WORKING-PAPER – UMR MOISA

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WORKING PAPER MOISA 2015-6

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Abstract
This paper analyses the role that quality standards and innovation play on trade volume, by using a gravity model. The role of innovative activity and quality standards in enhancing trade performance is widely accepted in the literature. However, in this paper, we argue that the net effect of quality standards on trade depends on the producers' ability to innovate and comply with these requirements. In particular, by using a sample of 60 exporting countries and 57 importing countries, for a wide range of 26 manufacturing industries over the period 1995-2000, we show that the most innovative sectors are more likely to enhance the overall quality of exports, and then gain a competitive advantage. We also find that this effect depends on the level of technology intensity at sector-level and on the level of economic development of exporting country.

Keywords: Non-tariff measures, Innovation, Gravity model, Trade policies, Trade flows

Résumé
Cet article analyse le rôle que jouent les normes de qualité et d'innovation sur le volume des échanges, en utilisant un modèle de gravité. Le rôle des normes de qualité et des activités innovantes dans l'amélioration de la performance commerciale sont largement reconnues dans la littérature. Toutefois, dans ce document, nous soutenons que l'effet net des normes de qualité sur le commerce dépend de la capacité des producteurs à innover et à se conformer à ces exigences. En particulier, en utilisant un échantillon de 60 pays exportateurs et 57 pays importateurs, pour une large gamme de 26 industries pour la période 1995-2000, nous montrons que les secteurs les plus innovants sont susceptibles d'améliorer la qualité globale des exportations, et ainsi obtenir un avantage concurrentiel. Nous constatons également que cet effet dépend du niveau d'intensité de la technologie au niveau sectoriel et du niveau de développement économique du pays exportateur.

Mots clés : Mesures non tarifaires, Innovation, Modèle de gravité, Politiques commerciales, Flux commerciaux

JEL : F12, F13, F14, O24, O30

Presented to the 17th World Congress of the International Economic Association, 06-10/06/2014, Dead Sea, Jordan
Presented to the 15th Annual Conference of the European Trade Study Group (ETSG), 12-14/09/2013, Birmingham, UK

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1. Introduction

The main goal of the paper is that of providing an assessment of the trade effects of quality standards, applied by importers in the manufacturing industries, achieved through improvements in the technological level of exporting industries. We apply a gravity model to examine whether the trade performance of industries might be attributed to their ability to deal with increasing standards of product quality through innovation, where quality is widely interpreted to incorporate several features of products. Over time, in a context of tariff reduction/elimination due to the proliferation of preferential trade policies, the role of non-tariff measures (NTMs) has been increasing. While the positive impact of tariff reduction is by and large confirmed, empirical evidence on the trade effects of NTMs is controversial and a clear prediction on their impact cannot be found.

On one hand, the literature on *non-tariff measures* to trade argues that facing higher requirements in foreign markets is likely to reduce trade, both in terms of imports and exports (Chen and Mattoo, 2004; Moenius, 2006a). For many traded products, NTMs such as standards, restrictive sanitary and phytosanitary regulations, are an obstacle for the access to foreign markets. Indeed, NTMs are often used to protect the domestic market in place of classical trade policy instruments and they are likely to play a much larger role than tariffs (Bureau et al., 2004; Iimi, 2007; Desta, 2008; Medvedev, 2010). Complying with standards is therefore likely to increase costs for exporters because of the investment required, and higher costs may discourage producers to sell abroad their products.

On the other hand, the literature on *non-price competitiveness* and trade states that stricter standard and/or regulation promote the domestic product quality and information on quality may increase the confidence of foreign consumers, thereby fostering exports (Fontagné et al., 2005; Moenius, 2004).

The innovation is an important factor of the non-price competitiveness of a nation's products (Buxton *et al.*, 1991), it takes the form of an expansion of the number of varieties of products or quality improvements for a range of existing kinds of products. Recent advances in international trade show, indeed, a strong impact of innovation activity on export performance. However, these theories differ in their predictions about how innovation increases exports (Chen, 2013). The first strand of the literature predicts that innovation has a positive impact on extensive margin of trade, by introducing new products and varieties that a country exports (Grossman and Helpman, 1989). The second strand stresses, instead, the impact of innovation also on intensive margin of trade by increasing product quality (Grossman and Helpman, 1991) or productivity (Eaton and Kortum, 2001, 2002).

While the literature on the standards and innovation trade effect (Swann et al., 1996; Blind, 2001; Blind and Jungmittag, 2005) argues that besides innovations, national technical standards provide additional indicators for the technological potential of a country, in this paper we argue that if producers in a sector aim to export products in presence of importer quality standards, those that innovate are more able to face the complex rules and then gain a competitive advantage in foreign markets. In other words, innovation becomes a key determinant to entry foreign markets that require quality standards and the net effect of standards on trade depends on the producers' ability to innovate and comply with these requirements.

We make the assumption that the greater the number of standards, the higher the quality of products that is required by the importing countries. Thus, the effects on trade are linked to the ability of a single industry for adapting products to the requirements of target markets: exports increase if industries stand out product quality.

