27}$$

where f designates a firm, n the HS 6-digit product level, j the importing country and t the year of observation. We measure the extensive margin by specifying Y_{fjnt} to be a dummy variable that equals one if the firm has positive exports and 0 otherwise. Alternatively, the dependent variable measures the intensive margin, i.e. total exports per firm f in a HS 6-digit category n to importing country j in year t (in logs). For the reasons laid out in section 5 (see table 9), we decompose the intensive margin into prices (proxied by unit values) and quantities[21] which are both included in logs. Equation 27 includes fixed effects on the firm-importer-HS6 level (f_{fjn}) as well as the firm-importer-year level (f_{fjt}).[22]

The results shown in table 12 are similar to the results obtained from bilateral product-level data. Similar to the product-level evidence, the increase in the trade flow is driven by the intensive margin (total sales in column (2)), while there is no reaction at the extensive margin (column (1)). The magnitude of the change in the intensive margin is 0.69% and similar in magnitude to the response at the product-level (see table 4). In column (3), we restrict the sample to those trade flows where we have information on quantities and prices. Mirroring the results obtained using bilateral product-level data, the positive effect on trade flows is mainly driven by quantities (column (4)) whereas prices (column (5)) react to a smaller extent.

Table 12: Regression results: Firm-level data

	(1) Ext. margin	(2) Total trade	(3) Total trade	(4) Price	(5) Quantity
Harm.	0.00084	0.00691***	0.00586***	0.00188*	0.00398**
	[0.185]	[0.000]	[0.002]	[0.080]	[0.044]
Observations	12634460	5285380	4506939	4506939	4506939
R^2	0.63	0.85	0.86	0.94	0.90
Adjusted R^2	0.55	0.80	0.80	0.91	0.86

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator. Columns (3)–(5) are based on a regression sample containing only observations for which information on quantities is available. Fixed effects are included as described in the regression specification 27. Standard errors are clustered at the HS6-year-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

As pointed out in section 5, in a model with constant mark-ups, theory predicts that prices only react to variable trade costs whereas quantities respond to both

[21] We define unit values in terms of number of kilograms shipped.

[22] We also ran our firm-level regressions with a less demanding fixed effects set-up as in Fontagné *et al.* (2015) by including HS2-destination-year ($f_{HS2,j,t}$) and firm (f_f) fixed effects. In this case, all coefficients for the extensive and intensive margin as well as prices and quantities are positive and significant at the 1% level.

demand and variable trade costs. High marginal production costs, however, can lead to an increase in prices. The results in table 12 favor the interpretation that standard harmonization increases product demand, for example by making intermediate inputs compatible or by reducing information asymmetries. We do not find much evidence that a reduction in variable costs drives the results as prices do not decrease. On the contrary, they increase on the firm-level, implying that marginal costs associated with the production of the standardized variety increase. We therefore conclude that standard harmonization acts as an important device to reduce existing negative externalities (such as information asymmetries) or to create positive ones (such as network effects arising from compatible, interconnected products). This effect is predominantly reflected in what our stylized model designates as "demand effects" d_{ijk} while the effect on prices via a reduction in τ_{ijk} is negligible.[23]

6.3 Differentiated vs. homogeneous products

One possible reason why product demand increases in response to standard harmonization relates to the reduction of information asymmetries. In particular, the use of a common standard renders extensive product descriptions obsolete as producers can simply make reference to the standard to convince importers of the properties of their product. In order to test this hypothesis, we use the classification by Rauch (1999) which categorizes products as either being differentiated or homogeneous.[24]

Though this distinction is a very stark one, we associate differentiated products with higher search barriers to trade (and thus a higher reduction of these barriers when standards are harmonized) and also expect that any effects of standard harmonization that affect the complementarity and compatibility of products should apply to a larger extent to differentiated than to homogeneous products.

[23]Note that any jk-specific price impact of tighter product standards is picked up by the fixed effects. See Mei (2017) for a theoretical discussion of an effect of these marginal costs $z(a_{jk})$.

[24]Rauch (1999) distinguishes between products traded on organized exchanges or products that have a reference price. In our exercise, we summarize these categories in one.

