The effect of standards harmonization on trade, prices and quality: evidence from EU pesticides MRLs *

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August 2022

Abstract

Using data on Maximum Residue Levels (MRLs) in pesticides for 53 trading partners over 2005-2014, we examine the effect of the EU's 2008 MRL harmonization on trade, prices and quality. We consider both relative dyadic MRL restrictiveness and regulatory heterogeneity across EU Member States in our empirical analysis and find strong evidence for adverse effects of both on intra-EU trade at the extensive and intensive margins in the pre-harmonization period, which questions the implementation of the Cassis de Dijon principle. Our findings further suggest that the EU's MRL harmonization may have increased both the export probability and the export value of its non-EU (both OECD and developing country) partners and led to quality upgrading and lower prices of the traded products. The harmonization-induced rise in non-EU OECD exports to the EU also underlines the need for UK product standards to be closely aligned with those of EU27 post-Brexit.

JEL classification: F13, F14, I18

Key words: Standards and trade; Pesticides MRLs; Regulatory harmonization; EU; Quality upgrading; Brexit

*The data that support the findings of this study are available from the corresponding author upon reasonable request.

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1 Introduction

The steady decline in tariffs due to trade negotiations at the WTO has resulted in an increased preference for the use of non-tariff measures (NTMs). These measures include sanitary and phytosanitary (SPS) standards and technical barriers to trade (TBT), which though imposed for legitimate reasons - alleviating information asymmetries, mitigating consumption risks and promoting environmental sustainability - can also serve as instruments of disguised protectionism (for instance see Mahe, 1997; Swinnen and Vandemoortele, 2011, 2012; Grundke and Moser, 2019).

Maximum residue levels (MRLs) in pesticides are commonly-used agricultural product standards that denote the maximum amount of pesticide residue that is legally permitted to remain on treated crops. MRLs are set by scientists based on a rigorous evaluation of each legally authorized pesticide after the residue is demonstrated to be safe for consumption. As policy measures, countries choose the products they regulate, the pesticides they regulate for each product, as well as the MRL for a given product-pesticide pair.

The standards literature has studied the impact of MRL regulation on trade.[1] In this paper, we re-visit the effect of regulatory heterogeneity and its harmonization on bilateral trade using the near-natural experiment setting provided by the harmonization of MRL regulation within the EU, which has not yet been studied in this literature.[2]

Regulation (EC) No 396/2005 contains a list of MRLs that came into effect in September 2008 and effectively repealed Member State MRL regulation from there onwards. Thus, before 1 September 2008, a mixed system was in place with harmonized Community MRLs for about 250 active substances and national MRLs for the remaining substances. After this date, harmonized MRLs became applicable for all active substances used in plant protection products that have the potential to enter the food chain.

We examine the effects of this MRL harmonization within the EU using the Homologa data[3] on pesticide MRLs over 2005-2014 for 53 exporting and importing countries (details in Section 4.3). In addition to looking at the trade effects, we also examine the impact of the harmonization on product price and quality[4], building on recent work on this subject (Fernandes et al. 2019; Fiankor et al. 2020).

[1] The following section provides a review of literature relevant to this paper. For a more extensive review of the MRL-trade literature see Fiankor et al. (2020) and Shingal et al. (2020).

[2] Fiankor et al. (2020) focus on the EU in their sensitivity analysis and refer to the EU's MRL harmonization in that context but do not provide a detailed analysis of its effects as we do.

[3] These data are obtained from LEXAGRI International, a private company that maintains Homologa, the Gobal Crop Protection Database.

[4] We follow Khandelwal et al. (2013) in estimating unobserved product quality (details in Section 4.2).

We include both relative dyadic MRL restrictiveness and regulatory heterogeneity across EU Member States in the Common Market in our empirical analysis. Literature suggests that both differences in regulatory standards between the exporting and importing countries and diversity of standards within a Common Market like the EU can impose trade costs on exporting firms (for instance see Fernandes et al. 2019). In its report[5] on non-tariff barriers (NTBs) faced by Indian agricultural products, India's Agricultural and Processed Food Products Export Development Authority (APEDA) lists both (i) the requirement to meet more stringent standards in the EU and (ii) the lack of harmonization of product standards in EU Member States resulting in the need to approve products/production units by individual member countries, amongst NTBs faced by Indian agri-exporters in the EU.

The ease with which exporting country firms can meet stricter importing country standards depends on the level of regulation in the exporting country, the relative restrictiveness of importing country standards and on whether exporting country firms have a comparative advantage in meeting stricter regulation. Moreover, having to comply with more stringent regulation not only has a trade cost effect, but can also be associated with a demand-enhancing effect, especially if the exports are destined for markets where consumer preferences are more pro-food-safety (Xiong and Beghin, 2014; Shingal et al. 2020).

At the same time, heterogeneity in regulatory standards in a common market such as the EU increases the fixed product adaptation costs that exporting firms must pay in order to access the common market, discouraging market entry and reducing both the range of exported product varieties and export destinations. This trade cost effect could even be prohibitive for poor countries and for exporting firms at the margin by impeding the ability to adapt production processes quickly and adequately to meet diverse product standards across destinations in the common market, or to obtain testing and certification services required to demonstrate conformity. Harmonization is expected to eliminate these costs.

We find strong evidence for relative dyadic MRL restrictiveness and regulatory heterogeneity across EU Member States in the pre-MRL-harmonized period to be associated with adverse effects on intra-EU trade along both extensive and intensive margins, which questions the implementation of the Cassis de Dijon principle. The Cassis de Dijon principle is a cornerstone of the EU's internal market. It requires Member States to mutually recognise their national regulations in cases where there are no generally binding EU regulations. This means that goods produced and marketed in one EU Member State may be sold without further restrictions in all other Member States.

Our findings further suggest that the EU's MRL harmonization may have increased both

[5] http://apeda.in/apedahindi/Databank/NTBs_March_08.pdf

the export probability and export values of its non-EU, both OECD and developing country, partners. The harmonization-induced rise in non-EU developed country exports to the EU has important implications for the UK in the aftermath of Brexit and emphasizes the need for product standards in that country to be closely aligned with those of EU27 to enhance access to the Common Market (for instance see Sampson, 2017).

In other results, relative dyadic MRL restrictiveness is found to be associated with lower quality and higher quality-adjusted prices, irrespective of the source of stringency, for both intra- and extra-EU-traded products. This is consistent with the findings in Asprilla et al.(2019) and also suggests that the costs involved in meeting more stringent standards may be getting passed on to consumers, even after adjusting for any quality improvements. Notably, harmonization is found to improve the quality of exports to the EU, combined with a significant decline in quality-adjusted prices of the traded products.

In sum, our results suggest that consumers in the Common Market may have benefitted from both higher quality and lower prices of imported products as a result of harmonization along with an increase in trade itself along both the extensive and intensive margins. Our overall findings are robust to accounting for reverse causality; focusing on relative importer stringency; using elasticities of substitution disaggregated at the HS6-digit product level; using a pooled sample to estimate all effects; and to phasing the underlying data over three-year time periods.

Our paper makes several contributions to the standards-trade literature. We are the first to provide a detailed examination of the effects of the September 2008 MRL harmonization within the EU on both EU and non-EU exports destined to the Common Market as well as on the price and quality of the traded products. Second, we consider both relative MRL restrictiveness between the importer and exporter (including by source of stringency) and regulatory heterogeneity across EU Member States in our empirical analysis. Third, in contrast to most early studies on standards that use count data, we use continuous measures of relative dyadic MRL stringency and regulatory heterogeneity within the EU that arguably enable a more direct identification of the treatment effect. Fourth, we add to the limited strand of this literature that goes beyond examining the direct trade effects of standards and regulatory heterogeneity to studying the effects on prices and quality of the traded products. Finally, our findings on the positive effect of MRL harmonization on non-EU OECD exports to the EU add to the growing literature on Brexit.

The rest of the paper is structured as follows. The following section reviews the relevant literature while Section 3 provides a theoretical discussion motivating our empirical analysis. The empirics Section 4 describes the measures of regulatory heterogeneity used to examine the effects of MRL harmonization in the EU; discusses the price and quality measures used in the empirical analysis; presents the data; and discusses the estimation strategy and related issues. Section 5 presents and discusses the estimation results and Section 6 concludes.

2 Literature review

This select review looks at a few studies that have explored product standards harmonization in the context of the EU. In early work, Otsuki et al. (2001a, b) found the EU's harmonized aflatoxin standard to be associated with a 63% larger decline in select African food exports relative to the standard set by Codex. Understandably, their empirical strategy did not incorporate recent advancements in the estimation of structural gravity.

Chen and Mattoo (2008) used a sample selection gravity model to examine the impact of EU Harmonization Directives and Mutual Recognition Agreements (MRAs) on intra- and extra-EU trade. Baller (2007) adopted the same approach using data on both EU and ASEAN harmonization and MRAs. Both studies found harmonization to boost trade among harmonizing countries, as well as imports from third countries. Shepherd (2007) examined the effect of the share of the EU's (CEN European) standards in textile, clothing and footwear sectors identical to ISO standards on the variety of exports coming from non-EU countries into the EU and found a positive extensive margin effect.

Achterbosch et al. (2009) studied the impact of differences in pesticide MRLs on Chilean fruits exports to the EU-15 over 1996-2007 and found a 5% reduction in the EU's regulatory tolerance levels for MRLs to lead to a 14.8% decline in export volumes. Meanwhile, the papers closest to ours are De Frahan and Vancauteren (2006) and Fiankor et al. (2020).

De Frahan and Vancauteren (2006) examined the trade effects of harmonization of food regulations in the EU on intra-EU trade in food products over 1990-2001 and found harmonization to have a large and positive effect on import intensity both at the aggregate level and for individual food sectors. However, the authors looked at trade flows associated with harmonization initiatives in EC Directives, which may not provide the cleaner identification associated with our continuous measures of regulatory heterogeneity.