Although the impact of standards and innovation on export performance has been extensively analysed, a further investigation of their interaction is needed. In this respect, the contribution of this paper is threefold. *First* of all, instead of focusing on country-specific analysis, we construct a large dataset including (*i*) 60 exporting countries and 57 importing countries, (*ii*) a wide range of 26 manufacturing industries at the 3 digit ISIC level, (*iii*) over the period 1995-2000. *Secondly*, our improvement consists in adopting a different source for quality standards, the *TradeProd Cepii* database, providing data disaggregated by sector for a sample of developed and developing countries. The advantage of using this specific database consists in providing a frequency index for NTMs taking into account for quality control measures. From a methodological point of view, the use of disaggregated data and a specific measure of quality standards lead to a more accurate assessment of policies that often discriminate among products and countries. *Thirdly*, we include an interaction term between standard and patent counts to explore whether more innovative sectors are able to implement the requirements of foreign sectors in terms of product quality and, therefore, to improve their trade performance. To this end, we use a standard gravity model augmented by the measure of quality standards, innovation and their interaction.

Our results show that: (*i*) producers sustain international market access by means of innovation; (*ii*) quality standards required by the importer country are likely to enhance exports and (*iii*) consistent with the *quality ladder model* (Grossman and Helpman, 1991), a higher level of innovation yields a better export performance for sectors interested by higher quality standards. The intuition is that more innovative countries are able to implement the requirements of foreign countries in terms of product quality and therefore to export more. We also check if these results depend on the level of technology intensity of sectors considered. Furthermore, the analysis by exporting countries reveals how the effect of innovation on quality standards is strongly related to the degree of development of the exporting countries.

The rest of the paper is structured as follows. Section 2 provides the most influential literature on standards, innovation and exports. Section 3 introduces the empirical strategy, including the gravity equation, and the estimation technique. Section 4 provides the data description. The results are described in Section 5, while conclusions are presented in Section 6.

2. Literature review

The recent literature testing the impact of (national and international) standards and innovation on trade adopts the approach developed by Swann *et al.* (1996), who estimates the effect of technical standards, as an indicator of technology, on UK trade performance, over the period 1985-1991. Swann *et al.* (1996) find that UK standards are likely to increase the UK exports and the UK imports and that national standards have a stronger impact than internationally equivalent standards, consistently with the intra-industry trade view and the comparative advantage approach.

Following this approach, Blind (2001) and Blind and Jungmittag (2005) integrate standards and innovation as technology measures to estimate, respectively, Switzerland's and German trade performance. In the first paper, Blind (2001) finds that both Switzerland's innovative capacity and national standards explain its export performance in Germany, France and the UK. Moreover, international standards affect imports into Switzerland and its export surplus. In the second paper, Blind and Jungmittag (2005) find that Germany's export performance in the UK is primarily explained by its innovative capacity and to a small extent by national standards. Coherently with the previous studies, they find that international standards exert a more significant impact on foreign trade flow than national ones.

Another important prediction in international trade theory is that innovation, interpreted as a non-price competition measure, improves trade performance. Specifically, this paper is closely related to sector-level studies adopting the perspective that considers the role of innovation in improving product quality and increasing exports.

In a seminal paper, Greenhalgh (1990) examines the UK net exports for 31 sectors and uses SPRU (Science and Technology Policy Research) innovation data finding that innovative industries will be net exporters rather than net importers, and that higher quality product will face lower price elasticity and higher income elasticity for their exported products. In a subsequent extension of the original analysis, Greenhalgh et al. (1994) consider innovation effects on both net export volumes and export prices using patents and other innovations data. In general terms, these measures produce results that are similar to the earlier study, suggesting a positive effect from the product quality on trade volumes and prices in the UK. In general, the interpretation of these results is that innovation improves the quality and range of products and attracts more demand.

In a similar vein, Wakelin (1998) adopts an approach from the technology gap tradition in examining sectoral trade flows for 22 industries and nine OECD countries. This study relates relative export flows to relative technology investments (R&D, patents, and SPRU innovation rates in the UK). Wakelin (1998)'s results also provide general support for a positive relationship between innovation and export flows, although this result is sensitive to the use of different technology and innovation indicators.

Anderton (1999a, 1999b) also considers the impact of R&D and patenting activity on trade (and prices) arguing that both technology indicators are considered proxies for the quality and/or variety of goods produced. Specifically, Anderton (1999a) estimates this impact for six industrial sectors in the UK. Both measures of technological activity are found to have significant negative effects on import volumes but much weaker effects on export volumes and import prices. In a more specific exercise, Anderton (1999b) considers bilateral trade between the UK and Germany and focuses on import volumes and values using similar technology variables. Anderton (1999b) finds some evidence that relative R&D expenditure and patenting activity are more important in high-technology intensity industries.

With regard to the literature on standards, several studies have diffusely discussed their use and their effects, finding that the impact varies in accordance with destination markets and sectors of economic activity.[1] Most notably, concerning sectors, some studies discover that for agricultural products, standards may constrain exports, whereas for manufactured products, standards tend to foster trade. For instance, Moenius (2004) examines the impacts of standards by using the information of *Perinorm* in a large data set covering 471 sectors defined at 4-digit SITC in 12

[1] With regard to the destination markets, several studies find that standards limit market access, particularly for developing countries (DCs) and Least Developed Countries (LDCs) towards developed countries and their impact can be more restrictive than tariffs.

