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.

Regulatory Heterogeneity, Trade, and Global Agricultural Value Chains

Dela-Dem Doe Fiankor
Agroscope, Switzerland

Bernhard Dalheimer
Purdue University, USA

Gabriele Mack
Agroscope, Switzerland

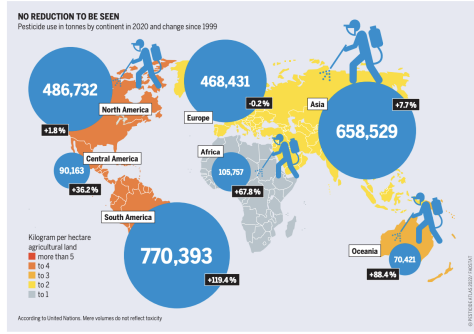
IATRC Annual Meeting

December 12, 2023

Roadmap

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

[1] Image source: Pesticide Atlas, DW, WTO

Pesticides and agriculture: a love-hate relationship

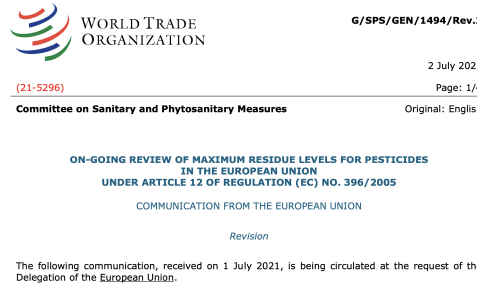
- Pesticide use in modern agriculture
- Consequences for the environment, biodiversity and human health
- Policy response — review and/or set new standards → maximum residue limits (MRL)

Consumers are taking action

[1] Image source: Pesticide Atlas, DW, WTO

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)



WORLD TRADE ORGANIZATION

G/SPS/GEN/1494/Rev.2

2 July 2021

(21-5296) Page: 1/4

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

[1]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
Carbaryl	Mandarins	0.01	0.01	7	10	10		15
Fenbutatin-Oxide	Apple	2	2	5	15	3	5	5
Acetamiprid	Apple	0.80	0.80	2	1	1	0.8	0.8
Azoxystrobin	Tomatoes	3	3	3	0.2	0.2	3	3
Folpet	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? $\longrightarrow$ Total imports, products, average imports per product

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? $\longrightarrow$ Total imports, products, average imports per product
   - Extends country-level supply-side analyses (Fiankor et al., 2021; Hejazi et al., 2022)
   - We deal with the endogeneity of the standards-trade relationship
   - Contribute to the empirical literature on firm-level importing behavior

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? $\longrightarrow$ Total imports, products, average imports per product
   - Extends country-level supply-side analyses (Fiankor et al., 2021; Hejazi et al., 2022)
   - We deal with the endogeneity of the standards-trade relationship
   - Contribute to the empirical literature on firm-level importing behavior
2. We augment our model with firm size and firm-level GVC activity to assess how productivity differences affect import behavior

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? $\longrightarrow$ Total imports, products, average imports per product
   - Extends country-level supply-side analyses (Fiankor et al., 2021; Hejazi et al., 2022)
   - We deal with the endogeneity of the standards-trade relationship
   - Contribute to the empirical literature on firm-level importing behavior
2. We augment our model with firm size and firm-level GVC activity to assess how productivity differences affect import behavior

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

Previewing our findings

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

Roadmap

(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
Carbaryl	Mandarins	0.01	0.01	7	10	10		15
Fenbutatin-Oxide	Apple	2	2	5	15	3	5	5
Acetamiprid	Apple	0.80	0.80	2	1	1	0.8	0.8
Folpet	Avocado	0.02	0.03	30	25	25		

(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)