Fiankor et al. (2020) study the effect of relative importer stringency in MRLs on trade, prices and quality more broadly and in their sensitivity analysis, find intra-EU dyadic differences in MRLs in the pre-harmonization period to induce product quality upgrading among EU Member States. However, they do not examine the effect of harmonization along any dimension on EU's trade with its non-EU partners. Moreover, relative to their work, our product coverage is more focussed on HS Chapters 7 and 8; we distinguish between both relative dyadic importer and exporter stringency in MRLs; and we also examine the effect of regulatory heterogeneity across EU Member States in the Common Market.

Finally, consistent with the recent empirical trade literature (for instance see Baier et al. 2014; Piermartini and Yotov, 2016), and other work in this area (for instance see Disdier et al. 2014; Fernandes et al. 2019; Fiankor et al. 2020; Shingal et al. 2020), we also use three-way fixed effects to mitigate endogeneity-induced biases in the standards-trade relationship. This is different from the IV estimation approach used in earlier work by Baller (2007), Shepherd (2007) and Chen and Mattoo (2008). Moreover, we include data on intra-national trade in our empirical analysis, which not only makes our estimation theory-consistent (Fally, 2015) but also sets us apart from all other studies on this subject.

3 Theoretical discussion

The essential role of fixed costs for production and exports has been emphasized in both "New-trade-theory" and the heterogeneous firm literature. Whereas the former is motivated to explain intra-industry trade by implementing product differentiation in a monopolistic competition framework, the latter relaxes the assumption of firm homogeneity by arguing that exporting firms have fundamentally different characteristics from non-exporting firms in terms of productivity, wages, production volumes, and profits (Mayer and Ottaviano, 2007).

Melitz (2003) introduces firm heterogeneity via a productivity parameter. In this set-up, firms need to pay sunk entry costs to draw their productivity level from a cumulative Pareto distribution. This productivity level determines whether the firm exits the market, serves the domestic market only, or exports to foreign markets. Production requires fixed costs for serving the domestic market that incorporate both market access and fixed production costs.

Compliance with stricter food standards, especially in the presence of heterogeneity across imposing jurisdictions, requires additional fixed costs. Melitz (2003) already defines fixed costs broadly as "market access" costs. Stricter (relative to domestic) standards in the importing country enhance the market access costs. Besides costs emanating from dyadic differences in standards, there are additional (variable) production and (fixed) compliance costs if the standard varies across imposing jurisdictions in a Common Market like the EU.[6] These costs have a negative bearing on a firm's decision to export; and conditional upon exporting, on the number of products it exports; on the number of export destinations; and on the quantity/value of exports. This suggests that a reduction in these costs via

[6]Regulatory heterogeneity across destination markets may also affect producers' final marketing options, leading to a market redistribution among surviving exporters (for instance see Gaigné and Larue, 2016).

harmonization is likely to be associated with a trade-enhancing effect at both the extensive and intensive margins.

At the same time, meeting a stricter product standard in the destination market may also boost foreign demand via a demand shifter that signals quality upgradation (Ferguson, 2009; Xiong and Beghin, 2014; Shingal et al. 2020). Food crops subject to strict MRLs may signal a more sophisticated production process, and, hence be associated with higher product quality.[7] More stringent agricultural production standards can also be seen as a ban on cheaper technology (Vandemoortele and Deconinck, 2014) - meeting higher quality levels associated with more stringent regulation necessitates farmers upgrading their production technologies to include expensive inputs/specialised human capital as well as avoiding complete use of some pesticides and determining correct pre-harvest intervals (Fiankor et al. 2020).

Complying with importer-specific regulation is also likely to reduce information asymmetries, which again enhances quality claims (Fernandes et al. 2019). In fact, if exporting country firms already comply with stricter standards at home, it may be even less costly for them to meet importing country standards, resulting in a positive effect on trade, which may be further accentuated by well-informed, pro-food safety importing country consumers (Shingal et al. 2020). Harmonization changes both dyadic MRL differences and the magnitudes of relative stringency among trading partners and can thus either reinforce or subdue these differential effects. This also suggests that it may be important to account for the source of dyadic stringency for the proper estimation of the effect of heterogeneous standards and their harmonization on trade.

While the above discussion suggests that more stringent standards may lead to quality upgradation, theoretical predictions on the effects of standards and their harmonization on quality and (quality-adjusted) prices are less definite and often ambiguous (Fontagne et al. 2015; Curzi et al. 2020). Meeting stricter and diverse standards involves higher costs which may get passed-through to consumers as higher prices (Abel-Koch, 2013), though such costs are likely to be low if domestic industry has a comparative advantage in meeting more stringent regulation (Xiong and Beghin, 2013). At the same time, consumers may be more willing to pay for the higher quality that is likely to be associated with more stringent product standards (Abel-Koch, 2013).

Another possibility is that the exclusion of low-quality exports via standards may limit the scope for product quality differentiation (as quality differences between surviving firms fall), inducing, instead, a rise in price competition and a consequent reduction in quality-adjusted prices (for instance see Ronnen, 1991). Conversely, surviving firms may exploit the reduced

[7] For alternative views on this subject, see Handford et al. (2015) and Winter and Jara (2015).

competition to exert some form of market power and may end up charging higher prices without necessarily increasing their market shares (Asprilla et al. 2019).

On the whole, therefore, the effect of heterogeneous standards and their harmonization on price and quality remains an empirical question.

4 Empirics

4.1 Measures of regulatory heterogeneity

Exisiting work (for instance see Xiong and Beghin, 2013; Shingal et al. 2020) suggests that accounting for the source of heterogeneity may matter for the proper estimation of the effect of heterogeneous standards (and by extension, their harmonization). We thus consider both relative dyadic importer and exporter stringency in our empirical analysis. In the spirit of Winchester et al. (2012) and following Fernandes et al. (2019) and Shingal et al. (2020), we define two sub-indices S^M_{ijpt} and S^X_{ijpt}, denoting relative importer and exporter stringency respectively, as follows[8]:

At the pesticide level:[9]

$$s^m_{ijpkt} = \begin{cases} \frac{MRL_{ipkt} - MRL_{jpkt}}{max(MRL_{pkt}) - min(MRL_{pkt})} & \text{if } MRL_{ipkt} > MRL_{jpkt} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

$$s^x_{ijpkt} = \begin{cases} \frac{MRL_{jpkt} - MRL_{ipkt}}{max(MRL_{pkt}) - min(MRL_{pkt})} & \text{if } MRL_{ipkt} \leq MRL_{jpkt} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

And at the product level:

[8] One advantage of using these indices is that they fulfill all the desirable properties of heterogeneity indices viz. scale-invariance, convexity in protectionism, invariance to regulation intensity, monotonicity and having lower and upper bounds (for instance see Li and Beghin, 2014). Moreover, the indices are dyadic by construction, which is a requirement of our research objective.

[9] As a robustness check, we experimented with a stronger definition of relative exporter stringency, i.e. $MRL_{ipkt} < MRL_{jpkt}$. Our empirical findings were found to be robust to this change in definition.

$$S_{ijpt}^{M} = \frac{1}{K}\sum_{k=1}^{K} s_{ijpkt}^{m} \quad (3)$$

$$S_{ijpt}^{X} = \frac{1}{K}\sum_{k=1}^{K} s_{ijpkt}^{x} \quad (4)$$

where mrl_{ipkt} is the maximum residue level of pesticide k allowed by the exporter i to remain on product p, mrl_{jpkt} is the maximum residue level of pesticide k allowed by the importer j to remain on product p[10], and $\max MRL_{pkt}$ and $\min MRL_{pkt}$ are the maxima and minima of pesticides across all sample countries. The indices thus measure the relative difference in MRL regulation between exporter i and importer j, regarding the maximum residue level of pesticide k, on average, allowed to remain on product p, depending on whether the importer or the exporter is more stringent. The value of the indices range from zero (absence of relative MRL stringency) to one (maximum dissimilarity in regulation between trading partners).

We measure regulatory heterogeneity across EU Member States by the standard deviation (σ_{pt}^{EU}) of MRLs for each HS-6 digit product (averaged across pesticides used for that product) across importing EU countries. This measure is positive over the pre-harmonization period (2004-2008) and zero thereafter (reflecting harmonized MRLs post-2008).

Finally, we would also like to point out a few cases in the construction of the heterogeneity indices. Not all countries set MRLs for the same pesticide/crop combination; it can therefore be the case that the importing country sets an MRL for a k, p pair for which the exporter has not set a limit (or vice-versa) and we would therefore have to drop this observation as no comparison is possible. To minimize this from happening, and without imputing values arbitrarily, we resort to using default MRL values.[11] Some countries set default MRLs for any k, p combination that is not explicitly cited in their MRL regulation, such as the EU that sets an MRL of 0.01 mg/kg for any pesticide on any crop that is not listed in the European Commission Regulation No 396/2005.

Table 1 summarizes the pertinent default MRL cases. Thus, in cases where one of the partner countries was missing the MRL, we resort to the missing country's default value to compute the heterogeneity measures. In cases where there is no default MRL in place either, we replace the missing MRL with the sample's highest MRL following recent literature (Drogué

[10]Thus, mrl_{ipkt} and mrl_{jpkt} are non-negative variables, whose lower values indicate higher stringency.

[11]This has become an established practice in more recent strands of this literature; Drogué and DeMaria (2012), Xiong and Beghin (2014), Fernandes et al. (2019), Fiankor et al. (2020) and Shingal et al. (2020) all resort to the use of default values.

et al. 2012; Ferro et al. 2015; Fernandes et al. 2019; Fiankor et al. 2020; Shingal et al. 2020). This yields the full sample used for empirical analysis in this paper.

<Insert Table 1 here>

4.2 Measures of price, quality and quality-adjusted price

The agricultural trade literature has traditionally used prices (measured as unit values or the ratio of value to quantity in trade data) as a proxy for quality (for instance see Fernandes et al. 2019). Bilateral trade data provide the total nominal value of imports in US dollars from a given exporter (V_{ijpt}) and the associated quantity (Q_{ijpt}) in tonnes for each HS6-digit product, p, which are used to construct unit values thus: $UV_{ijpt} = V_{ijpt}/Q_{ijpt}$.

