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## **Regulatory Heterogeneity, Trade, and Global Agricultural Value Chains**

**Dela-Dem Doe Fiankor, Bernhard Dalheimer, and Gabriele Mack**

*Selected presentation for the International Agricultural Trade Research Consortium's (IATRC's) 2023 Annual Meeting: The Future of (Ag-) Trade and Trade Governance in Times of Economic Sanctions and Declining Multilateralism, December 10-12, 2023, Clearwater Beach, FL.*

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# Regulatory Heterogeneity, Trade, and Global Agricultural Value Chains

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IATRC Annual Meeting

December 12, 2023

# Roadmap

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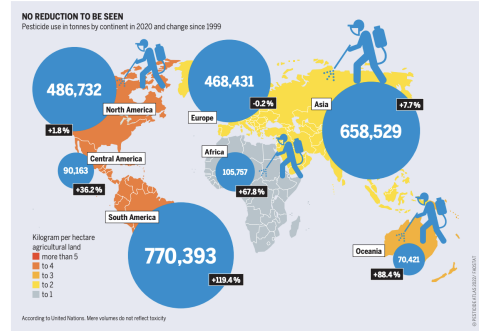
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# Pesticides and agriculture: a love-hate relationship

- Pesticide use in modern agriculture
- Consequences for the environment, biodiversity and human health
- Policy response — review and/or set new standards → maximum residue limits (MRL)



The global pesticide market is growing

<sup>1</sup>Image source: Pesticide Atlas, DW, WTO

# Pesticides and agriculture: a love-hate relationship

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- Consequences for the environment, biodiversity and human health
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Consumers are taking action

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<sup>1</sup>Image source: Pesticide Atlas, DW, WTO

# Pesticides and agriculture: a love-hate relationship

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Committee on Sanitary and Phytosanitary Measures

Original: English

ON-GOING REVIEW OF MAXIMUM RESIDUE LEVELS FOR PESTICIDES  
IN THE EUROPEAN UNION  
UNDER ARTICLE 12 OF REGULATION (EC) NO. 396/2005

COMMUNICATION FROM THE EUROPEAN UNION

*Revision*

The following communication, received on 1 July 2021, is being circulated at the request of the Delegation of the European Union.

## Announcing ongoing review of EU MRLs

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<sup>1</sup>Image source: Pesticide Atlas, DW, WTO

## Often there is nothing “standard” about standards across countries

**Table 1:** Maximum Residue Limits on selected products in 2018 (Source: Homologa)

Active element	Product	CHE	EU	Japan	USA	Canada	China	Codex
<i>Carbaryl</i>	Mandarins	0.01	0.01	7	10	10		15
<i>Fenbutatin-Oxide</i>	Apple	2	2	5	15	3	5	5
<i>Acetamiprid</i>	Apple	0.80	0.80	2	1	1	0.8	0.8
<i>Azoxystrobin</i>	Tomatoes	3	3	3	0.2	0.2	3	3
<i>Folpet</i>	Avocado	0.02	0.03	30	25	25		

Notes: MRLs are measured in parts-per-million (ppm).



## This paper: pesticide regulations and firm-level import decisions

1. Is there an effect of cross-country variations in pesticide regulations on firm-level import decisions? → Total imports, products, average imports per product

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**Setting:** exploit unique Swiss firm-level imports and data on MRLs.

## Previewing our findings

1. Regulatory heterogeneity decreases firm-level imports.
  - Total imports (↓↓↓) = Number of products (↓) + Average imports per product (↓↓)
  - Mechanism → Import prices (↑)
2. Firms that are engaged in GVC activity are more resilient
3. The effect is more pronounced for smaller firms

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## (1) Data on country and product specific pesticide regulations over time