OECD countries.[2] Overall, results including all SITC categories and three standards count variables show that NTMs promote trade. Moreover, results differ depending on sectors considered: (*i*) on food, beverages, crude materials and mineral fuels, country-specific importer standards act as a barrier to trade, and (*ii*) on oils, chemicals, manufacturing and machinery country-specific importer standards seem to support imports into that country.

In a similar vein, Fontagné et al. (2005) analyse the impact of NTMs on a sample of 161 group of manufacturing and agricultural products, for 114 exporting countries and 61 importing countries, by using all notified barriers at HS6 digit level to WTO by checking also for tariffs. A negative impact of these measures on trade is mainly found for agricultural products, while manufactured products report an insignificant or positive impact. Similarly, Disdier et al. (2008) evaluate the trade impact of NTMs notified by OECD importing countries on agricultural products.[3] Dataset includes 154 importing countries, 183 exporting countries and 690 products at HS6 digit level in 2004. On the one hand, results show that OECD exporters are not significantly affected by these measures in their exports to other OECD members; on the other hand, DCs and LDCs exporting to OECD countries are negatively affected by the regulations.[4]

3. Empirical strategy

[2] *Perinorm* is a database containing information on the standards published by the main national and international standards authorities.

[3] Three different variables as NTMs are used. The first indicator of NTMs is a dummy variable equal to one if the importing country notifies at least one barrier at the HS6 digit level; the second indicator is a frequency index, and finally a third dial is an ad-valorem equivalent.

[4] On a partially related ground, many studies find that the negative impact of sanitary and phytosanitary measures (SPS) and technical barriers to trade are stronger when exports to the EU market are considered. Other studies show how stringency measures, such as the MRLs of pesticides and contaminants, negatively affect bilateral trade flows (Otzuki et al., 2001; Xiong and Beghin, 2012; Disdier and Marette, 2010). While others point out that similar regulations between trading partners may promote bilateral trade flows (Drogué and Demaria, 2012; Vigani et al., 2011).

3.1 Econometric approach

From a methodological point of view, this paper is related to the gravity model literature developed by Tinbergen (1962) and Pöyhönen (1963). Gravity models are widely used in international trade literature and they are an application of the Newton's law of gravity. Their ability to correctly approximate bilateral trade flows makes the gravity equation one of the most successful empirical fact in economics.

We estimate the gravity model in multiplicative form, using the Pseudo Poisson Maximum Likelihood (PPML) estimator[5], commonly adopted in the recent empirical analyses (Anderson and Yotov, 2011, 2012). We also add our variable of interest and estimate the following augmented regression:

$$X_{ij,t}^{h} = \exp\Big\{\beta_1 \ln Y_{i,t}^{h} + \beta_2 \ln E_{j,t}^{h} - \beta_3 \ln Y_{t}^{h} + \gamma_1 \ln Distance_{ij} + \gamma_2 \ln Contiguity_{ij} + \gamma_3 \ln Language_{ij} + \gamma_4 \ln Tariff_{ij,t}^{h} + \gamma_5 \ln Patent_{ij,t-1}^{h} + \gamma_6 \ln Standard_{ji,t}^{h} + \gamma_7 \left(\ln Patent_{ij,t-1}^{h} * \ln Standard_{ji,t}^{h}\right) + \delta_1 Exp\_du_i + \delta_2 Imp_{du_j} + \delta_3 Sect\_du^{h} + \delta_4 Time\_du_t\Big\} + \varepsilon_{ij,t}^{k} \qquad (1)$$

where, *i* indexes exporter country, *j* importer country, *h* sector and *t* time. The dependent variable is the trade value between *i* and *j* in sector *h* at time *t*. Concerning explanatory variables, we include two groups of determinants of trade. The first includes standard gravity variables: *Y* and *E* indicate,

[5] Since the bilateral trade flows are collected from multiple countries, heteroskedasticity may be a challenge especially in the common practice of logarithmic transformation. As Santos Silva and Tenreyro (2006) showed, if the true gravity equation is in its multiplicative form and heteroskedasticity is present, estimates from the log-linearized gravity equation can be biased. This specification of the gravity model solves three kind of problems. Indeed, thanks to its multiplicative form, the PPML specification provides a natural way to deal with zero trade flows. In addition, the estimation of the gravity model by PPML are consistent in the presence of heterosckedasticity and are reasonably efficient, especially in large samples. Finally, the objective function is log-linear instead of log-log. This imply that the dependent variable do not have to be transformed logarithmically.

respectively, production of exporter and expenditure consumption of importer; *Distance* is the distance between country *i* and *j*; *Contiguity* and *Language* are dummy variables taking the value of 1 for pair of countries sharing, respectively, common border and common language, and zero otherwise; *Tariff* is the bilateral applied tariffs between two countries, in sector *h* at time *t*.

Most notably, the second set of variables is included to test our main hypothesis that a higher level of innovation yields a higher increase in export for sectors affected by higher quality standards required by the importing countries. To this end, we firstly include *Patent*, which controls for the level of innovation of sector *h* of exporter country, expressed as the number of patents granted by the US patent office, at time *t*-1. We use the lagged level of innovation in order to deal with potential endogeneity problems[6]. Because of such reverse causality, we recognize that our results should be interpreted as conditional associations, rather than causal relationships. Then, we include *Standard*, that is the NTM indicating the frequency of requirements on quality applied by country *j* to country *i* in a particular sector *h* at time *t*. We include our key explanatory variable, *Patent*Standard*, that is the interaction term between the innovation level and the quality standards.