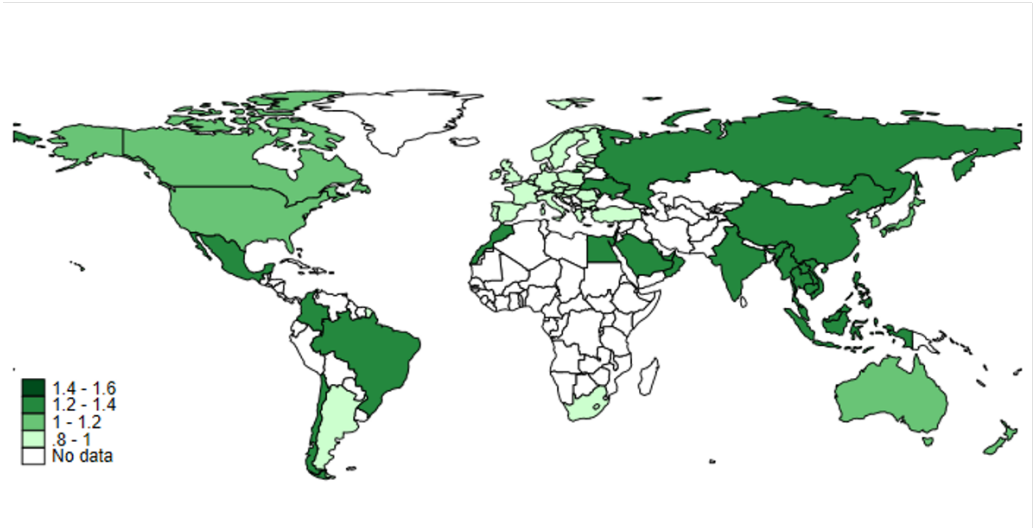
Active element	Product	CHE	EU	Japan	USA	Canada	China	Codex
Carbaryl	Mandarins	0.01	0.01	7	10	10		15
Fenbutatin-Oxide	Apple	2	2	5	15	3	5	5
Acetamiprid	Apple	0.80	0.80	2	1	1	0.8	0.8
Folpet	Avocado	0.02	0.03	30	25	25		

— Measuring regulatory heterogeneity across product and time

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

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

Roadmap

Introduction

Data

Theoretical framework

Empirical framework

Results

Mechanisms and Extensions

Conclusion

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.

Roadmap

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

$$\underbrace{X_{fopt}}_{\text{Total import values}} = \underbrace{N_{fopt}}_{\text{Extensive margin}} \times \underbrace{\bar{x}_{fopt}}_{\text{Intensive margin}} \tag{2}$$

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:

$$\ln X_{fopt} = \ln N_{fopt} + \ln \bar{x}_{fopt} \tag{3}$$

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*
- λ_{fpo}, λ_{ot} = firm-product-origin and origin-time fixed effects
- Equation (4) is estimated using OLS (with ε_{fopt} clustered at the *fpt* level)

3. Identification: estimating β_1

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

- Omitted variable bias — controlled using λ_{fpo} and λ_{ot}
- Simultaneity — Imports can affect standard setting.
- Country-level pesticide regulations are exogenous to firm-level decisions, i.e, $\mathrm{E}(\varepsilon_{fopt}|MRL_{opt}, \lambda_{fpo}, \lambda_{ot}) = 0$
- β_1 captures how cross-country and product variation in pesticide regulations affect within-firm import decisions.

Roadmap

(1) Pesticide regulatory differences decreases imports

	Total imports	Number of products	Average imports per product
	(1)	(2)	(3)
MRL_{opt}	−0.670***	−0.093*	−0.576**
	(0.249)	(0.048)	(0.246)
Log (1 + $Tariff_{opt}$)	−0.828***	−1.176***	0.347
	(0.206)	(0.135)	(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%

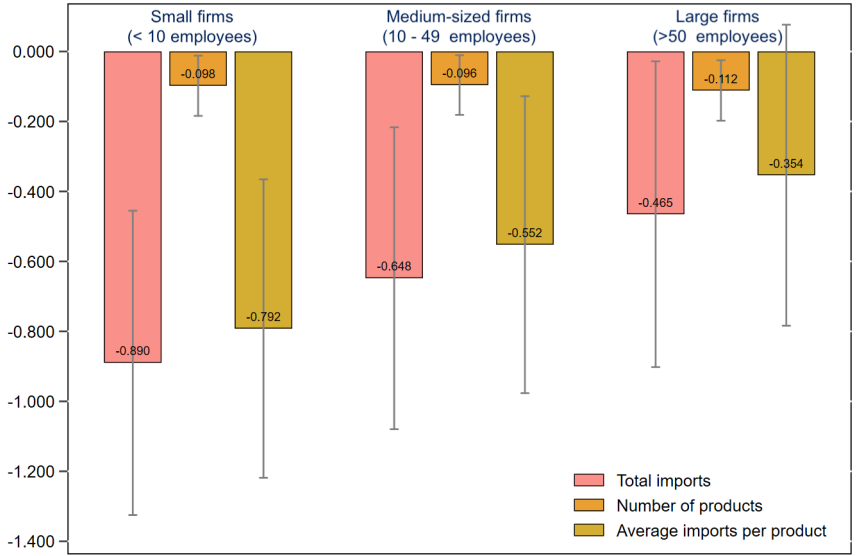
calculations

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

Dependent variable (Log)	Total imports	Extensive margin	Intensive margin
	(1)	(2)	(3)
MRL_{opt}	−0.742***	0.018	−0.760***
	(0.250)	(0.047)	(0.255)
GVC_{ft}	−0.121	0.021**	−0.142
	(0.092)	(0.008)	(0.091)
$MRL_{opt} \times GVC_{ft}$	0.174**	−0.011**	0.184**
	(0.021)	(0.003)	(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