Despite being available for a wide range of products and countries, unit values tend to be imprecise proxies for quality as prices, per se, may also reflect higher production costs, exchange rates or market power. Following Khandelwal et al. (2013), we therefore recover quality directly from the observed trade data[12], based on the intuition that conditional on prices, varieties with higher quantities (market shares) are associated with higher quality (this assumes that quality is any non-price consumer-demand-enhancing attribute).

Assuming that consumer preferences incorporate quality, we consider the following CES utility function:

$$U = \left[\int_{\nu \epsilon V} [\lambda(\nu) q(\nu)]^{\frac{\sigma-1}{\sigma}} d\nu \right]^{\frac{\sigma}{(\sigma-1)}} \tag{5}$$

where $q(\nu)$ is the quantity consumed of variety ν, with quality denoted by $\lambda(\nu)$ and $\sigma(>1)$ is the elasticity of substitution that is assumed to be constant.

Maximising (5) subject to usual budget constraints yields consumer demand for product p traded between countries i and j dependent upon consumer income, product price and quality, and prices of substitute products, thus:

$$q_{ijpt} = \lambda_{ijpt}^{\sigma-1} \psi_{ijpt}^{-\sigma} P_{jt}^{\sigma-1} Y_{jt} \tag{6}$$

[12]Since different producers/firms may produce different qualities, the absence of farm/firm-level trade data implies that the estimated quality reflects the average quality of exports from a country in a specific product. Similar use of this estimation strategy at the product–country–year level can be found in Curzi and Pacca (2015) and Breinlich et al. (2016).

where q_{ijpt} is the quantity demanded, ψ_{ijpt} and λ_{ijpt} are the price and relative quality attributed to product p and P_{jt}, Y_{jt} denote the the price index and income level in the importing country. If we log-linearise equation (6) and move the endogenous price (measured in terms of unit value) to the left-hand side, then product quality can be estimated as the residual from the following OLS regression:

$$lnQ_{ijpt} + \sigma_{jk} lnUV_{ijpt} = \alpha_p + \alpha_{jt} + \varepsilon_{ijpt} \tag{7}$$

where Q_{ijpt} and UV_{ijpt} denote the quantity and price (unit value) of product p traded between countries i and j at time t; α_p are product fixed effects that capture differences in attributes across product categories emanating from inherent product characteristics; α_{jt} are importer-year fixed effects that account for prices and income in the importing country; σ_{jk} is the elasticity of substitution; and ε_{ijpt} is the residual. Equation (7) is estimated for each country and HS6-digit product separately to yield residuals from which quality is estimated as

$$lnQual_{ijpt} \equiv \hat{\varepsilon_{ijpt}}/(\sigma_{jk} - 1) \tag{8}$$

where σ_{jk} differs across HS3-digit product classes based on data from Broda et al. (2017).

Finally, quality-adjusted prices (QAP_{ijpt}) denote the difference in product prices for the same level of quality and are computed as the difference between the log of unit value and and estimated quality:

$$lnQAP_{ijpt} = lnUV_{ijpt} - lnQual_{ijpt} \tag{9}$$

4.3 Data: description, sources and summary statistics

Data on MRL regulation cover the period between 2005 and 2014 for 53 importing and exporting countries[13]. The MRLs data are sourced from LEXAGRI International, a private company that maintains Homologa, the Gobal Crop Protection Database, compiling information from relevant national ministries and legal publications. Trade data (value in USD '000s and quantity in tonnes) are sourced from UN Comtrade while data on bilateral (simple average applied) tariffs are taken from the International Trade Center.

[13] These include Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Egypt, India, Israel, Japan, Korea, Mexico, Malaysia, Norway, New Zealand, Russia, Singapore, South Africa, Switzerland, Thailand, Turkey, Ukraine, UK, USA, Vietnam and the 27 EU Member States.

Our empirical analysis focuses on trade in 31 products from the Homologa data (reported in Annex Table 1) in HS Chapters 7 and 8 that correspond to the agricultural fruit and vegetables sectors where pesticide MRLs are relevant. The salience of fruits and vegetables for analysis arises because these products are rejected more often than others like meat or dairy products.

Constructed unit value measures tend to be noisy because of measurement errors in the trade data at the disaggregated product level, which is also likely to affect the quality estimates. Following Fiankor et al. (2020), we deal with potential outliers in the price and quality estimations by excluding extreme unit values and the associated annual growth rates within the 1^{st} and 99^{th} percentiles as well as the estimated quality values within the 5^{th} and 95^{th} percentiles. This results in a 4.8% loss in the total number of observations.

Summary statistics are provided in Annex Table 2 for the full sample and the sub-samples of the EU's intra- and extra-EU trading partners. While the full sample has more than 828,000 observations, export values are only positive for 14% of these. Note that the correlation coefficient between the dyadic MRL restrictiveness indices S^M_{ijpt} and S^X_{ijpt} in the full sample was found to be -0.03, which obviates concerns about multicollinearity in estimation and further supports our strategy statistically to distinguish between relative importer and exporter stringencies in the estimating equations.

In the pre-harmonization period, the mean value of σ^{EU}_{pt} is found to be 1.6 in the full sample (see Table 2), providing evidence for heterogeneity in pesticides MRLs across EU Member States over 2004-2008. This is also corroborated by Figure 1 that shows, in the left and right panels, respectively, values of pesticides MRLs in EU Member States for EU and non-EU exporters; the data are averaged over 2004-2008. For intra-EU trade, Austria, Italy and Portugal are amongst the least stringent pesticides MRL regulating countries while Ireland, Czech Republic and Greece are amongst the most stringent. For non-EU trade, Germany, Austria and Portugal are amongst the least stringent while Sweden, Ireland and Greece are amongst the most stringent pesticides MRL regulating countries.

<Insert Figure 1 here>

Meanwhile, other evidence from this literature suggests that harmonization within the EU has generally tended towards the high range of initial standards. For example, Vogel (2009) points out that the role of the EU's richest and most powerful members, which have traditionally imposed the strictest standards, has been critical in setting the standards agenda within the EU; their political and economic importance has served to make EU standards progressively stricter.

The Communities (1998) Single Market Review also concludes that the harmonized standards in most reviewed industries have been made more stringent than initial levels in most member countries. The history of EU automobile emission, chemical, and packaging standards also demonstrates that these standards have frequently been harmonized at levels slightly higher than those preferred by the EU's most stringent states (Germany, Denmark, Netherlands), but lower than those favoured by less stringent members (Italy, UK, and Spain).

This stringent harmonization of standards is also true of the EU's MRL harmonization. Descriptive analysis of the pesticides MRL data before and after 2008 in Table 2 reveals that the MRLs have been harmonized at lower levels in the importing EU Member States post-2008 i.e. the regulation has been made more stringent. Thus, any increase in exports to the EU over 2009-2014 despite stricter importer standards is likely on account of harmonization.

<Insert Table 2 here>

Finally, the sample averages in Table 2 also suggest that the period after MRL harmonization was associated with greater export value for both intra-EU and non-EU partners exporting to the Common Market as well as higher quality-adjusted prices of the traded products in each case. We examine this prima facie evidence more formally in the next section.

4.4 Estimation strategy

We estimate a structural gravity model to examine the effect of the EU's MRL harmonization. This approach is consistent with a wide class of models, including Armington (Armington, 1969), monopolistic competition (Krugman, 1979), heterogeneous firms under monopolistic competition (Melitz, 2003), and heterogeneous firms under perfect competition (Bernard et al. 2003). Following Anderson and van Wincoop (2004), the value of exports from country i to country j of product p at time t can be written as follows:

$$X^p_{ijt} = \frac{E^p_{jt} Y^p_{it}}{Y^p_t} \left(\frac{\phi^p_{ijt}}{P^p_{it} \Pi^p_{jt}} \right)^{(1-\sigma^p)} \tag{10}$$

where X^p_{ijt} denotes the value of exports of product p from country i to j at time t, E^p_j is the expenditure in the destination country j of product p, Y^p_i denotes the total sales of exporter i towards all destinations, Y^p is the total world output of product p, ϕ_{ij} are the bilateral trade costs and σ^p is the elasticity of substitution across products. P^p_{it} and Π^p_{jt} are the Multilateral Resistance Terms (MRTs) that reflect the outward and inward relative resistance of a country's exports towards *all* destinations and from *all* origins. As these terms are difficult to construct directly, time-varying importer-product and exporter-product fixed effects are used to control for the MRTs in a panel setting (Anderson and Yotov, 2012).

Bilateral trade costs in ϕ_{ijpt} arise from different sources such as import tariffs, τ_{ijpt}; geographical distance between trading partners, $ln(DIST_{ij})$; cultural distance proxied by dummy variables identifying whether the trading partners share a common border, $CNTG_{ij}$, had a colonial relationship, $CLNY_{ij}$, and share a common language, $LANG_{ij}$.

These variables enter ϕ_{ijpt} as follows:

$$\phi^{1-\sigma}{}_{ijpt} = exp[\beta_1 ln(1+\tau_{ijpt}) + \beta_2 ln(DIST_{ij}) + \beta_3 CNTG_{ij} + \beta_4 CLNY_{ij} + \beta_5 LANG_{ij}] \quad (11)$$

Substituting (11) into (10), adding an error term, and taking the log of the resulting multiplicative model, yields the following equation:

$$ln(X_{ijpt}) = \beta_1 ln(1+\tau_{ijpt}) + \beta_2 ln(DIST_{ij}) + \beta_3 CNTG_{ij} + \beta_4 CLNY_{ij} + \beta_5 LANG_{ij} + \mu_{ipt} + \gamma_{jpt} + \epsilon_{ijpt} \quad (12)$$

where μ_{ipt} and γ_{jpt} are the time-varying exporter-product and importer-product fixed effects that proxy the MRTs and ε_{ijpt} is the error term.