Relating to the "multilateral resistance (MR) terms" (Anderson and van Wincoop, 2003) , the direct estimation *à la* Anderson and van Wincoop (2003) requires the (non-linear) estimation of a structural equation in which multilateral resistance indexes are expressed as a function of the observable variables, while the use of published data on price indexes may not reflect true effects accurately (Feenstra, 2002). In the literature, a widely used and computationally easier approach to account for theoretical multilateral trade resistances is the use of importer and exporter fixed effects in the estimation. Then, in our specification we include four sets of dummies at the level of exporter (country) *i* (*Exp_du*), importer (country) *j* (*Imp_du*), sector *h* (*Sect_du*), and time *t* (*Time_du*). Such fixed-effects also account for all other unobserved variables, as country and product-specific characteristics.

[6] One solution to this problem would be to instrument innovation, but unfortunately finding credible instruments at disaggregated level is not an easy task.

4. Data and descriptive statistics

The dataset is built on information provided by the *TradeProd*, by the *GeoDist Cepii* database, and by the US Patent Office database, managed by the National Bureau of Economic Research (NBER).

The *TradeProd* database provides data by sector, for a wide sample of developed and developing countries, on bilateral trade, production, expenditure, tariffs and non-tariff barriers. It proposes these variables in a compatible industry classification, covering 26 industrial sectors in the ISIC classification at the 3-digits level of Revision 2, from 1980 to 2006.[7]

To limit the potential for omitted-variable bias, we add to the main variables of interest other controls that are based on the vast gravity literature focusing on trade. First of all, we control for production of exporting country, proxying for economic size, and consumption of importer country, proxying for expenditures, both obtained from the *TradeProd* database.

The impact of transport costs is proxied by distance, common border, language links (provided by *GeoDist* database) and trade policies, proxied by the *ad valorem* equivalent tariff factor imposed by country j on imports of commodity in sector h from country i at time t (provided by *TradeProd* database).

With regard to our first key explanatory variable, that is the NTM indicating requirements on quality, data issues are particularly problematic in the analysis of quality standards. In fact, in many cases this information is not available and sometimes also not easily obtained. Usually, information on standards include either the number (or changes in their number) or the descriptions of measures, which are given for specific products. Different methods related to the measurement of standards indeed exist. A binary choice variable, namely “count measures”, represents a first indicator (Disdier et al., 2008; de Frahan and Vancauteren, 2006; Fontagné et al., 2005; Moenius, 2004). This term is equal to one if a country-pair on a given product line in a specific year has a specific measure, and zero otherwise. The advantage of using the count measures (frequency and coverage

[7] For more information, see http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=5.

indexes) is the simplicity of their computation. The only necessary information is the product line and country specific knowledge of the existence of measures. The *TradeProd* database provides two kind of measures: five frequency index and five coverage index, other than an index grouping all measures.[8] In particular, it contains: (*i*) frequency index related to price effect, (*ii*) those with a restriction on quantity, (*iii*) restriction on quality, (*iv*) threatening measures and (*v*) a frequency related to advanced payments and finally. The same classification applies for coverage measures. Among these measures, we choose a frequency index related to the quality. It is calculated based on number of HS commodity subject to measures. The number of product categories subject to NTMs is a percentage of the total number of product categories in the HS group in order to get the frequency ratio. In this paper, since we use a frequency index covering the restrictions on quality, we make the assumption that the greater the number of the regulations the higher the quality of products.

The second key explanatory variable is a measure of innovation. The choice of the proxy for the unobservable technical change is not neutral in this case (Cipollina et al., 2012). Different proxies have been adopted in empirical models, ranging from measures of inputs involved into the innovation process, such as R&D expenditures (Coe and Helpman, 1995; Engelbrecht, 1997; Coe et al., 2009), to output measures such as the number of inventions which have been patented (Acs and Audretsch, 1989; Acs et al., 2002), to institutional characteristics such as the degree of patent protection (Bottazzi and Peri, 2003; Coe et al., 2009), to direct measures of innovative output originated in the work of Pavitt et al. (1987) and Edwards and Gordon (1984). In what follows, we use the number of patents (see, e.g., Griliches, 1990). Patents have long been recognized as a very rich and potentially fruitful source of data for the study of innovation and technical change (Hall et al., 2001). Indeed, the main advantages in using patent data are that: (*i*) each patent contains

[8] As a matter of fact, data on NTMs can also be obtained from United Nation's Conference on Trade and Development (UNCTAD), from World Trade Organization (WTO) and from the Trade Analysis and Information System (TRAINS) database.

detailed information on the innovation itself, the technological area to which it belongs, the inventors (e.g. their geographical location), the assignee, etc., and (*ii*) patent data include citations to previous patents and to the scientific literature, allowing to study spillovers, and to create indicators of the "importance" of individual patents.