- 522 products
- 511 active elements
- 65 countries

**Table 2:** Maximum Residue Limits on selected products in 2018  
(Source: The Global Crop Protection database)

Active element	Product	CHE	EU	Japan	USA	Canada	China	Codex
<i>Carbaryl</i>	Mandarins	0.01	0.01	7	10	10		15
<i>Fenbutatin-Oxide</i>	Apple	2	2	5	15	3	5	5
<i>Acetamiprid</i>	Apple	0.80	0.80	2	1	1	0.8	0.8
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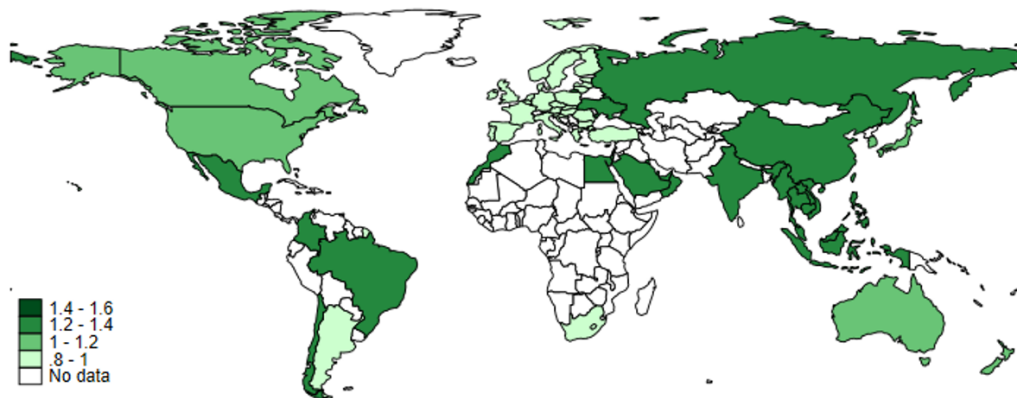
### — Measuring regulatory heterogeneity across product and time

$$MRL_{odpt} = \frac{1}{N_{cp}} \left[ \sum_{c \in N_p} \exp \left( \frac{MRL_{opt} - MRL_{dpt}}{MRL_{opt}} \right) \right] \quad (1)$$

$o$  = origin,  $d$  = Switzerland,  $p$  = product,  $t$  = time,  $c$  = active element



## Bilateral variation in pesticide regulations ( $MRL_{odpt}$ )



## (2) Data on firm-level imports from Swiss-Impex

Our unit of analysis is the firm

- Imports by firm-product-origin from 2016 – 2018
- 10,271 firms
- 255 products (HS8 digit level)
- 65 origin countries

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## Theoretical predictions

- Models that extend Melitz (2003) to incorporate the import of intermediate goods
  - Kasahara and Lapham (2013); Bas and Strauss-Kahn (2014); Antras et al. (2017); Movchan et al. (2020)
- Imports increase a firm's productivity but due to fixed costs of importing only inherently highly productive firms will import.
- Our fixed cost measure is an exogenous, government-imposed, minimum non-discriminatory quality regulation that moderates domestic market access.
- The marginal cost of trading increases with increasing differences in regulations across the source and destination.

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## 1. Decompose firm-level imports into extensive and intensive margins

$$\underbrace{X_{fopt}}_{\text{Total import values}} = \underbrace{N_{fopt}}_{\text{Extensive margin}} \times \underbrace{\bar{X}_{fopt}}_{\text{Intensive margin}} \quad (2)$$

where  $f$  = firms,  $o$  = origin,  $p$  = product,  $t$  = time

- The extensive margin is the unique number of products imported
- The intensive margin is the average import values per product per firm

This decomposition can be expressed in log form as:

$$\ln X_{fopt} = \ln N_{fopt} + \ln \bar{X}_{fopt} \quad (3)$$

## 2. Specify and estimate empirical model

$$\ln X_{fopt} = \beta_0 + \beta_1 MRL_{opt} + \beta_2 \ln(1 + Tariff_{opt}) + \lambda_{fpo} + \lambda_{ot} + \varepsilon_{fot} \quad (4)$$

- $X_{fopt}$  = Different import margins
- $MRL_{opt}$  = bilateral difference in MRL stringency between  $o$  and  $d$
- $Tariff_{opt}$  = MFN tariffs imposed by Switzerland on imports from  $o$
- $\lambda_{fpo}, \lambda_{ot}$  = firm-product-origin and origin-time fixed effects
- Equation (4) is estimated using OLS (with  $\varepsilon_{fopt}$  clustered at the  $fpt$  level)

### 3. Identification: estimating $\beta_1$

$$\ln X_{fot} = \beta_0 + \boxed{\beta_1 MRL_{opt}} + \beta_2 \ln(1 + Tariff_{opt}) + \lambda_{fpo} + \lambda_{ot} + \varepsilon_{fopt} \quad (5)$$

- Omitted variable bias — controlled using  $\lambda_{fpo}$  and  $\lambda_{ot}$
- Simultaneity — Imports can affect standard setting.
- Country-level pesticide regulations are exogenous to firm-level decisions, i.e.,  $E(\varepsilon_{fopt} | MRL_{opt}, \lambda_{fpo}, \lambda_{ot}) = 0$
- $\beta_1$  captures how cross-country and product variation in pesticide regulations affect within-firm import decisions.