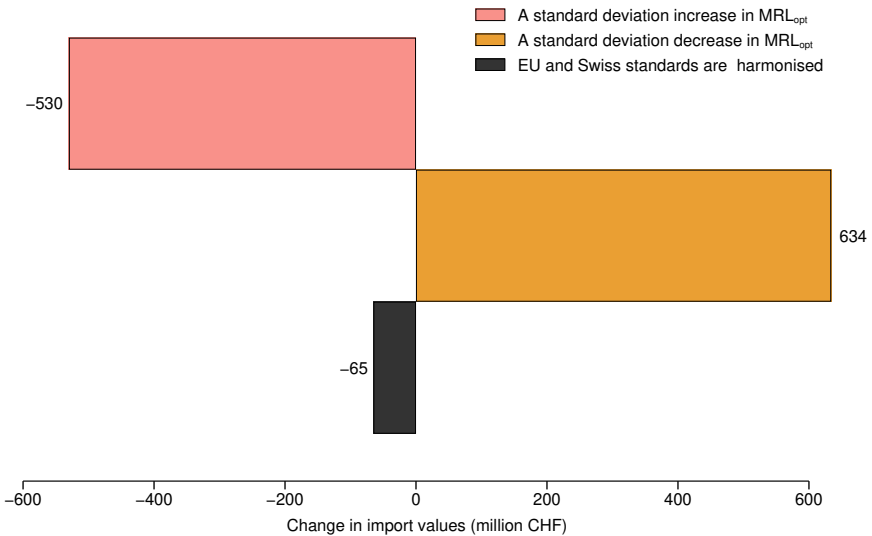
Roadmap

Mechanism: lower import quantities due to increased import prices

Dependent variable (Log)	Import quantity (1)	Import prices (2)
MRL_{opt}	−0.471*	0.122***
	(0.246)	(0.027)
Log (1 + $Tariff_{opt}$)	−1.043***	0.312***
	(0.212)	(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



Roadmap

Introduction

Data

Theoretical framework

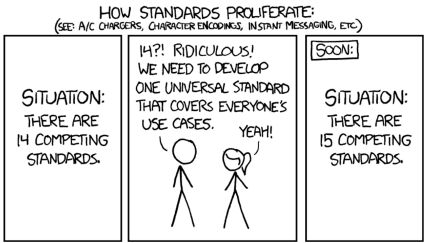
Empirical framework

Results

Mechanisms and Extensions

Conclusion

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

[1] Image source: https://www.arc2020.eu

Thank you for your attention

References

Antras, P., Fort, T. C. and Tintelnot, F. (2017). The margins of global sourcing: Theory and evidence from us firms. *American Economic Review* 107: 2514–2564.

Bas, M. and Strauss-Kahn, V. (2014). Does importing more inputs raise exports? firm-level evidence from france. *Review of World Economics* 150: 241–275.

Fiankor, D.-D. D., Curzi, D. and Olper, A. (2021). Trade, price and quality upgrading effects of agri-food standards. *European Review of Agricultural Economics* 48: 835–877.

Hejazi, M., Grant, J. H. and Peterson, E. (2022). Trade impact of maximum residue limits in fresh fruits and vegetables. *Food Policy* 106: 102203.

Kasahara, H. and Lapham, B. (2013). Productivity and the decision to import and export: Theory and evidence. *Journal of international Economics* 89: 297–316.

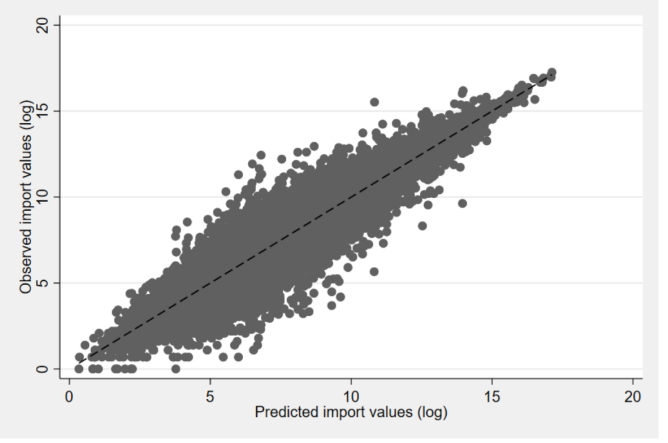
Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica* 71: 1695–1725.