Table 13: Regression results / Rauch classification

(a) Differentiated products

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00764***	0.00143***	0.00621***	-0.00412***	0.01033***
	[0.000]	[0.001]	[0.001]	[0.003]	[0.000]
Observations	3521105	3521105	3521105	3521105	3521105
R^2	0.89	0.90	0.87	0.83	0.87
Adjusted R^2	0.86	0.88	0.84	0.79	0.83

(b) Homogeneous products

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00122	0.00077	0.00046	-0.00260	0.00306
	[0.753]	[0.306]	[0.901]	[0.293]	[0.516]
Observations	1781380	1781380	1781380	1781380	1781380
R^2	0.86	0.89	0.84	0.83	0.84
Adjusted R^2	0.82	0.86	0.78	0.77	0.79

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator, splitting the sample in differentiated and homogeneous products according to the Rauch (1999) classification. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

Table 13 shows that the previously positive results are entirely driven by differentiated products. We do not find any such effects for homogeneous products, leading us to interpret this as suggestive evidence that standard harmonization can reduce information asymmetries or increase complementarity/compatibility and thus can act as a demand shifter. An alternative way to think about the reduction of information asymmetries and search barriers is the framework by Arkolakis (2010) where exporting firms have to incur marketing costs in order to reach new consumers. In the light of our results, the reduction of information asymmetries via standard harmonization should translate into lower marketing costs and thus higher trade flows in the Arkolakis (2010) model. We also note that the magnitudes of the coefficients in panel a of table 13 are higher: total trade flows of differentiated products increase by almost 0.76% (compared to 0.67% for the entire sample).

7 Endogeneity

Concerning the robustness of our results, we first want to point out that trade policies almost always concern product standards, but not all product standards are formulated with a trade objective in mind. The standards in our database are formulated by private and public actors alike and are released for a variety of reasons (such as to ensure the compatibility of technological devices or address health concerns) and do not primarily target exporters or importers. Still, our estimated positive effect of harmonization is subject to endogeneity concerns, which we address in this section.

The first concern is that harmonization primarily happens in product categories where trade flows are generally large; higher trade flows after standard harmonization are thus simply a result of the preference of SSOs to standardize more important product categories. Second, special interest groups or firms may lobby for the accreditation of a standard in the anticipation of higher sales. In order to address these concerns, we want to point out that all our regressions include a rich set of fixed effects, that controls for any non-discriminatory standard common to all exporters or importers. In addition, we resort to several robustness tests below, namely (1) estimating our regression model in differences, thus ruling out the size effect of large trade flows, (2) testing for the existence of pre-trends, (3) assuring that the standards in question have a supranational and thus largely exogenous character (by testing so-called European Standards) and (4) instrumental variables estimation where we use the harmonization events of neighboring countries as an instrument for a country's own events.

7.1 Difference equation

One key identification concern is that our main results in table 4 are driven by the fact that standard harmonization is primarily done in sectors where exporters are already present and where trade volumes are high. To address part of these concerns, we specify our baseline regression in terms of first differences:

$$\Delta X_{ijkt} = \beta \Delta h_{ijkt} + f_{ikt} + f_{jkt} + f_{ijt} + \varepsilon_{ijkt} \tag{28}$$

The variable of interest, Δh_{ijkt}, is the first-difference of the cumulative measure of standard harmonization h_{ijkt}. Δh_{ijkt} is a binary indicator that equals one in the year the standard harmonization took place and zero otherwise. In addition, we follow Baier *et al.* (2014) and allow for multi-year differences. The regression equation looks as follows:

$$\Delta_m X_{ijkt} = \beta \Delta_m h_{ijkt} + f_{ikt} + f_{jkt} + f_{ijt} + \varepsilon_{ijkt} \tag{29}$$

where Δ_m indicates differencing the dataset by m years. The reasons for multi-year differencing are twofold. When differencing the data by several years instead of just one, the reference year in the control and treatment group is shifted back in the past. As a consequence, the regression set-up (1) is picking up some of the longer-run effects and (2) is safeguarding against anticipation effects (if any effect of standard harmonization is already present in the year before the actual release, one-year differing is more likely to lead to insignificant results while differencing by several years makes the result more robust to anticipation effects).

The results are presented in table 14 for one-, two-, three- and four-year differences.