In this empirical study, we adopt the number of utility patents granted by the US Patent Office, provided by the National Bureau of Economic Research (NBER), as a measure of technological intensity.[9] The annual number of US granted utility patents are classified according to the US Patent Classification (USPC).[10]

Matching our different sources, we construct an original database that associates bilateral trade at the sector level and sector and country level variables, for a sample of developed as well as developing countries. Our final dataset includes 60 exporters, 57 importers, 26 manufacturing sectors at the 3-digits ISIC (codes between 311 and 385), over the period 1995-2000.

Table 1 presents descriptive statistics of our variables of interest.[11] Concerning the dependent variable, i.e. exports, it shows an average value of more than 35 million dollars and a high variability, with values ranging between 0 and 526 million dollars. Total production reflects the economic development of exporter countries, with minimum value of 638,000 dollars for Panama (in 1996), and the maximum value of more than 639 billion dollars for USA (in 1999). Moreover,

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[9] Data are available at http://www.nber.org/patents/. Broadly speaking, the dataset comprises detailed information on almost 3 million US patents granted between January 1963 and December 1999, all citations made to these patents between 1975 and 1999 (over 16 million), and a reasonably broad match of patents to *Compustat* (the data set of all firms traded in the US stock market) (Hall et al., 2001).

[10] Since the original data on patents are classified according to the US Patent Classification, we combined them with other information adopting the correspondence scheme between the US Patent Classification and the International Patent Classification and between the latter and the ISIC Rev. 3 provided by Johnson (2002). Finally, concordances between ISIC Rev. 3 and ISIC Rev. 2 are applied.

[11] Descriptive statistics are calculated on the whole sample, after excluding influential observations, i.e. observations with a value of trade higher that the 95^{th} percentile of the world distribution.

consumption show minimum values of 1,163 thousand dollars for Cameroon (in 1997) and the highest value of 698 billion dollars for USA (in 1999).

Table 1. Descriptive statistics

This table reports descriptive statistics of variables used in the empirical estimates.

Variable	Mean	St. Dev.	Min	Max
X	35.89	79.51	0.00	526.21
Y	19,100	45,900	0.638	639,000
E	10,600	34,700	1.16	698,000
Distance	7,317	4,839	80	19,781
Contiguity	0.04	0.19	0	1
Language	0.09	0.29	0	1
Tariff (%)	5.45	11.42	0	268
Patent	4.41	22.46	0	924
Standard	0.11	0.22	0	1

Notes: Descriptive statistics are calculated on variables in levels after excluding influential observations (i.e. observations with the value of Trade flow (*X*) higher than the 95^{th} percentile of the world distribution). Trade flow (*X*), total production (*Y*) of exporter and consumption (*E*) of importer are expressed in million dollars. Descriptive statistics are calculated on the sample of 124,384 observations.

Among bilateral characteristics, Distance shows an average of more than 7 thousand kilometres, with values ranging between 80 and more than 19 thousand kilometres. Tariffs show a high variability, with values ranging between 0 and 268% and an average level of about 5%.

Moreover, the number of patents, which reflects the technological development, is also highly variable in our sample, with values ranging between 0 (for manufacture of fabricated metal products in China) and 924 (for manufacture of food, beverages and tobacco in USA) and an average equal to 4. The frequency index of restrictions on quality ranges between 0 and 1 and shows and average value of 0.11.

Table 2 reports simple correlations among the variables used in the empirical model. As expected, exports are positively correlated with production, consumption common language and innovation. Negative correlations are reported between exports distance, tariff barriers, and, surprisingly, quality standards. Moreover, a positive and significant correlation (0.24) is reported between tariff and non-tariff measures. Even though summary statistics and bilateral correlations are suggestive, they do not control for potentially confounding factors. For this reason, in what follows we perform a more refined econometric analysis.

Table 2. Correlation matrix

This table reports correlations between variables used in the empirical estimates.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) *X*	1									
(2) Y^a	0.31*	1								
(3) E^a	0.36*	0.14*	1							
(4) *Distance*^{a}	-0.28*	0.09*	-0.08*	1						
(5) *Contiguity*	0.22*	-0.02*	0.04*	-0.37*	1					
(6) *Language*	0.08*	-0.02*	0.04*	-0.02*	0.16*	1				
(7) *Tariff (%)*^{b}	-0.12*	0.01*	-0.01*	0.39*	-0.10*	0.02*	1			
(8) *Patent* ^{a}	0.24*	0.44*	-0.02*	0.02*	-0.03*	-0.01*	0.05*	1		
(9) *Standard*^{b}	-0.07*	0.002	0.06*	0.18*	-0.03*	0.02*	0.24*	0.03*	1	
(10) *Patent*Standard*	0.11*	0.18*	-0.04*	-0.07*	-0.01*	-0.02*	-0.08*	0.42*	-0.46*	1

Notes: Correlations are calculated after excluding influential observations (i.e. observations with the value of Trade flow (*X*) higher than the 95th percentile of the world distribution). * indicate significance at 5% level. ^{a}: this variable is included in the estimates as the ln(*variable*). ^{b}: this variable is included in the estimates as the ln(1+*variable*).