In the context of this study, equation (12) is augmented to include S^M_{ijpt}, S^X_{ijpt} and σ^{EU}_{pt}. Note that dyadic differences in MRL regulation can not only add to bilateral trade costs but the information disclosed by more stringent regulation can also enhance demand in the importing country by altering consumer preferences (for instance see Xiong and Beghin, 2014; Shingal et al. 2020). Thus, the coefficients of $S^M{}_{ijpt}$ and $S^X{}_{ijpt}$ can be negative or positive. In contrast, regulatory heterogeneity across EU Member States is only likely to be associated with a trade cost effect and the coefficient of σ^{EU}_{pt} is thus expected to be negative.

To compare the average trade effects over 2005-2008 and 2009-2014 i.e. in the pre- and post-MRL harmonization periods, we interact these variables with H, a binary dummy that takes the value one over 2009-2014 and the value zero otherwise[14]. The coefficients of the interaction terms are expected to be positive.

Finally, recent advancements in the estimation of structural gravity advocate the use of three-way fixed effects to mitigate endogeneity-induced biases in estimation (for instance see

[14]Given the global financial crisis towards the end of 2008, H could also be interpreted as a pre- and post-GFC dummy; however, the use of year fixed effects in our estimating equations are expected to address confounding influences emanating from that recession.

Baier and Bergstrand, 2007; Baier et al. 2014; Piermartini and Yotov, 2016; Shingal et al. 2020). The bilateral trade cost variables in equation (12) are thus subsumed in bilateral pair-wise fixed effects (χ_{ij}), leading to the following baseline equation for OLS estimation:

$$ln(X_{ijpt}) = \beta_1 S^M{}_{ijpt} + \beta_2 H.S^M{}_{ijpt} + \beta_3 S^X{}_{ijpt} + \beta_4 H.S^X{}_{ijpt} + \beta_5 \sigma^{EU}_{pt} + \beta_6 H.\sigma^{EU}_{pt} + \beta_7 ln(1 + \tau_{ijpt}) + \mu_{ipt} + \gamma_{jpt} + \chi_{ij} + \epsilon_{ijpt} \quad (13)$$[15]

Since MRL harmonization is a EU-specific reform and the composition and determinants of intra-EU trade are different from those of the EU's trade with its non-EU partners, we split our country sample into two sub-samples:(i) the sample of intra-EU trading partners; and (ii) the sample of non-EU exporters accessing the Common Market. In further specifications, we also interact all regulatory indices with $OECD$, a binary dummy that takes the value one if an exporter belongs to the group of OECD countries and the value zero otherwise. This enables an examination of any differential effect of MRL harmonization for the EU's OECD and developing country partners.

4.4.1 Estimation issues

Two stylized features of trade data that challenge the estimation of structural gravity models are sample selection and heteroskedasticity (Xiong and Chen, 2014). In the agricultural trade sample we focus on, X_{ijpt} was found to equal 0 in 86% of all observations (see Annex Table 2). Sample selection was therefore clearly a concern with our data.

The Poisson Pseudo-Maximum Likelihood (PPML; Silva and Tenreyro, 2006) estimator is now regarded as the gold standard (Piermartini and Yotov, 2016) in the estimation of structural gravity models characterized by sample selection and heteroskedasticity. We therefore account for zero trade flows in the data using the PPML, which also addresses problems associated with heteroskedastic errors by characterizing trade multiplicatively in levels as opposed to log-linearly, leading to the following baseline PPML estimating equation:

$$X_{ijpt} = exp[\beta_1 S^M{}_{ijpt} + \beta_2 H.S^M{}_{ijpt} + \beta_3 S^X{}_{ijpt} + \beta_4 H.S^X{}_{ijpt} + \beta_5 \sigma^{EU}_{pt} + \beta_6 H.\sigma^{EU}_{pt} + \beta_7 ln(1 + \tau_{ijpt}) + \mu_{ipt} + \gamma_{jpt} + \chi_{ij}] + \epsilon_{ijpt} \quad (14)$$

Consistent with recent advancements in estimating structural gravity models (Piermartini and Yotov, 2016), the dependent variable also includes data on "internal" trade[16] i.e. the dependent variable includes data from country i to country j as well as country i to i.

[15] Note that H is collinear with the fixed effects and hence not explicitly included in this equation and the others that follow.

[16] This is the value of domestic agricultural production (sourced from FAOSTAT) less global exports for each sample country in the HS Chapters 7 and 8 products included in the analysis in this paper.

Inclusion of intra-national trade data is crucial for PPML to produce theory-consistent fixed effects estimates (Fally, 2015) and also accounts for the fact that any positive effects of harmonization on cross-border trade may be at the expense of intra-national trade. Including data on internal trade also sets us apart from all existing studies in the literature on this subject, none of which account for intra-national trade flows in their analysis.[17]

Finally, the price, quality and quality-adjusted price regressions are estimated using OLS as unit values cannot be computed for zero-value traded products, which are thus excluded from the sample for price and quality regressions. The dependent variable in equation (13) is replaced by $lnUV_{ijpt}$, $lnQual_{ijpt}$ and $lnQAP_{ijpt}$ in each case.

5 Results and analysis

In this section, we report estimation results on the effects of the EU's MRL harmonization on EU and non-EU exports destined to the Common Market for the full sample (missing MRLs replaced by default MRLs and sample maxima). This sample maximizes the number of observations available in our self-assembled database. Moreover, sample averages of importing country MRLs in Table 2 suggest that MRLs have been harmonized at lower levels (i.e. made more stringent) for both intra-EU and non-EU exporters for this sample. Thus, any increase in exports to EU destinations post-harmonization for this sample despite stricter importing country standards is most likely on account of harmonization, which enables a clear identification of the treatment effect.

5.1 Intra-EU trading partners

Table 3, columns (1) and (2), reports the baseline results using OLS and PPML for intra-EU trading partners in the data. All estimations include bilateral pair-wise and time-varying importer-product and exporter-product fixed effects. Note that the relative dyadic MRL indices are constructed at the HS6-digit level and are only bilateral by construction and not by definition. The product dimension in the fixed effects is thus defined at the HS-4 digit level to obviate concerns about collinearity with all the heterogeneity measures that are constructed at the HS6-digit level. This is a crucial element of our identification strategy and is motivated by existing work that uses fixed effects constructed at lower product dimensions than those of the outcome/main explanatory variables (for instance see Cadot et al. 2014; Fontagné et al. 2015; Beestermöller et al. 2018). Also, since the dyadic restrictiveness indices vary by dyad-product-year, the standard errors are also clustered at that level.

[17]That said, our overall findings remained unchanged if we excluded data on intra-national trade.

<Insert Table 3 here>

A priori, if the Common Market and the Cassis de Dijon principle were working perfectly, MRL harmonization within the EU should be redundant. Thus, we should not expect MRL harmonization within the EU to have any effect on intra-EU trade. In fact, even the coefficients of S^M_{ijpt}, S^X_{ijpt} and σ^{EU}_{pt} in the results reported in Table 3 columns (1) and (2), should be either economically or statistically indifferent from zero.

However, relative dyadic MRL restrictivenss, irrespective of the source of stringency, as well as regulatory heterogeneity across EU Member States, both have an adverse effect on intra-EU exports in both the OLS and PPML estimates, which are precisely estimated at the 1% level. This questions the implementation of the Cassis de Dijon principle.

Table 3 reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case[18] except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. In these results, a 1 s.d. increase in relative importer stringency leads to a 13.4% decline in intra-EU exports in the OLS results in column (1), ceteris paribus and on average; relative exporter stringency is found to reduce intra-EU trade by 6.7% and 28.1% in the OLS and PPML results, respectively. Moreover, a 1 s.d. increase in the standard deviation of MRLs across EU Member States is associated with a 16.4% and 18.2% decline in intra-EU exports in the OLS and PPML estimates, respectively.

These results thus provide strong evidence on the (non)working of the Internal Market and the Cassis de Dijon principle within the EU. While S^M_{ijpt}, S^X_{ijpt} and σ^{EU}_{pt} are zero by construction for intra-EU partners over 2009-2014, the negative coefficients on the variables in the pre-harmonization period suggest that regulatory heterogeneity within the EU had an adverse effect on intra-EU -trade over 2005-2008 and that this effect could likely be mitigated, if not completely reversed, by the EU's MRL harmonization in September 2008.

5.2 Non-EU countries exporting to the EU

Columns (6) and (7) of Table 3 report the baseline results for non-EU countries exporting to the EU. Again, all estimations include dyadic and time-varying importer-product and exporter-product fixed effects, with the product defined at the HS-4 digit level. The standard errors are again clustered by dyad-product-year.

[18]In the case of relative importer stringency, for instance, the marginal effect is calculated as $[exp(\hat{\beta}_1 * s.d.^{S^M_{ijpt}}) - 1]$ using the standard deviation of S^M_{ijpt} reported for the intra-EU sample in Annex Table 2.

Relative importer stringency, as well as regulatory heterogeneity across EU Member States, both have an adverse effect on non-EU exports to the Common Market in both the OLS and PPML estimates; relative exporter stringency also has a negative impact in the OLS results. In terms of magnitude, a 1 s.d. increase in relative importer stringency is associated with a 58.9% and 73.4% decline in extra-EU imports in the OLS and PPML results, respectively; the corresponding declines from a 1 s.d. increase in MRL differences within the EU are 7.7% and 15.4%.

Notably, the coefficients of the interaction terms are found to be positive and statistically significant for relative importer stringency in both OLS and PPML estimates and for relative exporter stringency in the OLS estimates. The magnitudes of these coefficients suggest that the adverse effect of relative importer stringency on non-EU exports to the EU over 2005-2008 may have been almost completely offset by the positive impact of the EU's MRL harmonization over 2009-2014. For non-EU exports destined to the Common Market, the effect of the EU's MRL harmonization translates into a 55.0% increase in exports (associated with relative importer stringency) in the OLS results[19]; in the PPML results the positive impact of harmonization is even more pronounced.[20]

Finally, while intra-EU tariffs are zero, tariffs are precisely estimated at the 1% level for extra-EU imports in the OLS estimates but lack statistical significance in the PPML results.