While the one-year and two-year differences hardly show any significant results, differencing over three and four years shows the same results as the baseline regression, i.e. standard harmonization leads to an increase of the trade flow driven by the intensive margin, which itself is primarily driven by an increase in the quantities sold. These results suggest that the effect of standard harmonization needs time to develop. The coefficients in column (1) of the various specifications are consistent with this interpretation. After one year, the estimate on the growth rate of total trade flows is not statistically significant from zero. After two years, the effect increases to 0.3% and remains significant at around 0.6% after three and four years.

Table 14: Regression results / Multi-year differences

(a) First differences

	(1) Δ Total	(2) Δ Ext. margin	(3) Δ Int. margin	(4) Δ Price	(5) Δ Quantity
Harm.	-0.00129	0.00005	-0.00134	-0.00094	-0.00039
	[0.540]	[0.943]	[0.508]	[0.627]	[0.886]
Observations	5016796	5016796	5016796	5016798	5016798
R^2	0.22	0.19	0.22	0.23	0.23
Adjusted R^2	0.08	0.03	0.07	0.09	0.08

(b) Two-year differences

	(1) Δ Total	(2) Δ Ext. margin	(3) Δ Int. margin	(4) Δ Price	(5) Δ Quantity
Harm.	0.00297*	0.00077	0.00221	-0.00161	0.00382*
	[0.098]	[0.105]	[0.199]	[0.281]	[0.092]
Observations	4676255	4676255	4676255	4676257	4676257
R^2	0.25	0.21	0.25	0.25	0.25
Adjusted R^2	0.11	0.06	0.10	0.11	0.10

(c) Three-year differences

	(1) Δ Total	(2) Δ Ext. margin	(3) Δ Int. margin	(4) Δ Price	(5) Δ Quantity
Harm.	0.00630***	0.00116***	0.00514***	0.00023	0.00491**
	[0.000]	[0.006]	[0.002]	[0.865]	[0.021]
Observations	4370740	4370740	4370740	4370742	4370742
R^2	0.27	0.24	0.27	0.27	0.26
Adjusted R^2	0.13	0.09	0.12	0.13	0.12

(d) Four-year differences

	(1) Δ Total	(2) Δ Ext. margin	(3) Δ Int. margin	(4) Δ Price	(5) Δ Quantity
Harm.	0.00576***	0.00120***	0.00455***	-0.00062	0.00518**
	[0.001]	[0.003]	[0.006]	[0.619]	[0.013]
Observations	4078531	4078531	4078531	4078533	4078533
R^2	0.30	0.26	0.29	0.29	0.28
Adjusted R^2	0.16	0.11	0.15	0.15	0.14

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator. Regression model corresponds to the differenced version of the baseline model (regression specification 29). Standard errors are clustered at the exporter-product-level. Fixed effects are included as described in the regression specification 29. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

7.2 Pre-trends

Another identification concern is that our difference-in-difference estimator picks up different pre-trends between harmonized and non-harmonized products. Different pre-trends arise if harmonization primarily happens in product categories where trade flows are large or when firms anticipate future standardization efforts and thus react prior to the actual harmonization event. Given that we have multiple harmonization events within a exporter-importer-product triplet, we focus only on observation that did not have any standard harmonization 4 years prior to the first harmonization event.[25] The regression specification with pre-trends looks as follows:

$$\log(X_{ijkt}) = \beta_h h_{ijkt} + \sum_{n=1}^{4} \beta_n d^{1st}_{ijkt-n} + f_{ikt} + f_{jkt} + f_{ijt} + f_{ijk} + \varepsilon_{ijkt} \quad (30)$$

where the variable d^{1st}_{ijkt-n} represents a dummy which is equal to one n years prior to the first harmonization event. Results are displayed in table 15. The magnitudes are comparable to the baseline specification. Once again, total trade, the extensive and intensive margin and quantities are positively affected while prices decrease. Pre-trend dummies for these regressions are not significant at any margin.