5. Results and major implications

5.1 Baseline results

This section provides the main results of the empirical analysis conducted on the whole sample of 124,384 observations. Results of the equation (2) are reported in Table 3. In order to analyse the impact of our variables of interest (namely, the proxy for innovation and the quality standards measure), we first introduce these variables separately, and then we control contemporaneously for both. Finally, we allow these measures to simultaneously interplay in order to estimate the accelerator effect. In all specifications, we control for exporter, importer, time and sector fixed effects, as specified in Section 3.1.

Column (1) of Table 3 shows results of the standard gravity equation. The production level of exporter and the consumption of importer countries have positive and significant coefficients (0.704 and 0.203, respectively). This means that market size of both origin and destination countries matters for trade. As it can be inferred from the coefficients of other explanatory variables, trade costs (i.e., distance, contiguity, language and bilateral tariffs) show the expected impact on exports. Specifically, a 10% increase in distance implies a trade reduction equal to 7.8%. As expected, common border and common language exert a positive and significant impact on trade with coefficients 0.356 and 0.343, respectively. Moreover, an increase in tariff of 10% implies a decrease of export equal to 0.3%.

In column (2), we estimate the same baseline gravity model, augmented by our measure of innovation, namely the number of utility patents. The sign and significance of the gravity variables are comparable to those reported in column (1). Most interestingly, the coefficient of our proxy for innovation is positive (0.042) and highly significant at the 1% level. In terms of the economic impact, this coefficient means that an increase of 10% of the number of utility patents implies an increase of trade equal to 0.4%. This result is consistent with most part of the literature on the relationship between innovation and export, showing that more innovative manufacturing sectors are more likely to export in foreign countries.

Table 3. Baseline results

This table reports the estimated coefficients of the gravity model.

	(1) Gravity variables	(2) Introducing innovation	(3) Introducing quality standards	(4) Introducing interaction effect
Y^a	0.704***	0.696***	0.696***	0.696***
	(0.010)	(0.010)	(0.010)	(0.010)
E^a	0.203***	0.202***	0.201***	0.201***
	(0.010)	(0.010)	(0.010)	(0.010)
Distance[a]	-0.785***	-0.787***	-0.788***	-0.788***

	(0.011)	(0.011)	(0.011)	(0.011)
Contiguity	0.356***	0.356***	0.356***	0.356***
	(0.020)	(0.020)	(0.020)	(0.020)
Language	0.343***	0.342***	0.342***	0.342***
	(0.016)	(0.016)	(0.016)	(0.016)
Tariff[b]	-0.028***	-0.027***	-0.028***	-0.028***
	(0.005)	(0.005)	(0.005)	(0.005)
Patent[a]		0.042***	0.042***	0.041***
		(0.004)	(0.004)	(0.004)
Standard[b]			0.107**	0.112***
			(0.042)	(0.042)
*Patent*Standard*				0.018*
				(0.011)
Observations	124,384	124,384	124,384	124,384
R^2	0.60	0.60	0.60	0.60

Notes: The dependent variable is the trade flow (*X*) between exporter and importer. *Y* indicates total production of exporter and *E* indicates consumption of importer. *Patent* is lagged one year. *Patent*Standards* is the interaction term between the natural logarithm of *Patent* and the natural logarithm of 1+*Standard*. Estimations are conducted by using the Poisson Pseudo Maximum Likelihood estimator, after excluding influential observations, i.e. observations with the value of trade flow (*X*) higher than the 95th percentile of the world distribution. All estimations include (unreported) exporter, importer, sector and year fixed effects. Robust standard errors are reported in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level, respectively. [a]: this variable is included in the estimates as the ln(*variable*). [b]: this variable is included in the estimates as the ln(1+*variable*).

Similarly, in column (3) we aim to control both for innovation measure and for quality standards. Reassuringly, previous results remain unchanged. The coefficient of importer standards shows a positive (0.107) and significant coefficient at the 5% level. These interesting results can be interpreted in the sense that a high frequency of quality standards imposed in different sectors by the importer induces the counterpart to export higher quality products and to register a high volume of exports. In other terms, high quality standards are an incentive, and not a barrier, to trade for exporting countries to produce and sell in the foreign markets high valued manufactured products.[12]

Manufactured product may, indeed, be defined as products with high value added: once internalized, the cost of complying with the importing requisites, there are no more obstacles to enter that specific market. Furthermore, our results suggest that the absolute value of the effect of NTMs is higher than the impact of tariffs.

[12] Since in our sample the 25% of the distribution of quality standards includes values equal to zero, we re-estimate our model on the sample of positive quality measures and the results, available on request, remain unchanged.

Up to now, we have shown that innovation and quality standards required by the importer have an independent effect on bilateral trade, consistent with some part of the literature. However, the two measures, other than showing an independent effect on trade, are expected to interact. The hypotheses of our empirical model imply indeed that sectors that innovate are more likely to face to the complex rules concerning quality, gain a competitive advantage, and then export more.

For this reason, in column (4) we introduce the interaction term between the frequency index of quality and our proxy for innovation, alongside interacted variables. The coefficients of the gravity variables remain almost unchanged. The interacted variables show a positive impact on trade, as in the previous estimates, and their coefficients are comparable to those reported in column (3). Most notably, the interaction term shows a positive (0.018) and significant coefficient (at the 10% level). It implies that innovation helps sectors in a country to export high quality products, as required by the standards imposed by the importing partner.