Movchan, V., Shepotylo, O. and Vakhitov, V. (2020). Non-tariff measures, quality and exporting: evidence from microdata in food processing in ukraine. *European Review of Agricultural Economics* 47: 719–751.

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

Dependent variable (Log)	Total imports	Extensive margin	Intensive margin
	(1)	(2)	(3)
MRL_{opt}	-1.463^{***}	-0.098^{**}	-1.365^{***}
	(0.254)	(0.048)	(0.249)
MRL_{opt} × Medium-size firm	0.726^{***}	0.006	0.719^{***}
	(0.034)	(0.004)	(0.034)
MRL_{opt} × Large-size firm	1.179^{***}	0.006	1.173^{***}
	(0.065)	(0.008)	(0.065)
Log $(1 + Tariff_{opt})$	-0.872^{***}	-1.176^{***}	0.304
	(0.205)	(0.135)	(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

Dependent variable (Log)	Total imports		Extensive margin		Intensive margin	
	(1)	(2)	(3)	(4)	(5)	(6)
MRL_{opt}	−0.785***	−0.772***	−0.096**	−0.104**	−0.689***	−0.667***
	(0.251)	(0.249)	(0.049)	(0.048)	(0.248)	(0.246)
MRL_{opt} × Multi-industry firms	0.120***		0.003		0.117***	
	(0.034)		(0.006)		(0.034)	
MRL_{opt} × Multi-origin firms		0.104***		0.011***		0.093***
		(0.030)		(0.004)		(0.029)
Log $(1 + \text{Tariff}_{opt})$	−0.832***	−0.827***	−1.176***	−1.175***	0.344	0.348*
	(0.207)	(0.207)	(0.135)	(0.135)	(0.211)	(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

Dependent variable (Log)	Import value	Import volume
	(1)	(2)
MRL_{opt}	−0.973**	−2.244***
	(0.454)	(0.791)
Log (1 + $Tariff_{opt}$)	−0.946***	0.123
	(0.275)	(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

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

where α measures a unit change in the policy variable.

- If we take the β_1 and $\sigma = \beta_2$ coefficients from column (1) of Table 5, we can compute the AVEs for different values of α.

- For a one standard-deviation increase in MRL_{opt}, we obtain a tariff rate of 24%.

Measuring regulatory heterogeneity relative to Codex standards

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

Table: Pesticide regulations and firm-level imports

Dependent variable (Log)	Total imports	Extensive margin	Intensive margin
	(1)	(2)	(3)
MRL_{pt}	−0.242***	−0.045	−0.197***
	(0.081)	(0.028)	(0.076)
Log (1 + $Tariff_{opt}$)	−0.295***	−0.229***	−0.066***
	(0.015)	(0.005)	(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

Dependent variable (Log)	Import value		Import volume	
	(1)	(2)	(3)	(4)
MRL_{opt}	−0.276***	−0.321***	−0.364***	−0.492***
	(0.044)	(0.112)	(0.048)	(0.130)
Log $(1 + Tariff_{opt})$	−1.608*	−3.471**	−1.560*	−2.609**
	(0.876)	(1.386)	(0.940)	(1.174)
Log GDP_{ot}	0.138***	0.121***	0.130***	0.251***
	(0.013)	(0.031)	(0.014)	(0.051)
Log $Distance_o$	−0.064***	−0.172***	−0.100***	−0.150***
	(0.019)	(0.051)	(0.021)	(0.057)
$Border_o$	0.565***	0.884***	0.516***	0.446**
	(0.068)	(0.138)	(0.073)	(0.176)
$Language_o$	−0.368***	−1.006***	−0.440***	−0.687***
	(0.062)	(0.120)	(0.067)	(0.152)
RTA_{ot}	0.176***	0.086	0.308***	0.273*
	(0.048)	(0.115)	(0.051)	(0.149)
Firm-product-year FE	Yes	Yes	Yes	Yes
N	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

	High quality products		Low quality products	
Dependent variable	Import values	Import prices	Import values	Import prices
	(1)	(2)	(3)	(4)
MRL_{opt}	−1.986***	0.239***	−0.202	−0.005
	(0.675)	(0.033)	(0.303)	(0.025)
Log (1 + $Tariff_{opt}$)	−1.747***	−0.047	−2.016***	0.491
	(0.401)	(0.467)	(0.385)	(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.