Table 15: Regression results / Controlling for pre-trends

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00793***	0.00203***	0.00590***	-0.00425***	0.01015***
	[0.000]	[0.000]	[0.002]	[0.003]	[0.000]
1st Harm. (t+1)	-0.00315	-0.00032	-0.00283	-0.00619	0.00337
	[0.515]	[0.786]	[0.538]	[0.129]	[0.583]
1st Harm. (t+2)	-0.00654	-0.00174	-0.00480	0.00259	-0.00738
	[0.240]	[0.195]	[0.363]	[0.577]	[0.299]
1st Harm. (t+3)	-0.00467	-0.00242	-0.00225	-0.00132	-0.00093
	[0.448]	[0.105]	[0.700]	[0.798]	[0.906]
1st Harm. (t+4)	0.00056	-0.00129	0.00185	0.00752	-0.00567
	[0.932]	[0.422]	[0.765]	[0.179]	[0.499]
Observations	4580411	4580411	4580411	4580413	4580413
R^2	0.89	0.90	0.86	0.86	0.87
Adjusted R^2	0.85	0.87	0.82	0.81	0.83

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator and dummy variables for the first harmonization event shifted in time. Standard errors are clustered at the exporter-product-level. Fixed effects are included as described in the regression specification 30. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

7.3 Endogeneity and European Standards (EN)

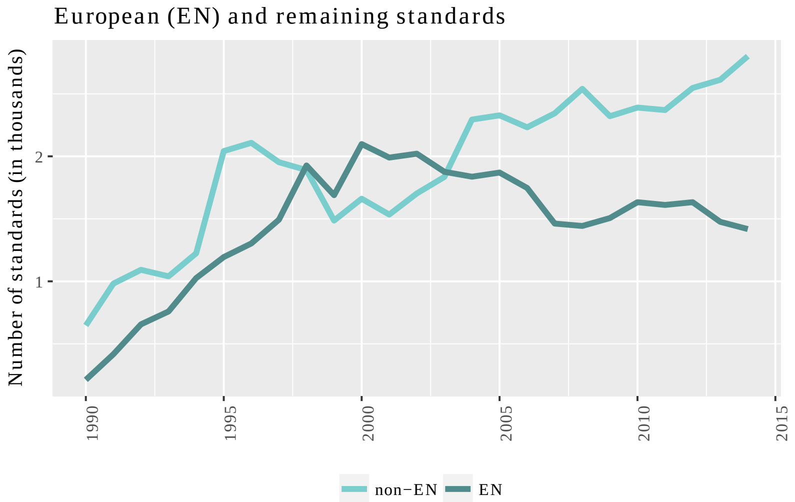
In order to address the question of endogeneity of harmonization efforts, we exploit the fact that the European Commission officially works with three European SSOs, namely the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI), as providers of so-called "European Standards". These can be used to support EU legislation. Once a standard is qualified as a European Standard (identified through the reference code containing the letters "EN"), it "carries with it the obligation to be implemented at national level by being given the

[25]Since our sample starts in 1996, we do not consider any observations that experience a harmonization events prior to the year 2000.

status of a national standard and by withdrawal of any conflicting national standard" (CEN-CENELEC Internal Regulations).

The European Commission actively supports the development of European Standards. Figure 8 displays the number of original releases of all unique harmonized standard documents, broken down by their categorization as a European Standard (EN) or another standard. As is obvious from figure 8, Europen standardization efforts picked up over the 1990s and even outnumbered other standards to a considerable extent.

Figure 8: European Standards, 1990–2014



Notes: The figure displays the number of original standard releases of all harmonized standards, broken down by the year of their original release as well as whether they constitute a European Standard or not.

The supranational character of these European standards reduces endogeneity concerns. Even if one were to make the argument that European standards are primarily released in fields where one expects a lot of trade, fixed effects will take up these kt-specific factors and identification therefore only comes from the cross-country variation as well as the timing of implementation of European into national standards. In our dataset, non-European countries also accredit European Standards (EN), although to a considerably smaller extent than EU/EFTA members. Whereas the accreditations of EN standards by national SSOs take place in the same year as the original release in approximately 46% of all cases, the remaining 54% have a time lag of one year or longer.

We run the same regression model as before, but limit the construction of the harmonization indicator to European standards. The results are displayed in table 16. The results are quantitatively and qualitatively very similar to the baseline specification. As is in line with statistics presented in table 1, cross-country standardization is largely a process supported by international and European SSOs which helps reducing endogeneity concerns.