To sum up, not only standards on quality required in a sector are not considered as trade barriers in our sample, but they are more likely to be reached the higher the level of innovation in that sector for the exporter country. This interesting result also recognizes a different role to the innovation process: it amplifies the positive effect of quality standards on exports. In other terms, innovation allows firms in a sector to improve the product quality and to export highly value added products, consistent with the non-price competitiveness view. In the following sections we aim to analyse whether this relationship depends on the level of technological intensity in a sector and on country's development level.

5.2. Does the level of technological development matter?

In this section, we argue that the impact of innovation and quality standards on trade may be substantially different, depending on the level of technological development of the industrial sector in the exporting countries. For example, the impact of quality standards might act as incentive to export high-valued products in the low and middle-tech sectors and as a barrier for trade in high-tech sectors. To this end, we split the sample according to the level of technological intensity, measured by the total number of patents that has been granted to each sector by the US patent office to inventors all over the world. In all cases, estimates are conducted using our preferred econometric specification, including the interaction term and country, year and sector dummies.

The results are presented in Table 4. In general, in all sub-samples of sectors the impact of gravity variables is comparable to that obtained on the whole sample. With regard to our variables of interest, some differences need to be emphasized. The level of innovation seems not be relevant for exports in low-tech sectors, while it stimulates trade both in the middle and high-tech sectors, with an impact of 0.6% and 0.5%, corresponding to an increase of 10% on the innovation activity.

As far as quality standards are concerned, their impact is higher the lower the technology intensity of sectors involved. The coefficient of quality is positive and significantly different from zero for low (1.104) and middle-tech (0.294) sectors. When we consider high-tech sectors, the estimated coefficient of quality standards is negative, equal to -0.116, and statistically significant, meaning that quality required by the importer country act as a barrier to trade in high-tech sectors. However, the interaction effect shows a positive and significant coefficient for both low and high-tech industries. This means that innovation activity exerts an accelerator effect on quality standards to stimulate trade both in the low-tech sectors and in sectors characterized by high technology intensity. In the latter category, even if the impact of quality standards on trade is negative, innovation helps exporter countries to overcome this barrier and to increase the value of exports.

Table 4. Sample split on technology intensity

This table reports the estimated coefficients of the gravity model by splitting the sample according to the technology intensity. Model (1) includes observations for which the number of patents is below the 33.3th percentile of the world distribution. Model (2) includes observations for which the number of patents is between the 33.3th and 66.7th percentile of the world distribution. Model (3) includes observations for which the number of patents is above the 66.7th percentile of the world distribution.

	(1) Low-tech	(2) Middle-tech	(3) High-tech
Y[a]	0.564***	0.727***	0.664***
	(0.021)	(0.019)	(0.014)
E[a]	0.240***	0.191***	0.229***
	(0.024)	(0.016)	(0.012)
Distance[a]	-1.012***	-0.817***	-0.729***
	(0.022)	(0.017)	(0.017)
Contiguity	0.329***	0.357***	0.307***
	(0.037)	(0.032)	(0.030)
Language	0.281***	0.435***	0.331***
	(0.034)	(0.029)	(0.022)
Tariff[b]	-0.047***	-0.024**	-0.038***
	(0.014)	(0.010)	(0.006)
Patent[a]	-0.010	0.061***	0.046***
	(0.016)	(0.014)	(0.009)
Standard[b]	1.104***	0.294**	-0.116*
	(0.343)	(0.150)	(0.070)
*Patent*Standard*	0.210***	0.047	0.048**
	(0.076)	(0.076)	(0.023)
Observations	41,402	41,541	41,441
R^2	0.57	0.61	0.63

Notes: see Table 3

5.3. Different groups of countries

In line with the previous analysis, Table 5 reports the results of the gravity equation obtained by splitting the original sample according to the level of income of exporting countries: middle income economies, high income economies and high income OECD members. Our purpose is twofold. On the one hand, we would determine whether sectors in countries showing different level of income react in the same way to higher frequency standards. This means the higher the frequency of quality standards the higher trade. On the other hand, we verify whether innovations directly aim at improving quality products and increasing the effectiveness and efficiency of countries to trade.

Table 5. Sample split on different groups of exporter countries

This table reports the estimated coefficients of the gravity model by splitting the sample according to the level of economic development. The sample split has been based on the World Bank classification of countries by income level. Model (1) includes middle income economies; model (2) high income economies; model (3) OECD economies.

	(1) Middle Income Economies	(2) Higher Income Economies	(3) High OECD Economies
Y^a	0.679***	0.696***	0.771***
	(0.032)	(0.011)	(0.011)
E^a	0.270***	0.203***	0.191***
	(0.032)	(0.010)	(0.010)
Distance[a]	-1.000***	-0.805***	-0.868***
	(0.044)	(0.013)	(0.013)
Contiguity	0.529***	0.346***	0.301***
	(0.084)	(0.020)	(0.021)
Language	0.423***	0.360***	0.316***
	(0.046)	(0.017)	(0.018)
Tariff[b]	-0.036**	-0.028***	-0.020***
	(0.015)	(0.006)	(0.006)
Patent[a]	0.032**	0.031***	0.023***
	(0.014)	(0.004)	(0.005)
Standard[b]	0.231	0.003	-0.018
	(0.174)	(0.045)	(0.050)
*Patent*Standard*	0.014	0.052***	0.063***
	(0.048)	(0.012)	(0.014)
Observations	18,135	106,249	82,639
R^2	0.56	0.62	0.64