5.2.1 Decomposition of non-EU exporters into OECD and developing countries

Table 4 reports the marginal effects obtained from decomposing the results for the EU's non-EU exporters into OECD and developing country partners to enable an examination of any differential effect of MRL harmonization. The baseline suggests that a 1 s.d. increase in relative importer stringency reduces non-EU developing country exports to the EU by 54.8% and 82.1% in the OLS and PPML results, respectively; the corresponding declines for the EU's non-EU OECD partners are higher at 62.1% and 91.8%, respectively.

<Insert Table 4 here>

Harmonization leads to positive trade effects (via relative importer stringency) for both sets of partners, but with larger gains for the OECD group. These findings suggest that a post-Brexit UK may be well-served by aligning its product standards with those of EU27.

[19] This is calculated as $[exp(\hat{\beta}_2 * s.d.^{S^M_{ijpt}} * mean^H) - 1] * 100$ using the standard deviation of S^M_{ijpt} and mean of H as reported for the extra-EU sample in Annex Table 2.

[20] Unfortunately, the interaction term $H.\sigma^{EU}_{pt}$ was dropped in both the OLS and PPML estimations, so the effect of the EU's MRL harmonization could not be examined along this dimension.

Moreover, non-EU developing country exporters to the EU witness a 50.0% rise in exports from harmonization even via relative exporter stringency.

5.3 Price and quality analysis

MRL heterogeneity across EU Member States in the pre-harmonization period is found to be inversely related with unit values and product quality for intra-EU exporters (see columns 3-4 under panel A, Table 3); a 1 s.d. rise in the standard deviation of MRLs across EU Member States leads to respective declines of 11.1% and 9.9%. In the case of extra-EU imports, a 1 s.d. rise in MRL heterogeneity across EU Member States is found to lead to 7.0% and 8.0% declines, respectively, in the unit value and quality-adjusted prices of the traded products (see columns 8 and 10 under panel B, Table 3).

In contrast, relative MRL stringency, irrespective of its source, is found to be associated with higher unit values and quality-adjusted prices of both intra- and extra-EU traded products. This suggests that costs involved in meeting divergent standards may be getting passed on to consumers, even after adjusting for quality improvements.

A 1 s.d. increase in relative exporter stringency is also found to reduce product quality of intra-EU exports by 9.4% and that of extra-EU exports by 5.4%, ceteris paribus and on average. Meanwhile, relative importer stringency does not have a statistically significant effect on the quality of products traded within the EU, though a 1 s.d. rise in it reduces the quality of the EU's non-EU imports by 24.0% (see columns 4 and 9, Table 3).

Our results are consistent with the findings in Asprilla et al. (2019). Since relatively stringent standards induce exit of lower-quality firms, surviving firms exploit the reduced competition to exert some form of market power - they end up charging higher prices without necessarily increasing their market shares.

Meanwhile, harmonization is found to lead to a distinct improvement (9.0% and 12.4% via relative importer and exporter stringency, respectively) in the quality of non-EU exports to the EU, combined with 4.8% and 12.8% declines in quality-adjusted prices of the traded products. These findings are again consistent as a response to the adverse effects of regulatory heterogeneity observed in Asprilla et al. (2019) and point to gains for EU consumers from MRL harmonization both in terms of reduced prices and improved product quality.

Finally, in the context of the EU's extra-EU trade in these products, it is also interesting to observe how product prices and quality react to tariffs. Tariffs increase the price of imports relative to domestic production, but this also decreases the demand faced by foreign exporting firms and their market shares, leading to lower quality.

5.4 Extensive margin analysis

We also consider the impact of the EU's MRL harmonization on two alternative measures of trade at the extensive margin - the probability of exporting $[pr(X_{ijpt})]$ and the number of destination countries $(X_{ipt}^{\#j})$. The dependent variable in equation (13) is replaced by these measures in distinct regressions to examine the impact of the EU's MRL harmonization along these two dimensions of the extensive margin with the results reported in Table 5; the table again reports marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable.[21]

<Insert Table 5 here>

A 1 s.d. increase in relative importer stringency is found to reduce the probability of exporting by 1.1% and the number of export destinations by 14.1% in the sub-sample of intra-EU traders (see panel A), ceteris paribus and on average; the corresponding declines for non-EU exporters are 1.4% and 77.6%, respectively (see panel B). Notably, MRLs harmonization is found to offset these adverse effects on extra-EU trade by increasing the probability of exporting by 0.7% and almost doubling the number of export destinations.

Relative exporter stringency and divergence in MRL standards across EU Member States are also found to deter the probability of exporting by non-EU exporters; they also reduce the number of destination markets within the EU that non-EU exporters have access to by almost a third (see panel B). Meanwhile, harmonization is found to completely offset the adverse effect of relative exporter stringency on non-EU export probability and increase their number of export destinations by 59.4%.

5.5 Sensitivity analysis

5.5.1 Reverse causality

The level and stringency of MRLs may not depend solely on scientific and health concerns regarding the pesticide but also on economic and political determinants thereby leading

[21] Note that the number of observations reported in column (3) of Table 5 is far in excess of those reported in column (7) of Table 3. While both regressions include data on zero trade flows, more than 130,000 observations were singletons that were dropped in the high-dimensional fixed effects regressions (using ppmlhdfe in STATA; Correia et al. 2019) in the results reported in column (7) of Table 3 to prevent incorrect inference (see Correia, et al. 2015 for details). However, this also shows that our findings on the adverse effects of relative importer stringency and the positive impact of harmonization for extra-EU imports are robust to different effective sample sizes.

to reverse causality in the standards-trade relationship (Shingal et al. 2020). Thus, policy makers may adopt stringent standards to shield domestic industries from international competition in import-intensive sectors; analogously, exporting countries may deploy more stringent standards for products that are more likely to be exported (Xiong and Beghin, 2013). While the use of three-way fixed effects minimizes endogeneity-related concerns emanating from omitted variables and simultaneity, it does not account for reverse causality in the standards-trade relationship, which can still bias the estimates (Shingal et al. 2020). We thus lag all the heterogeneity indices by one year to account for potential endogeneity emanating from reverse causality. The results from these regressions are reported in Table 6 and are found to be qualitatively similar to the baseline estimates reported in Table 3.

<Insert Table 6 here>

5.5.2 Relative importer stringency

Descriptive analysis of the pesticides MRL data in Table 2 reveals that the MRLs have been harmonized at lower levels in the importing EU Member States i.e. the regulation has been made more stringent. Thus, any increase in exports to the EU over 2009-2014 despite stricter importer standards is likely on account of harmonization. In another robustness check, we therefore only included S^{M}_{ijpt} in the estimating equation and found the impact of relative importer stringency on trade, prices and quality to be qualitatively similar to the baseline results reported in Table 3. These results are reported in Table 7 .

<Insert Table 7 here>

5.5.3 Data phased over three-year time periods

Recent advancements in estimating structural gravity models (Piermartini and Yotov, 2016) suggest that the time-varying data be phased over different time periods to allow for adjustment effects. We thus phased all the underlying data over three-year time periods i.e. we re-estimated all equations only using data for the following four years - 2005, 2008, 2011 and 2014. All results from this reduced sample are reported in Table 8.

<Insert Table 8 here>

While the effects of all regulatory heterogeneity measures and the EU's MRL harmonization on extra-EU trade, prices and quality are qualitatively similar to the baseline results reported in Table 3 columns (6)-(10), this analysis also enables a direct examination of the impact of harmonization on intra-EU trade. The reported marginal effects suggest that harmonization, both via relative importer and exporter stringency, may have been associated with a large positive effect on intra-EU trade, especially in the OLS results (column 1), as well as significant improvements in quality and reductions in price of products traded within the EU.

5.5.4 Elasticities of substitution disaggregated at the HS6-digit level

In the price and quality analysis in Section 5.3, the elasticities of substitution needed for equation (8) are sourced from Broda et al. (2017) but these are based on highly aggregated HS3-digit product classes. As an additional robustness check, we used elasticities of substitution based on tariff elasticities computed by Fontagné et al. (2022) at the HS6-digit level. The results from this analysis, reported in Table 9, were also found to be qualitatively similar to those discussed in Section 5.3 and reported in columns (3)-(5) and (8)-(10) of Table 3.

<Insert Table 9 here>

5.5.5 Pooled sample

As a final robustness check, we relax the assumption of different data generating processes for intra- and extra-EU imports and estimate all results on a pooled sample using interaction terms with a binary dummy, EU, that takes the value one for intra-EU trading partners in the sample and the value zero for non-EU exporters to the Common Market. The results from these regressions, reported in Table 10, confirm that our overall findings on the positive effects of harmonization are robust to using a pooled sample.

<Insert Table 10 here>

The marginal effects associated with a 1 s.d. increase in ${S^M}_{ijpt}$, ${S^X}_{ijpt}$, σ^{EU}_{pt} and the variables interacted with the harmonization dummy in these results pertain to extra-EU imports and suggest that the 66.8% (55.0%) decline in extra-EU imports from relative importer (exporter) stringency may have been more than offset by a 91.5% (77.0%) increase post-harmonization in the PPML (OLS) results, ceteris paribus and on average. The marginal effects associated with a 1 s.d. increase in the EU-interacted variables suggest that relative importer and exporter stringency in the pre-harmonization period may have reduced intra-EU exports by 81.5% and 45.6%, respectively, in the OLS results. Moreover, a 1 s.d. increase in the standard deviation of MRLs across EU Member States may have been associated with a 5.8% decline in intra-EU exports.