Table 16: Regression results / European Standards

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00527***	0.00064	0.00463**	-0.00354***	0.00817***
	[0.009]	[0.131]	[0.015]	[0.009]	[0.001]
Observations	6194752	6194752	6194752	6194754	6194754
R^2	0.88	0.90	0.86	0.85	0.86
Adjusted R^2	0.85	0.87	0.82	0.82	0.83

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator which only takes into consideration EN standards. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

7.4 IV regressions

We resort to instrumental variable techniques to further analyze to what extent our results are robust to endogeneity bias, for example due to the possibility that the accreditation of standards is subject to special interest groups. A commonly used instrument in the literature on non-tariff measures is to instrument a home trade policy with the trade policies of its neighboring countries (see for example Kee and Nicita, 2016). The underlying idea is that trade policies of neighboring countries, due to similarities in terms of economic structure, geographic characteristics or membership in supranational organizations, are a good predictor of a country's own policies, but are however not impacting its exports towards other countries.

Using CEPII's GeoDist database (Mayer and Zignago, 2011), we identify an exporting countries' neighbors among the countries in our database and calculate the mean number of harmonization events with respect to each importing country. If this average is larger or equal to 0.5, we code it as a harmonization event ($h^{IV}_{ijkt} = 1$).We consider a country to be a neighbor if it shares a common language or a land border with another country.[26]

The results are displayed in table 17. The upper panel displays the results of the first-stage: the mean standard harmonizations of neighboring countries constitute a relevant predictor of a country's own harmonizations and the F-statistic dismisses the possibility that the IV estimates are biased due to weak instruments. The second-stage results, displayed in the lower panel of table 17, show that the results hold across all dependent variables: overall trade increases, due to both an increase in the extensive and the intensive margin, whereas the decomposition of the intensive margin shows again a decrease in prices and an increase in quantities.

[26] A certain number of countries do not share a language or border with any of the rest of the countries in our database: Brazil, Japan, Jordan, South Korea and Turkey. For Japan and South Korea, we consider the countries with which they share a maritime border as neighbors. For Brazil, Jordan and Turkey, we define the three closest countries in our database as neighbors.

In terms of economic magnitudes, the IV estimates are larger than the OLS ones. However, for columns (1)–(3) of table 17, the Durbin-Wu-Hausman test shows that we cannot reject the null hypothesis of the OLS estimator yielding consistent estimates; we thus conclude that there are no statistically significant differences between the OLS and IV estimates. Under the assumption that our instrument is indeed exogenous and given that the OLS estimator is more efficient, we thus rely on the OLS magnitudes rather than the IV ones.

Table 17: Regression results / Instrumental variables

(a) First-stage

	(1) Harm.
Harm. neighbors	0.23845*** [0.000]
Observations	5848622
F-statistic	3810

(b) Second-stage

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.01862** [0.013]	0.00402*** [0.010]	0.01460** [0.040]	-0.02106*** [0.000]	0.03566*** [0.000]
Observations	5848622	5848622	5848622	5848624	5848624

Notes: Instrumental variables regression of the respective dependent variable (designated in column headers) on harmonization indicator where harmonization is instrumented by neighbors' harmonization. Panel a shows the first-stage results and panel b shows the second-stage results. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

Overall, the evidence presented in this section suggests that our results are robust to endogeneity concerns. We can exclude that the results are driven by the size effect of large trade flows. Including pre-trends into the analysis shows that these are not significant. Finally, addressing potential endogeneity bias with IV techniques and using a measure of largely exogenous, supranational standards yields results that are consistent with the baseline approach.

8 Conclusion

Based on a novel dataset on international standard harmonization across 26 countries, this paper contributes to the literature by quantifying the effects of standard harmonization on international product trade flows. By decomposing trade flows into their different margins, we are able to analyze the channels through which the presumed gains from standard harmonization materialize. Our results show that harmonizing standards leads to a 0.67% increase in trade flows. This increase is predominantly driven by the intensive margin as there is limited evidence of changes on the extensive margin.

In terms of ad-valorem equivalents, our results imply a trade-promoting effect comparable to a reduction of tariffs by 2.1 percentage points (on impact). An additional decomposition of the price and quantity changes shows that quantity effects are the main determinant for the changes on the intensive margin. These results speak in favor of an explanation where standard harmonization leads simultaneously to a net increase in fixed costs (as exporters have to adapt their production structures to the new standard) while simultaneously increasing demand for harmonized products. The increase in demand counteracts the increase in fixed costs, thus resulting in higher overall exports.