Notes: see Table 3

Standards and regulations differ from country to country. As a consequence, in order to protect domestic consumers and market, importing countries demand compliance with their standards. The capacity of exporters to comply with standards of the importing country is relevant because non-compliance is likely to diminish the competitiveness of the exporting countries. In this context, innovation may be a strategy to overcome compliance difficulties, capture new opportunities and gain new markets. In other words, innovation plays a key role in providing “safe” products by creating greater value and establishing a way to overcome any entry barriers. All these considerations allow us to investigate the effect of our three variables of interest (*Patents, Standard* and *Standards***Patents*) by country groups.

In this respects, our hypothesis is that the standards quality imposed between developed countries could affect the exports of our sample in a different fashion.

Column (1) of Table 5 considers exports of middle income economies toward the rest of the world, column (2) analyses the exports of high income economies toward the rest of the world and finally column (3) considers the exports of OECD economies to the rest of the world.

In column 1, the production level of the exporting countries and consumption of importing ones show a positive and significant coefficient (0.679 and 0.27, respectively). As expected, common border and common language exert a positive and significant impact on trade (0.529 and 0.423 respectively), while distance and tariff reduces trade. Indeed, an increase in tariff of 10% implies a decrease of export equal to 0.4%.

The coefficient of our proxy of innovation is positive and significant. This implies that an increase of 10% of the number of utility patents increases trade by 0.3%. However, the coefficient of our quality measure is positive and not significant. The positive sign means that higher standards promote trade. Similarly, the interaction term between quality and patents is positive, but not significant.

In column 2, as expected, the effects of standard gravity variables are consistent with the theoretical gravity equation. While our proxy of innovation has a positive and significant coefficient, quality measure does not. The interaction variable shows a positive (0.052) and significant impact on trade at the 10% level. This implies that innovation helps sectors in high income economies to export high quality products, as required by the standards imposed by the importing partner.

In column 3, we still have the same results. Again, the standard gravity variables show the expected sign. Our key variables continue to exert the same impact. The positive and significant coefficient (0.063) of the interaction means that the OECD economies are able to comply with the standards introduced by the importing country.

These results are not surprising since countries with higher degree of development tend to offer similar products, in terms of quality, than those offered by other developed countries.

Therefore, developed countries are able to more easily fulfil the regulations imposed on their exports.

6. Concluding remarks

Our goal has been to provide an empirical analysis of the key role of the innovation to improve trade in presence of product standards required by the importing countries, in particular those concerning quality. Indeed, countries exporting in markets requiring higher product quality have more incentive to invest in innovation in order to enter international market, to be more competitive and then to gain a competitive advantage. We argue that innovation exerts an accelerator effect on quality standards. This paper also contributes to the literature investigating the role of standards on exports of manufactured products.

From a methodological point of view, the main contribution of the paper is to provide micro-level assessment of the impact of the simultaneous presence of NTMs imposed on foreign markets and a positive degree of innovation in exporting countries on trade flow. We estimate this impact using a gravity model based on disaggregated data at 3-digit level, to account for the heterogeneity of the policy across products.

From a policy perspective, we investigate whether measure of quality standards have been effective in stimulating additional exports and whether innovation is aimed at enabling countries to participate more fully in international trade. The issue concerning the NTMs is contentious, and widely debated in the literature, and this paper provides new evidence showing that some NTMs, as quality standards, increase the confidence of foreign consumers and have a significant impact on trade.

This analysis highlights that complying with foreign standards or regulations is a crucial element across trading partners. These measures may act as an additional cost of entering to the foreign markets. However, if a country is able to overcome these kind of barriers, then standards do not constrain trade and can even foster it through the support received from innovation and competitiveness across countries. In this context, we may think about the standards as a tool helping to improve quality of products through innovation and thus boost trade. This requires a major interaction between policy makers and industry needs. This might support innovation and promote the adoption of new technologies in order to increase consumers and environment protection.

Our analysis shows two important results. Firstly, at sector level, NTMs and patents have on average a positive impact on trade. Most notably, the coefficient of the interaction term between the measure of quality standards and the measure of innovation is even positive, implying that innovation helps sectors in a country to export high quality products, as required by the standards imposed by the importing partner. This interesting result recognizes a different role to the innovation process in the sense that it not only impacts on trade, but it also amplifies the positive effect of NTMs on exports.

Secondly, by splitting the original sample on the level of technology, we find that patents show a positive impact on the middle- and high-tech sectors. Quality standards have a positive impact on low- and middle-tech sectors, but a negative impact on high-tech ones. On the other hand, innovation seems to amplify the impact of quality standards on exports for low-tech sectors, whereas it reduces the negative impact of standards on exports for high-tech sectors. Splitting the sample by destination country, we show that the accelerator effect of the innovation on quality is strongly related to the level of development of exporting countries. On the one hand, adaptation costs imposed by international standards can be very high for less developed countries. As a consequence, countries that innovate are not able to face the complex rules linked to quality requirements and lose competitiveness. On the other hand, this reasoning does not apply to developed countries.

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