The absence of a quality-upgrading effect of regulatory heterogeneity for both intra- and extra-EU imports is also observed in these results along with the positive effect on unit values and quality-adjusted prices of the traded products. The quality-upgrading and QAP-dampening impact of harmonization on extra-EU imports, observed in the baseline results reported in Table 3 columns (8)-(10), also persists in these results.

6 Conclusion

In September 2008, MRL regulation at the EU Member State level was replaced by Community-wide regulation, providing a near-natural experiment setting for analysis. In an original empirical contribution, this paper studies the effect of this MRL harmonization within the EU on its intra- and extra-EU imports and on the price and quality of the traded products.

Relative MRL differences betweeen intra-EU trading partners as well as regulatory heterogeneity across EU Member States in the pre-MRL-harmonized period are found to be associated with adverse effects on intra-EU trade at both intensive and extensive margins, which questions the implementation of the Cassis de Dijon principle. Our findings further suggest that MRL harmonization may have enhanced EU's trade with its non-EU partners at both margins and led to quality upgrading and reduced prices of imports, which are clear gains for consumers of these products in the Common Market.

The harmonization-induced increase in trade is observed for both non-EU developing and developed country exporters but is more pronounced for the latter; the finding has important implications for the UK following Brexit and emphasizes the need for product standards in that country to be closely aligned with those of EU27 to enhance access to the Common Market. Our overall findings are robust to accounting for reverse causality; focusing on relative importer stringency; using elasticities of substitution disaggregated at the HS6-digit level; using a pooled sample to estimate all effects; and to phasing the underlying data over three-year time periods.

One limitation of the analysis undertaken in this study is the application of insights from heterogeneous firm models at the country level, which ipso facto, cannot account for productivity and quality differences across firms within a country. It would therefore be useful to re-visit the findings from this study using firm-level data.

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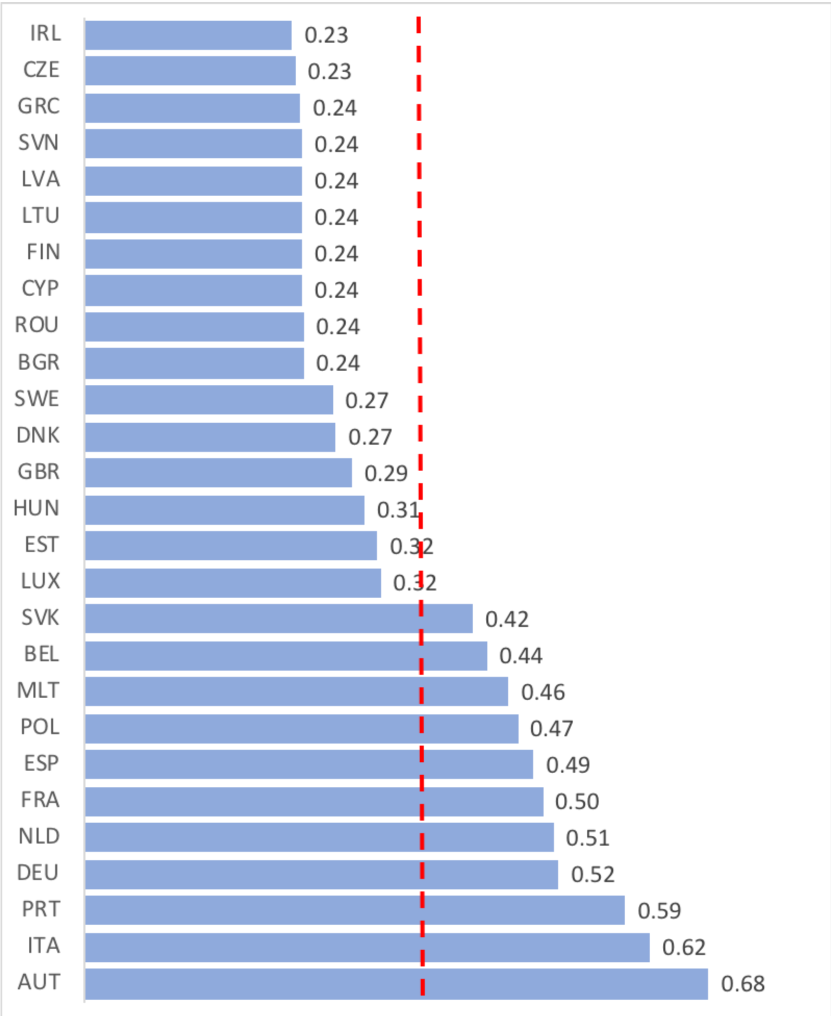
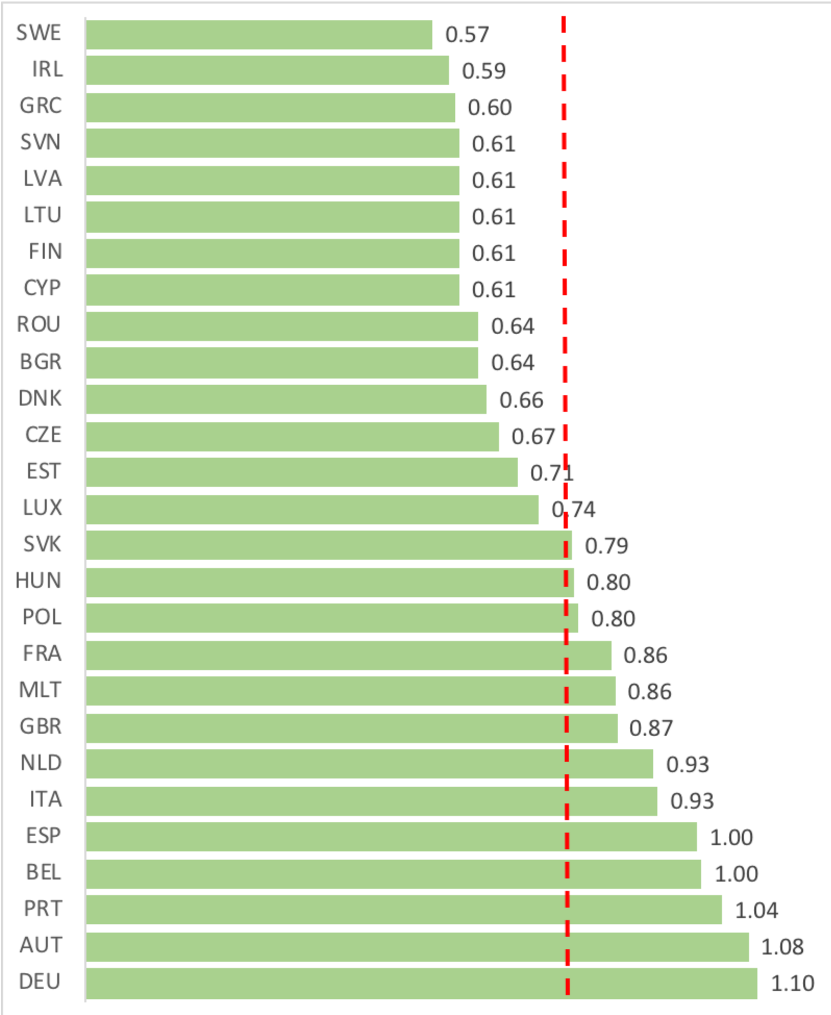
Figure 1: Pesticides MRLs in EU Member States on EU (left) and non-EU (right) exporters (avg. 2004-2008)





Note: The broken red lines denote the average MRLs across EU Member States on EU (left panel) and non-EU (right) exporters. Croatia only joined the EU in 2013 and is hence, excluded from this figure.

Table 1: Countries using Codex MRLs as default values if national regulation is missing

Country	First default	Second default
Argentina	Codex	0.01
Australia	0.01	
Brazil	Codex	
Canada	0.01	
Chile	Codex	
China	Codex	
Egypt	Codex	
European Union	0.01	
India	Codex	
Israel	Codex	
Japan	0.01	
South Korea	Codex	
Malaysia	Codex	0.01
Mexico	Codex	
New Zealand	0.01	
Norway	0.01	
Russia	Codex	
Singapore	Codex	
South Africa	Codex	0.01
Switzerland	EU	0.01
Thailand	Codex	
Turkey	Codex	
Ukraine	Codex	
USA	0.01	
Vietnam	Codex	0.01

Note: Default MRL information from mrldatabase.com (US FDA) except otherwise stated.

Table 2: Sample averages

	Intra-EU partners		Non-EU exp to EU imp	
	2005-2008	**2009-2014**	**2005-2008**	**2009-2014**
Average export propensity	0.288	0.289	0.070	0.066
Average export value ($)	657986	663587	86069	120459
Standard deviation of MRL across EUMS	1.646	0	1.643	0
Average unit value ($/kg)	4.071	3.119	2.872	4.572
Average quality (ln)	-0.121	-0.251	-0.330	-0.285
Average quality-adjusted price (ln)	0.545	0.812	0.840	1.017
Average importer MRL	1.177	0.401	2.176	0.989
Average exporter MRL	1.177	0.401	2.759	2.769