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Appendix: ICS

Table 18: 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

Appendix: 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").

I 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 19: 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.[27]

We use graph theory to identify all standards that belong to one group by assigning them the same group identifier.[28] In particular, we use the following 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.

[27]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.
[28]We particularly thank François Farago for helping us out with this procedure.

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.

II 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.[29] International SSOs also constitute a "country" (country code "IX" in figure 9). 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 (as it is very likely that the national SSO is a member organization of the international SSO and simply accredits standards of the international SSO at the same date as the latter 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.

[29] 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.

III 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

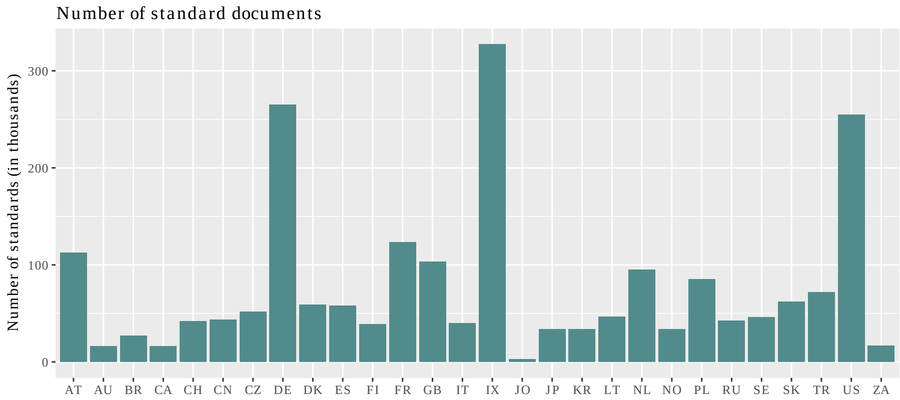
We also collect the number of purely national standards to compare cross-country accreditations against trends in national standard-setting. The appendix describes the dataset construction in more detail. The appendix also lists the country codes as well as the different industries ("ICS classes") which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

Table 20: Procedure to define subset of data

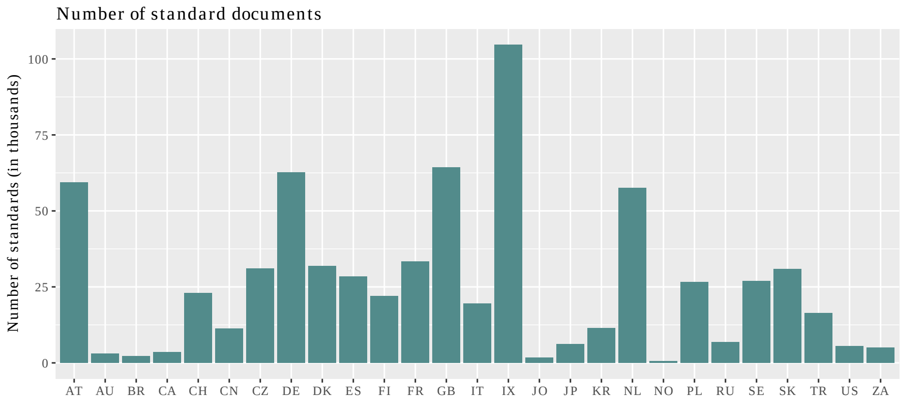
Initial number of standards	2146726
Standards that are not linked to other standards (step 1)	1042359
Duplicate accreditations within one country (step 2)	650483
Remaining national standards	29195
Remaining standards in database	709794
of which: original bilateral standards	11421
of which: accreditations of bilateral standards	52048
of which: by national SSOs	45828
of which: by international SSOs	6220
of which: original international standards	100348
of which: accreditations of international standards	545977

Figure 9: 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 1960–2018 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 9 (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 9 (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.