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# (1) Pesticide regulatory differences decreases imports

	Total imports	Number of products	Average imports per product
	(1)	(2)	(3)
$MRL_{opt}$	-0.670*** (0.249)	-0.093* (0.048)	-0.576** (0.246)
$\text{Log}(1 + \text{Tariff}_{opt})$	-0.828*** (0.206)	-1.176*** (0.135)	0.347 (0.211)
Firm-origin-product FE	Yes	Yes	Yes
Origin-Year FE	Yes	Yes	Yes
$N$	50488	50488	50488
adj. $R^2$	0.868	0.991	0.887
Estimator	OLS	OLS	OLS

Notes:  $p$  values are in parentheses. \*\*\*, \*\* and \* denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. Standard errors are clustered at the firm-product-year level.

A one s.d. increase in  $MRL_{opt}$  reduces imports by 18%.

≡ *ad-valorem* tariff rate of 24%

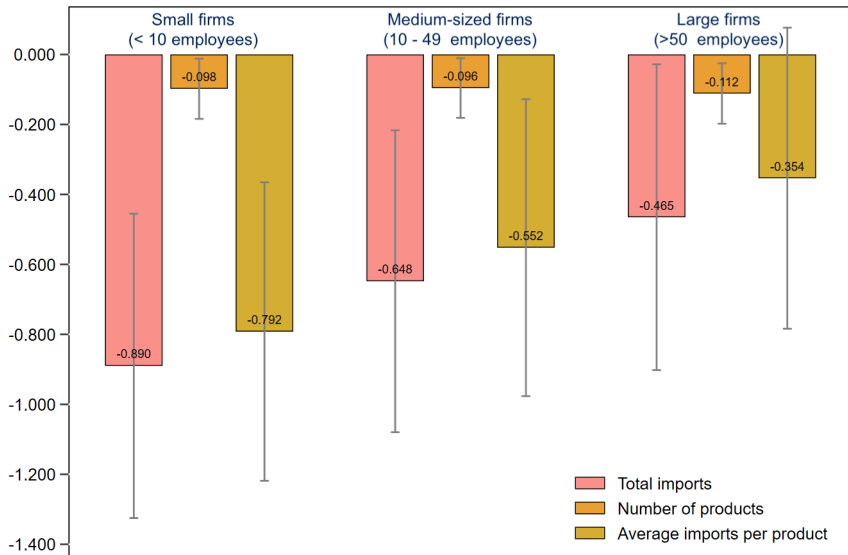
calculations

## (2) GVC firms are more resilient to pesticide regulatory differences

<i>Dependent variable (Log)</i>	Total imports	Extensive margin	Intensive margin
	(1)	(2)	(3)
$MRL_{opt}$	-0.742*** (0.250)	0.018 (0.047)	-0.760*** (0.255)
$GVC_{ft}$	-0.121 (0.092)	0.021** (0.008)	-0.142 (0.091)
$MRL_{opt} \times GVC_{ft}$	0.174** (0.021)	-0.011** (0.003)	0.184** (0.021)
Controls	Yes	Yes	Yes
Firm-origin-product FE	Yes	Yes	Yes
Origin-Year FE	Yes	Yes	Yes
$N$	50488	50488	50488
adj. $R^2$	0.868	0.991	0.887
Estimator	OLS	OLS	OLS

Notes:  $p$  values are in parentheses. \*\*\*, \*\* and \* denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. Standard errors are clustered at the firm-product-year level.  $GVC_{ft}$  is a dummy variable that takes the value 1 if firm  $f$  imports and exports in year  $t$ .