Table 3: Baseline estimates

	A: Intra-EU exports					B: Non-EU exports				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	(6)	(7)	**(8)**	**(9)**	**(10)**
	$\ln(X_{ijpt})$	**X_{ijpt}**	**$\ln(UV_{ijpt})$**	**$\ln(Qual_{ijpt})$**	**$\ln(QAP_{ijpt})$**	**$\ln(X_{ijpt})$**	**X_{ijpt}**	**$\ln(UV_{ijpt})$**	**$\ln(Qual_{ijpt})$**	**$\ln(QAP_{ijpt})$**
S^{M}_{ijpt}	-0.134***	-0.001	0.026***	-0.032	0.050**	-0.589***	-0.734***	0.088***	-0.240***	0.422***
	(13.127)	(20.320)	(4.697)	(13.846)	(14.844)	(2.006)	(9.655)	(0.488)	(0.778)	(1.067)
H. S^{M}_{ijpt}						0.550***	0.729***	0.031	0.090**	-0.048*
						(2.138)	(9.685)	(0.531)	(0.888)	(1.142)
S^{X}_{ijpt}	-0.067***	-0.281***	0.063***	-0.094***	0.184***	-0.226***	0.188	0.0830***	-0.054**	0.147***
	(16.706)	(27.763)	(3.873)	(9.852)	(10.798)	(7.618)	(11.731)	(0.855)	(2.083)	(2.303)
H. S^{X}_{ijpt}						0.484***	-0.057	-0.009	0.124***	-0.128***
						(11.939)	(18.953)	(1.771)	(4.109)	(4.012)
σ^{EU}_{pt}	-0.164***	-0.182***	-0.111***	-0.099***	-0.012	-0.077**	-0.154***	-0.070***	0.009	-0.080***
	(0.018)	(0.029)	(0.006)	(0.014)	(0.016)	(0.040)	(0.055)	(0.010)	(0.025)	(0.026)
$\ln(1+\tau_{ijpt})$						-2.664***	-0.972	0.825***	-0.626***	1.453***
						(0.286)	(0.475)	(0.056)	(0.145)	(0.149)
N	61,767	162,518	57,387	48,466	48,466	13,043	74,131	25,833	22,163	22,163
R2/Pseudo R2	0.678	0.792	0.564	0.568	0.611	0.701	0.763	0.683	0.626	0.69
Exp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Imp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exp-Imp FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The table reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. Columns (2) and (7) report PPML estimates; all other columns report OLS estimates. Product dimension in the fixed effects is at the HS4 digit level. Robust standard errors, clustered by dyad-product-year, included in parentheses. Significance levels *p<0.1, **p<0.05, ***p<0.01. H is a binary dummy that takes the value 0 over 2004-2008 and the value 1 after that.

Table 4: Non-EU exports (OECD vs non-OECD partners)

	Non-EU exports	
	(1)	**(2)**
	ln(X_{ijpt})	**X_{ijpt}**
S^{M}_{ijpt}	-0.548***	-0.821***
	(2.025)	(9.014)
H. S^{M}_{ijpt}	0.467***	0.828***
	(2.159)	(9.041)
S^{X}_{ijpt}	-0.161	-0.467
	(9.755)	(36.163)
H. S^{X}_{ijpt}	0.500***	0.380
	(13.363)	(39.372)
OECD.S^{M}_{ijpt}	-0.621***	-0.918***
	(12.980)	(22.032)
H.OECD.S^{M}_{ijpt}	0.718**	1.104***
	(14.044)	(25.084)
OECD.S^{X}_{ijpt}	-0.080	0.636
	(15.041)	(42.093)
H.OECD.S^{X}_{ijpt}	-0.018	0.036
	(26.454)	(70.405)
σ^{EU}_{pt}	-0.117*	0.003
	(0.058)	(0.078)
OECD.σ^{EU}_{pt}	0.023	-0.146***
	(0.080)	(0.104)
ln(1+τ_{ijpt})	-2.627***	1.011**
	(0.288)	(0.479)
N	13,043	74,131
R2/Pseudo R2	0.702	0.765
Method	OLS	PPML
Exp-prod-year FE	Yes	Yes
Imp-prod-year FE	Yes	Yes
Exp-Imp FE	Yes	Yes

Note: The table reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. Product dimension in the fixed effects is at the HS4 digit level. Robust standard errors, clustered by dyad-product-year, included in parentheses. Significance levels *p<0.1, **p<0.05, ***p<0.01. H is a binary dummy that takes the value 0 over 2004-2008 and the value 1 after that. OECD is a binary dummy that takes the value 1 for OECD Member States and 0 otherwise.

Table 5: Extensive margin analysis (OLS estimates)

	A: Intra-EU exports		B: Non-EU exports	
	(1)	**(2)**	**(3)**	**(4)**
	pr(X_{ijpt})	**$X_{ipt}^{\#j}$**	**pr(X_{ijpt})**	**$X_{ipt}^{\#j}$**
S^{M}_{ijpt}	-0.011***	-0.141***	-0.014***	-0.776***
	(1.293)	(13.329)	(0.033)	(2.563)
H. S^{M}_{ijpt}			0.007***	0.995***
			(0.034)	(2.642)
S^{X}_{ijpt}	-0.003	-0.111***	-0.001***	-0.273***
	(1.225)	(17.621)	(0.037)	(9.291)
H.S^{X}_{ijpt}			0.001***	0.594***
			(0.060)	(13.386)
σ^{EU}_{pt}	-0.018***	-0.251***	-0.003***	-0.289***
	(0.001)	(0.022)	(0.001)	(0.044)
$\ln(1+\tau_{ijpt})$			-0.015**	-5.450***
			(0.006)	(0.236)
N	214,536	61,767	206,810	13,043
R2/Pseudo R2	0.611	0.908	0.490	0.894
Fixed effects:				
Exp-prod-year	Yes	Yes	Yes	Yes
Imp-prod-year	Yes	Yes	Yes	Yes
Exp-Imp	Yes	Yes	Yes	Yes

Note: The table reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. Product dimension in the fixed effects is at the HS4 digit level. Robust standard errors, clustered by dyad-product-year, included in parentheses. Significance levels *p<0.1, **p<0.05, ***p<0.01. H is a binary dummy that takes the value 0 over 2004-2008 and the value 1 after that.

Table 6: Lagged estimates

	A: Intra-EU exports					B: Non-EU exports				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	$\ln(X_{ijpt})$	X_{ijpt}	$\ln(UV_{ijpt})$	$\ln(Qual_{ijpt})$	$\ln(QAP_{ijpt})$	$\ln(X_{ijpt})$	X_{ijpt}	$\ln(UV_{ijpt})$	$\ln(Qual_{ijpt})$	$\ln(QAP_{ijpt})$
S^{M}_{ijpt-1}	-0.183***	-0.009	0.029***	-0.022	0.049*	-0.487***	-0.831***	0.078***	-0.200***	0.334***
	(12.996)	(20.370)	(5.042)	(14.825)	(15.797)	(2.575)	(9.316)	(0.546)	(0.881)	(1.217)
H. S^{M}_{ijpt-1}						0.344***	0.418***	0.026	0.061**	-0.027*
						(2.750)	(9.681)	(0.615)	(1.038)	(1.330)
S^{X}_{ijpt-1}	-0.074**	-0.325***	0.067***	-0.115***	0.212***	-0.299***	0.083	0.076***	-0.059**	0.144***
	(16.814)	(27.818)	(4.097)	(11.023)	(12.014)	(6.834)	(9.198)	(0.899)	(2.144)	(2.423)
H. S^{X}_{ijpt-1}						0.503***	0.088	-0.004	0.116***	-0.115***
						(14.981)	(21.412)	(1.622)	(3.692)	(3.656)
σ^{EU}_{pt-1}	-0.193***	-0.172***	-0.112***	-0.095***	-0.017	-0.093**	-0.145***	-0.085***	0.004	-0.089***
	(0.018)	(0.028)	(0.007)	(0.016)	(0.018)	(0.041)	(0.054)	(0.011)	(0.028)	(0.029)
$\ln(1+\tau_{ijpt-1})$						-2.737***	-1.210***	0.752***	-0.890***	1.642***
						(0.285)	(0.443)	(0.064)	(0.157)	(0.163)
N	56,146	144,788	50,731	42,822	42,822	11,548	64,014	22,492	19,340	19,340
R2/Pseudo R2	0.679	0.791	0.559	0.572	0.612	0.705	0.763	0.678	0.626	0.688
Exp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Imp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exp-Imp FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The table reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. Columns (2) and (7) report PPML estimates; all other columns report OLS estimates. Product dimension in the fixed effects is at the HS4 digit level. Robust standard errors, clustered by dyad-product-year, included in parentheses. Significance levels *p<0.1, **p<0.05, ***p<0.01. H is a binary dummy that takes the value 0 over 2004-2008 and the value 1 after that.

Table 7: Considering only relative importer stringency

	A: Intra-EU exports					B: Non-EU exports				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
	$\ln(X_{ijpt})$	**X_{ijpt}**	**$\ln(UV_{ijpt})$**	**$\ln(Qual_{ijpt})$**	**$\ln(QAP_{ijpt})$**	**$\ln(X_{ijpt})$**	**X_{ijpt}**	**$\ln(UV_{ijpt})$**	**$\ln(Qual_{ijpt})$**	**$\ln(QAP_{ijpt})$**
S^{M}_{ijpt}	-0.155***	-0.043	0.060***	-0.083***	0.151***	-0.583***	-0.903***	0.075**	-0.233***	0.390***
	(11.893)	(25.982)	(4.062)	(12.376)	(12.979)	(1.967)	(9.574)	(0.501)	(0.786)	(1.095)
$H. S^{M}_{ijpt}$						0.540***	0.946***	0.035	0.074**	-0.029*
						(2.103)	(9.601)	(0.541)	(0.892)	(1.166)
σ^{EU}_{pt}	-0.162***	-0.169***	-0.118***	-0.087***	-0.033**	-0.079**	-0.157***	-0.069***	0.007	-0.075***
	(0.018)	(0.029)	(0.006)	(0.014)	(0.016)	(0.041)	(0.054)	(0.010)	(0.025)	(0.026)
$\ln(1+\tau_{ijpt})$						-2.830***	-0.910*	0.824***	-0.668***	1.500***
						(0.287)	(0.473)	(0.055)	(0.144)	(0.149)
N	61,767	162,518	57,387	48,466	48,466	13,209	75,227	25,920	22,246	22,246
R2/Pseudo R2	0.678	0.791	0.563	0.567	0.610	0.700	0.762	0.680	0.627	0.690
Exp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Imp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exp-Imp FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The table reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. Columns (2) and (7) report PPML estimates; all other columns report OLS estimates. Product dimension in the fixed effects is at the HS4 digit level. Robust standard errors, clustered by dyad-product-year, included in parentheses. Significance levels *p<0.1, **p<0.05, ***p<0.01. H is a binary dummy that takes the value 0 over 2004-2008 and the value 1 after that.