The data presented in figure 9 show that a large number of standards documents are released by 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 21 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 21: Top ten international SSOs (release of original standards)

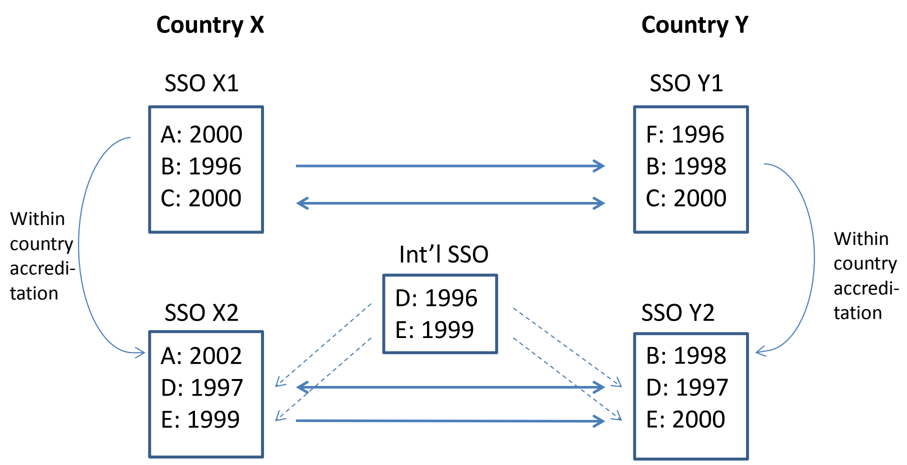
SSO	Number	%
CEN – European Committee for Standardization	33276	33.6
ISO – International Organization for Standardization	28428	28.7
IEC – International Electrotechnical Commission	19158	19.4
CENELEC – European Committee for Electrotechnical Standardization	8762	8.9
ETSI – European Telecommunications Standards Institute	5643	5.7
ASD – AeroSpace and Defence Industries Association of Europe	1964	2.0
ITU – International Telecommunication Union	535	0.5
ECMA – European Asso. for Standardizing Info. and Comm. Systems	218	0.2
ECSS European Cooperation for Space Standardization	122	0.1
EC – European Communities/European Union	110	0.1
Other	771	0.8
Sum	98987	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.

IV Construction of identifiers for harmonization events

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 10), 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 10).

Figure 10: Terminology



We consider a standard harmonization event to take place whenever the importer of a product accredits a standard that was already released or is being released in the same year by the exporter. As demonstrated in figure 10, this can be the case when country Y accredits the standard B in 1998 which was originally released by country X in 1996. A harmonization event also takes place whenever two countries accredit a standard that was originally released by an international SSO. In the example in figure 10, this is the case for standards D and E.

Table 22: Coding of harmonization events

Exporter	Importer	Year	Harm. events	Dummy	Time lag
X	Y	1996	–	0	0
X	Y	1997	D	1	0
X	Y	1998	B	1	2
X	Y	1999	–	0	0
X	Y	2000	C + E	1	(0+1)/2=0.5
Y	X	1996	–	0	0
Y	X	1997	D	1	0
Y	X	1998	–	0	0
Y	X	1999	–	0	0
Y	X	2000	C	1	0

In table 22, we show how we code the harmonization events as well as the variable which measures the time lag of harmonization. The year of the harmonization is the point in time when the importing country accredits the standard, i.e. 1998 for the case of standard B in the example of figure 10. When the two countries accredit the same standard in the same year, as it is the case of standard C in the example, we record it as a harmonization event both when considering exports from X to Y in the years 2000 as well as exports from Y to X in the year 2000.

Appendix: Additional empirical results

V Intensive and extensive margin à la Hummels and Klenow

As a robustness check to the decomposition of trade flows in their different margins as implemented in the baseline specification, we use the cross-sectional decomposition developed by Hummels and Klenow (2005). The main difference is to weigh the extensive margin by the importance of the trade flow rather than assuming that each 6-digit HS product has the same importance weight within a HS 4-digit category. Hummels and Klenow (2005) argue that this adjustment reduces concerns about the level of aggregation of the classification scheme and the grouping of product categories according to non-economic characteristics. We define the extensive margin as:

$$N_{ijkt} = \frac{\sum_{l \in \Omega_{ijkt}} p_{sjlt} q_{sjlt}}{\sum_{l \in \Omega_k} p_{sjlt} q_{sjlt}} \tag{31}$$

and the intensive margin as:

$$\frac{X_{ijkt}}{N_{ijkt}} = \bar{x}_{ijkt} = \frac{\sum_{l \in \Omega_{ijkt}} p_{ijlt} q_{ijlt}}{\sum_{l \in \Omega_{ijkt}} p_{sjlt} q_{sjlt}} \tag{32}$$

where s is the reference country, i.e. the rest of the world. The share of overall exports can then be decomposed into an intensive and extensive margin:

$$\frac{\sum_{l \in \Omega_{ijkt}} p_{ijlt} q_{ijlt}}{\sum_{l \in \Omega_k} p_{sjlt} q_{sjlt}} = \bar{x}_{ijkt} N_{ijkt} \tag{33}$$