### (3) Size matters: large firms are more resilient to pesticide regulatory differences



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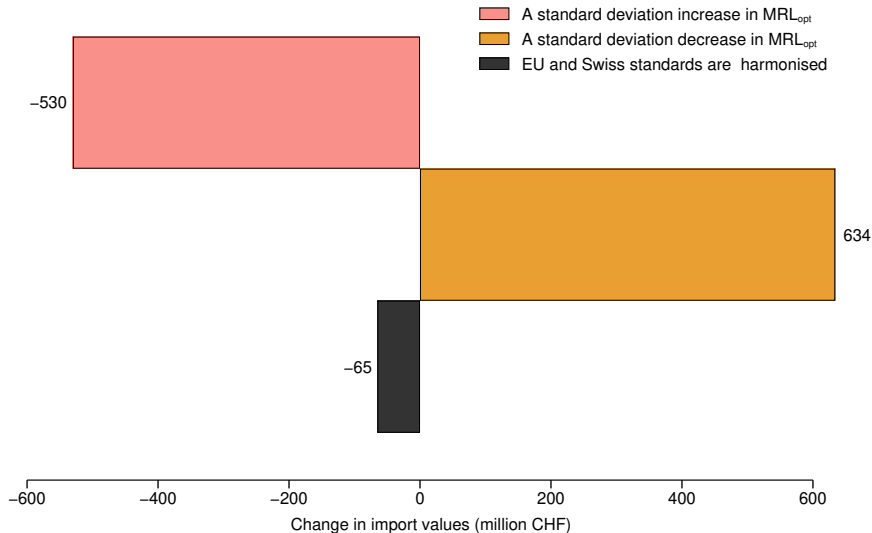
Conclusion

## Mechanism: lower import quantities due to increased import prices

<i>Dependent variable (Log)</i>	Import quantity (1)	Import prices (2)
$MRL_{opt}$	-0.471* (0.246)	0.122*** (0.027)
$\text{Log}(1 + \text{Tariff}_{opt})$	-1.043*** (0.212)	0.312*** (0.068)
Firm-origin-product FE	Yes	Yes
Origin-Year FE	Yes	Yes
$N$	50305	50305
adj. $R^2$	0.893	0.854
Estimator	OLS	OLS

Notes: The dependent variable in column (1) is the import volume in kg. The dependent variable in column (2) is import price, measured as unit values, for product  $p$  imported from origin country  $o$  in year  $t$ ,  $UV_{opt}$ .

## Simulating imports due to hypothetical country-product equivalence



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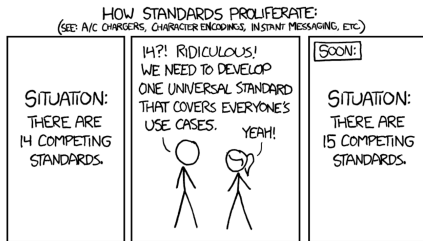
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# Implications for policy



## What is the policy goal?

- Regulatory convergence → efficiency gains
- Whose standard becomes the “standard”?
- In Shingal and Fiankor (forthcoming) we show the benefit of regulatory convergence

## Concluding remarks and main takeaways



- Differences in pesticide regulations decreases imports.
- Trade-off in welfare between prices and pesticide risks
- Smaller firms are less resilient  $\Rightarrow$  threatens inclusive supply chains

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<sup>1</sup>Image source: <https://www.arc2020.eu>

*Thank you for your attention*

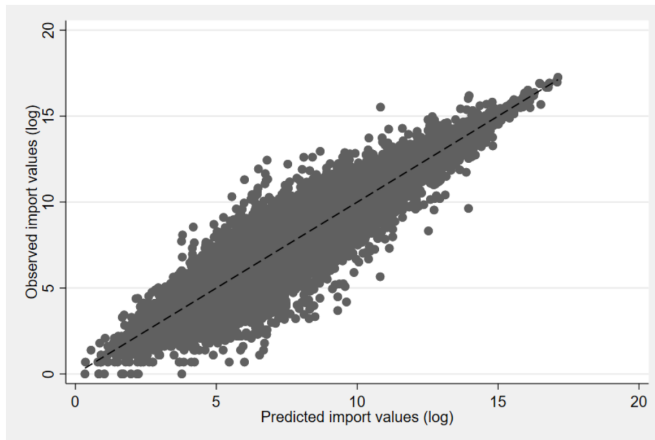
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## Summary statistics

Variable	Mean	SD	Min	Max	N
Import value (000 CHF)	69965	520647	1	31340624	50488
Import volumes (tonnes)	53780	1033227	0	159124704	50488
Extensive margin	529	776	1	2503	50488
Intensive margin	1050	48206	0.001	7445081	50488
$MRL_{opt}$	1.044	0.267	0.795	2.371	50488
$Tariff_{opt}$ (CHF/kg)	40	86	0	1756	50488
GVC	0.443	0.497	0	1	50488