Table 8: Data phased over three-year time periods

	A: Intra-EU exports					B: Non-EU exports				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	$\ln(X_{ijpt})$	X_{ijpt}	$\ln(UV_{ijpt})$	$\ln(Qual_{ijpt})$	$\ln(QAP_{ijpt})$	$\ln(X_{ijpt})$	X_{ijpt}	$\ln(UV_{ijpt})$	$\ln(Qual_{ijpt})$	$\ln(QAP_{ijpt})$
S^{M}_{ijpt}	-0.829***	-0.379	0.125***	-0.243***	0.485***	-0.649***	-0.683*	0.031	-0.196***	0.272***
	(9.001)	(8.476)	(0.919)	(1.813)	(2.230)	(4.132)	(12.659)	(0.648)	(1.144)	(1.438)
H. S^{M}_{ijpt}	1.285***	0.258	-0.012	0.101**	-0.103**	0.592***	0.761*	0.031*	0.069**	-0.033*
	(9.070)	(8.534)	(0.959)	(1.891)	(2.288)	(4.269)	(12.694)	(0.707)	(1.265)	(1.525)
S^{X}_{ijpt}	-0.611	-0.970**	2.102***	-0.461**	4.955****	-0.650**	-0.481	0.550***	-0.144	0.839***
	(12.367)	(29.325)	(2.615)	(5.570)	(6.255)	(10.260)	(21.369)	(1.209)	(3.438)	(3.617)
H. S^{X}_{ijpt}	2.370***	6.235**	-0.401***	0.771***	-0.677***	0.748***	0.756	-0.153**	0.411**	-0.423***
	(19.654)	(35.010)	(3.548)	(8.330)	(8.625)	(18.616)	(28.703)	(2.726)	(7.191)	(6.955)
σ^{EU}_{pt}	-0.145***	-0.144***	-0.095***	-0.094***	0.000	-0.152***	-0.144***	-0.099***	-0.059***	-0.043*
	(0.025)	(0.039)	(0.008)	(0.020)	(0.022)	(0.029)	(0.047)	(0.009)	(0.022)	(0.025)
$\ln(1+\tau_{ijpt})$						-2.451***	0.636	0.727***	-0.842***	1.556***
						(0.458)	(0.877)	(0.095)	(0.238)	(0.248)
N	30,986	90,444	34,043	28,817	28,817	27,042	84,746	31,603	26,774	26,774
R2/Pseudo R2	0.737	YES	0.603	0.578	0.630	0.743	YES	0.607	0.588	0.639
Exp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Imp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exp-Imp FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The table reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. Columns (2) and (7) report PPML estimates; all other columns report OLS estimates. Product dimension in the fixed effects is at the HS4 digit level. Robust standard errors, clustered by dyad-product-year, included in parentheses. Significance levels *p<0.1, **p<0.05, ***p<0.01. t = 2005, 2008, 2011, 2014. H is a binary dummy that takes the value 0 in 2005 and 2008 and the value 1 in 2011 and 2014.

Table 9: Substitution elasticities disaggregated at the HS6-digit level (OLS estimates)

	A: Intra-EU exports			B: Non-EU exports		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	$\ln(UV_{ijpt})$	**$\ln(Qual_{ijpt})$**	**$\ln(QAP_{ijpt})$**	**$\ln(UV_{ijpt})$**	**$\ln(Qual_{ijpt})$**	**$\ln(QAP_{ijpt})$**
S^{M}_{ijpt}	0.024***	-0.009	0.032**	0.060*	-0.025*	0.032*
	(4.981)	(8.651)	(8.420)	(0.516)	(0.788)	(0.846)
H. S^{M}_{ijpt}				0.026	0.001*	-0.029*
				(0.583)	(0.893)	(0.942)
S^{X}_{ijpt}	0.061***	-0.033*	0.026**	0.089***	-0.054***	0.149***
	(4.072)	(3.947)	(7.119)	(0.887)	(1.655)	(1.701)
H. S^{X}_{ijpt}				-0.018	0.070***	-0.067***
				(1.909)	(3.268)	(3.113)
σ^{EU}_{pt}	-0.126***	-0.123***	-0.008	-0.087***	-0.027	-0.060***
	(0.006)	(0.011)	(0.011)	(0.010)	(0.022)	(0.023)
$\ln(1+\tau_{ijpt})$				0.762***	-0.134	1.196***
				(0.060)	(0.135)	(0.132)
N	58,259	55,689	55,689	26,291	24,555	24,555
R2/Pseudo R2	0.564	0.299	0.434	0.687	0.363	0.510
Exp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Imp-prod-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exp-Imp FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The table reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. Product dimension in the fixed effects is at the HS4 digit level. Robust standard errors, clustered by dyad-product-year, included in parentheses. Significance levels *p<0.1, **p<0.05, ***p<0.01. H is a binary dummy that takes the value 0 over 2004-2008 and the value 1 after that.

Table 10: Pooled estimates

	(1) $\ln(X_{ijpt})$	(2) X_{ijpt}	(3) $\ln(UV_{ijpt})$	(4) $\ln(Qual_{ijpt})$	(5) $\ln(QAP_{ijpt})$
S^{M}_{ijpt}	-0.456***	-0.668***	0.049**	-0.145***	0.223***
	(2.127)	(8.763)	(0.475)	(0.761)	(1.026)
$H.S^{M}_{ijpt}$	0.355***	0.915***	0.0245*	0.043*	-0.014*
	(2.254)	(8.802)	(0.516)	(0.858)	(1.095)
S^{X}_{ijpt}	-0.550***	0.252	0.337***	-0.215***	0.723***
	(6.587)	(9.429)	(0.825)	(2.008)	(2.260)
$H.S^{X}_{ijpt}$	0.770***	0.013	-0.031	0.536***	-0.391***
	(11.587)	(18.133)	(1.684)	(4.088)	(4.094)
σ^{EU}_{pt}	-0.055	-0.138**	-0.071***	0.004	-0.073***
	(0.039)	(0.068)	(0.010)	(0.024)	(0.025)
$\ln(1+\tau_{ijpt})$	-2.614***	0.937	0.816***	-0.592***	1.411***
	(0.275)	(0.531)	(0.055)	(0.140)	(0.144)
$EU.S^{M}_{ijpt}$	-0.815***	0.098	0.269***	-0.508***	1.344***
	(11.356)	(20.448)	(3.554)	(10.380)	(11.009)
$EU.S^{X}_{ijpt}$	-0.456*	-0.986***	1.073***	-0.666***	5.913***
	(15.544)	(27.743)	(3.250)	(8.531)	(9.257)
$EU.\sigma^{EU}_{pt}$	-0.058***	-0.026	-0.022***	-0.052***	0.032**
	(0.043)	(0.074)	(0.011)	(0.028)	(0.030)
N	75,188	247,358	83,527	70,847	70,847
R2/Pseudo R2	0.669	0.79	0.596	0.573	0.627
Method	OLS	PPML	OLS	OLS	OLS
Fixed effects:					
Exp-prod-year	Yes	Yes	Yes	Yes	Yes
Imp-prod-year	Yes	Yes	Yes	Yes	Yes
Exp-Imp	Yes	Yes	Yes	Yes	Yes

Note: The table reports the marginal effects from a 1 s.d. increase in the value of the explanatory variable in each case except for the estimated coefficients of the tariff variable that are directly interpreted as elasticities. Column (2) reports PPML estimates; all other columns report OLS estimates. Product dimension in the fixed effects is at the HS4 digit level. Robust standard errors, clustered by dyad-product-year, included in parentheses. Significance levels *p<0.1, **p<0.05, ***p<0.01. H is a binary dummy that takes the value 0 over 2004-2008 and the value 1 after that. EU is a binary dummy that takes the value 1 for intra-EU trading partners in the sample and the value 0 for non-EU exporters to the Common Market.

Annex table 1: List of included products

HS code	Product	HS code	Product	HS code	Product	HS code	Product
080211/2	Almonds	080920	Cherries	080710	Melons	080430	Pineapples
080810	Apples	080240	Chestnuts	100820	Millet	080940	Plums
080910	Apricots	070320	Garlic	071120	Olives	081020	Raspberries
070920	Asparagus	080221/2	Hazelnuts	070310	Onions	070970	Spinach
070930	Aubergine	081050	Kiwi	080510	Oranges	081010	Strawberries
080440	Avocados	080530	Lemons	080720	Papayas	080231/2	Walnuts
070410	Broccoli	080520	Mandarins	080930	Peaches	080711	Watermelons
070940	Celery	080450	Mangoes	080820	Pears		

Annex table 2: Summary statistics

	Full sample			Intra-EU			Non-EU to EU		
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**
X_{ijpt}	828,266	3932678	180000000	214,536	661479	7257731	210,560	106694	1960613
S^{M}_{ijpt}	816,321	0.010	0.044	214,536	0.000	0.002	210,560	0.021	0.067
S^{X}_{ijpt}	816,321	0.010	0.044	214,536	0.000	0.002	206,981	0.004	0.012
σ^{EU}_{pt}	828,266	0.600	0.490	214,536	0.619	0.998	210,560	0.658	1.016
H	828,266	0.600	0.490	214,536	0.624	0.484	210,560	0.600	0.490
UV_{ijpt}	120,479	2.675	2.978	57,584	2.481	2.720	26,623	2.881	3.142
$\ln(Qual_{ijpt})$	96,767	-0.270	2.160	48,675	-0.184	1.961	22,856	-0.304	1.985
$\ln(QAP_{ijpt})$	96,767	0.835	2.452	48,675	0.692	2.237	22,856	0.923	2.284
$\ln(1+\tau_{ijpt})$	828,266	0.052	0.121	214,536	0.000	0.000	210,560	0.054	0.110
Share of zero exports	86%			71%			93%		
Correlation bet. S^{M}_{ijpt} and S^{X}_{ijpt}	-0.0284			-0.0073			-0.0454		