It is also possible to decompose the intensive margin into a price effect as well as a quantity effect (see Hummels and Klenow, 2005). This takes the form

$$\bar{x}_{ijkt} = P_{ijkt} Q_{ijkt} \tag{34}$$

where the price index, P_{ijkt}, is defined as

$$P_{ijkt} = \prod_{l \in N_{ijkt}} \left(\frac{p_{ijlt}}{p_{sjlt}} \right)^{w_{ijlt}} \tag{35}$$

The exponent w_{ijlt} is the logarithmic mean of the shares of HS6-category l in country i's and country s's exports to j at time t s_{ijlt}:

$$s_{ijlt} = \frac{p_{ijlt} q_{ijlt}}{\sum_{l \in \Omega_{ijkt}} p_{ijlt} q_{ijlt}} \quad , \quad s_{sjlt} = \frac{p_{sjlt} q_{sjlt}}{\sum_{l \in \Omega_{ijkt}} p_{sjlt} q_{sjlt}} \tag{36}$$

$$w_{ijlt} = \frac{\frac{s_{ijlt} - s_{sjlt}}{\ln s_{ijlt} - \ln s_{sjlt}}}{\sum_{l \in \Omega_{ijkt}} \frac{s_{ijlt} - s_{sjlt}}{\ln s_{ijlt} - \ln s_{sjlt}}} \tag{37}$$

The quantity index, Q_{ijkt}, is obtained by dividing the intensive margin by the price index.

Table 23: Regression results / HK decomposition

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00662***	0.00079	0.00582***	-0.00282**	0.00855***
	[0.000]	[0.235]	[0.001]	[0.011]	[0.000]
Observations	5842797	5842797	5842797	5848855	5843027
R^2	0.88	0.68	0.84	0.60	0.81
Adjusted R^2	0.85	0.59	0.79	0.49	0.76

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

Results are displayed in table 23. The estimated coefficients very much mirror the results from table 4. In the bottom panel of table 23 where we control for the time lag of harmonization, the extensive margin and the prices react negatively to harmonization. However, the positive effect of the volumes and intensive margin more than offset these negative effects leading to significant higher overall trade flows of similar magnitude as in the baseline specification.

VI Results using the keyword matching table

Table 24: Regression results / Concordance based on keyword matching

	(1) Total	(2) Ext. margin	(3) Int. margin	(4) Price	(5) Quantity
Harm.	0.00406**	-0.00016	0.00422**	-0.00164	0.00586***
	[0.035]	[0.694]	[0.019]	[0.192]	[0.009]
Observations	4260144	4260144	4260144	4260144	4260144
R^2	0.88	0.90	0.86	0.85	0.87
Adjusted R^2	0.85	0.87	0.83	0.81	0.83

Notes: Regression of the respective dependent variable (designated in column headers) on harmonization indicator. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.

VII Lagged effects

Table 25: Regression results / Lagged effects

	(1) Total	(2) Total	(3) Total	(4) Total
Harm. (t-1)	0.00661***			
	[0.000]			
Harm. (t-2)		0.00616***		
		[0.001]		
Harm. (t-3)			0.00499***	
			[0.007]	
Harm. (t-4)				0.00395**
				[0.039]
Observations	5593594	5332559	5065584	4798552
R^2	0.88	0.89	0.89	0.89
Adjusted R^2	0.85	0.85	0.86	0.86

Notes: Regression of log total trade flows on lagged values of the harmonization indicator. Fixed effects are included as described in the regression specification 1. Standard errors are clustered at the exporter-product-level. P-values are reported in brackets. ***, ** and * indicate respectively 1%, 5% and 10% significance levels.