## Observed and predicted import values



## Alternative measure of firm size

<i>Dependent variable (Log)</i>	Total imports	Extensive margin	Intensive margin
	(1)	(2)	(3)
$MRL_{opt}$	-1.463*** (0.254)	-0.098** (0.048)	-1.365*** (0.249)
$MRL_{opt} \times \text{Medium-size firm}$	0.726*** (0.034)	0.006 (0.004)	0.719*** (0.034)
$MRL_{opt} \times \text{Large-size firm}$	1.179*** (0.065)	0.006 (0.008)	1.173*** (0.065)
$\text{Log}(1 + \text{Tariff}_{opt})$	-0.872*** (0.205)	-1.176*** (0.135)	0.304 (0.209)
Firm-origin-product FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
$N$	50488	50488	50488
adj. $R^2$	0.871	0.991	0.889

Notes: The dependent variable in column (1) is the aggregate value of firm  $f$  imports from origin  $o$  in year  $t$ . The extensive margin is the number of active firms importing product  $p$  from origin  $o$  in year  $t$ , and the intensive margin is the average import value per product per firm in year  $t$ .  $p$  values are in parentheses. \*\*\*, \*\* and \* denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. Standard errors are clustered at the firm-product-year level. Intercept included but not reported.

### (3) Size matters: multi-product and multi-origin firms are more resilient

Table: Pesticide regulations and firm-level imports: multi-industry and multi-origin firms

<i>Dependent variable (Log)</i>	Total imports		Extensive margin		Intensive margin	
	(1)	(2)	(3)	(4)	(5)	(6)
$MRL_{opt}$	-0.785*** (0.251)	-0.772*** (0.249)	-0.096** (0.049)	-0.104** (0.048)	-0.689*** (0.248)	-0.667*** (0.246)
$MRL_{opt} \times \text{Multi-industry firms}$	0.120*** (0.034)		0.003 (0.006)		0.117*** (0.034)	
$MRL_{opt} \times \text{Multi-origin firms}$		0.104*** (0.030)		0.011*** (0.004)		0.093*** (0.029)
$\text{Log}(1 + \text{Tariff}_{opt})$	-0.832*** (0.207)	-0.827*** (0.207)	-1.176*** (0.135)	-1.175*** (0.135)	0.344 (0.211)	0.348* (0.211)
Firm-origin-product FE	Yes	Yes	Yes	Yes	Yes	Yes
Origin-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
$N$	504	50499	50488	50488	50488	50488
adj. $R^2$	0.868	0.868	0.991	0.991	0.887	0.887

Notes: The dependent variable in column (1) is the aggregate value of firm  $f$  imports from origin  $o$  in year  $t$ . The extensive margin is the number of active firms importing product  $p$  from origin  $o$  in year  $t$ , and the intensive margin is the average import value per product per firm in year  $t$ .  $p$  values are in parentheses. \*\*\*, \*\* and \* denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. Standard errors are clustered at the firm-product-year level. Intercepts included but not reported. Multi-industry firms are firms that import products in more than one four-digit industry over the study period. Multi-origin firms are firms that imported from more than one country over the study period.



## Alternate estimator: PPML

$$X_{fopt} = \exp \left[ \beta_0 + \beta_1 MRL_{opt} + \beta_2 \ln(1 + Tariff_{opt}) + \lambda_{fpo} + \lambda_{ot} \right] + \varepsilon_{fopt} \quad (6)$$

Table: Pesticide regulations and firm-level imports: PPML estimator

<i>Dependent variable (Log)</i>	Import value	Import volume
	(1)	(2)
$MRL_{opt}$	-0.973** (0.454)	-2.244*** (0.791)
$\text{Log}(1 + \text{Tariff}_{opt})$	-0.946*** (0.275)	0.123 (0.365)
Firm-origin-product FE	Yes	Yes
Origin-Year FE	Yes	Yes
Estimator	PPML	PPML
$N$	50488	50439

Notes: The dependent variable in column (1) is total Swiss import values in CHF of product  $p$  from origin country  $o$  in year  $t$ . The dependent variable in column (2) is total Swiss import volumes in kilograms of product  $p$  from origin country  $o$  in year  $t$ .  $p$  values are in parentheses. \*\*\*, \*\* and \* denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported.

## Ad-valorem tariff equivalents of pesticide regulatory heterogeneity

$$AVE_{MRL} = \left[ \exp \left( \frac{\alpha \beta_1}{\sigma} \right) - 1 \right] \times 100 \quad (7)$$

where  $\alpha$  measures a unit change in the policy variable.

- If we take the  $\beta_1$  and  $\sigma = \beta_2$  coefficients from column (1) of Table 5, we can compute the AVEs for different values of  $\alpha$ .
- For a one standard-deviation increase in  $MRL_{opt}$ , we obtain a tariff rate of 24%.

## Measuring regulatory heterogeneity relative to Codex standards

$$MRL_{pt} = \frac{1}{N_{cp}} \left[ \sum_{c \in N_p} \exp \left( \frac{MRL_{Codex_{pt}} - MRL_{dpt}}{MRL_{Codex_{pt}}} \right) \right] \quad (8)$$

Table: Pesticide regulations and firm-level imports

<i>Dependent variable (Log)</i>	Total imports	Extensive margin	Intensive margin
	(1)	(2)	(3)
$MRL_{pt}$	-0.242*** (0.081)	-0.045 (0.028)	-0.197*** (0.076)
$\text{Log}(1 + \text{Tariff}_{opt})$	-0.295*** (0.015)	-0.229*** (0.005)	-0.066*** (0.014)
Firm-origin FE	Yes	Yes	Yes
Origin-Year FE	Yes	Yes	Yes
$N$	20435	20435	20435
adj. $R^2$	0.554	0.387	0.570

Notes: The dependent variable in column (1) is total Swiss import values in CHF of product  $p$  from origin country  $o$  in year  $t$ . The dependent variable in column (2) is total Swiss import volumes in kilograms, of product  $p$  from origin country  $o$  in year  $t$ .  $p$  values are in parentheses. \*\*\*, \*\* and \* denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported.

## Alternative set of fixed effects

Table: Pesticide regulations and firm-level imports

<i>Dependent variable (Log)</i>	Import value		Import volume	
	(1)	(2)	(3)	(4)
$MRL_{opt}$	-0.276*** (0.044)	-0.321*** (0.112)	-0.364*** (0.048)	-0.492*** (0.130)
$\text{Log}(1 + \text{Tariff}_{opt})$	-1.608* (0.876)	-3.471** (1.386)	-1.560* (0.940)	-2.609** (1.174)
$\text{Log GDP}_{ot}$	0.138*** (0.013)	0.121*** (0.031)	0.130*** (0.014)	0.251*** (0.051)
$\text{Log Distance}_o$	-0.064*** (0.019)	-0.172*** (0.051)	-0.100*** (0.021)	-0.150*** (0.057)
$\text{Border}_o$	0.565*** (0.068)	0.884*** (0.138)	0.516*** (0.073)	0.446** (0.176)
$\text{Language}_o$	-0.368*** (0.062)	-1.006*** (0.120)	-0.440*** (0.067)	-0.687*** (0.152)
$\text{RTA}_{ot}$	0.176*** (0.048)	0.086 (0.115)	0.308*** (0.051)	0.273* (0.149)
Firm-product-year FE	Yes	Yes	Yes	Yes
<i>N</i>	37614	37614	37485	37599
Estimator	OLS	PPML	OLS	PPML

Notes: *p* values are in parentheses. \*\*\*, \*\* and \* denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. Standard errors are clustered at the firm-product-year level. Intercepts included but not reported.

## Trade and price effects are more pronounced for higher quality products

<i>Dependent variable</i>	High quality products		Low quality products	
	Import values	Import prices	Import values	Import prices
	(1)	(2)	(3)	(4)
$MRL_{opt}$	-1.986*** (0.675)	0.239*** (0.033)	-0.202 (0.303)	-0.005 (0.025)
$\text{Log}(1 + \text{Tariff}_{opt})$	-1.747*** (0.401)	-0.047 (0.467)	-2.016*** (0.385)	0.491 (0.318)
Firm-origin-product FE	Yes	Yes	Yes	Yes
Origin-Year FE	Yes	Yes	Yes	Yes
$N$	24429	18474	23988	17868
adj. $R^2$	0.875	0.740	0.869	0.772

Notes:  $p$  values are in parentheses. \*\*\*, \*\* and \* denote significance at 1%, 5% and 10% respectively. Standard errors are clustered at the firm-product-year level. Intercepts included but not reported. The lower number of observations is because the elasticity of substitution used to estimate product quality are not available for all product-origin country pairs. We compute the quality ladder as the difference between the maximum and the minimum value of estimated quality in a given product category. Products with quality ladder values below or equal to the median fall in the short-quality ladder category.