A State-level Analysis of the Impact of a TTIP Harmonization of Food Safety Standards on US Agricultural Exports

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Abstract:

Abstract The Trans-Atlantic Trade and Investment Partnership (TTIP) agreement has the potential to intensify agricultural trade between the United States and the European Union. In particular, the cooperation on non-tariff barriers including food safety standards and sanitary and phytosanitary issues will expand agricultural trade. Using bilateral trade data at the U.S. state level, we empirically assess the impacts of a TTIP harmonization of food safety regulatory standards on US state agricultural exports to the E.U. We provide the first economic analysis of the possible TTIPagreement with policy implications for individual U.S. states. Quarterly trade series pertaining to major ports in the US and the MRLs that exemplify differences in food safety standards across the Atlantic are used. Deploying state-of-the-art gravity models and probit equations that address the high frequency of missing trade, we find that MRLs significantly diminish agri-food trade. The results reveal that a 10% reduction in MRL stringency would promote trade by nearly 6%. If the final provisions endorse the Codex MRLs, the TTIP agreement would boost US agricultural exports to the EU by more than one billion dollars a year. Coastal states with large agricultural sectors benefit the most from the reforms induced by a TTIP agreement.

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#608

1. Introduction

The Trans-Atlantic Trade and Investment Partnership (TTIP) negotiations between the United States (US) and the European Union (EU) have the potential to result in a comprehensive trade agreement that further integrates the two markets. The negotiation items range from the gradual removal of bilateral customs duties to the convergence of domestic regulations across the Atlantic. In particular, the agricultural sectors on both sides will be significantly affected by a forthcoming TTIP agreement as policies governing the agricultural sectors diverge substantially across the two markets.

Several studies in the literature have projected the economic impacts of a forthcoming TTIP agreement, with different scopes in the coverage of products, sectors, and policy reforms. In a report for the European Parliament, Bureau et al. (2014) project that the removal of tariffs and the 25% reduction in NTMs will raise EU's agricultural export to the US by 60% and import from the US by 120%. Beghin, Bureau, and Gohin (2017) show that the removal of tariffs and tariff-rate quotas in the biofuel and feedstock markets will boost the ethanol and biodiesel sector in the US and the sugar and isoglucose sector in Europe. Using a computational general equilibrium model, Cororaton and Orden (2016) report a modest gain in agricultural exports in both economies if the TTIP agreement does not substantially reduce non-tariff barriers, with larger gains from reductions in the latter. In an econometric analysis, Arita, Mitchell, and Beckman (2015) find that NTMs are highly restrictive for agri-food exporters from both the US and the EU. Akgul, Hertel and Villoria (2016) examine the possible removal of EU's ban on hormone-treated beef within a GTAP model accounting for productivity difference among beef processors. They find that beef trade across the Atlantic would rise by more than $400 million a year. Focusing on the elimination of tariffs and the harmonization of food safety standards, Xiong and Beghin (forthcoming) project that TTIP would promote US food exports to the EU by a quarter to a third. It is worth noting that the study utilizes country-level trade data and therefore misses the distribution of economic gains across individual states.

In this article, we leverage bilateral trade data at the US state level and evaluate the impacts of TTIP on U.S. food exports for individual states. As in Xiong and Beghin (forthcoming), we focus on Maximum Residue Limits (MRLs) across the Atlantic in order to illustrate the economic gains that could result from the reconciliation or harmonization of non-tariff barriers between the US and the EU.[1] Deploying a state-of-the-art econometric model, we find that MRLs significantly suppress agricultural trade. Specifically, we estimate that a 10% reduction in MRL stringency would promote trade by more than 6%. In the context of a forthcoming TTIP agreement, the adherence to Codex standards across the Atlantic would increase US agricultural exports to the EU by over one billion dollars a year. In particular, coastal states with large agricultural sectors would benefit most from the reforms induced by TTIP.

The remainder of the article is organized as follows. Section 2 reviews the progress of TTIP negotiations and the regulatory environments across the Atlantic. Section 3 focus on the divergence of MRLs across the US and the EU and highlights the room for harmonization in a few selected products. Section 4 uses an econometric model to quantify the impact of MRLs on the bilateral trade between US, EU, and third markets. In Section 5, we present the empirical results as well as simulate the economic gains from a potential TTIP agreement, with emphasis on the implications for various US states. Section 6 offers concluding remarks.

[1] Among all policy instruments of non-tariff barriers, MRLs are good candidates for empirical studies because (a) pesticide residue standards diverge substantially across the US and the EU markets, and (b) the measurement of pesticide residue standards usually takes the form of Maximum Residue Limit, which is numeric in nature (Xiong and Beghin, forthcoming).

2. Background of TTIP and agricultural markets across the Atlantic

The integration and cooperation of the EU and US economies are longstanding agendas. The proposed TTIP negotiations were initially launched in July, 2013, with the objectives of fostering market access, regulatory coherence, and modes of cooperation between the US and the EU (European Commission, 2015a). Although the TTIP negotiations remain in progress, official press releases indicate that the removal of tariffs and the minimization of the impacts of Sanitary and Phytosanitary (SPS) measures are top priorities. For instance, an EU position paper outlines that EU aims to "remove nearly all customs duties on EU-US trade" (European Commission, 2015b). In addition, both sides look forward to a SPS chapter in the potential TTIP agreement that "builds upon the key principles of the SPS Agreement of the World Trade Organization (WTO)" (European Commission, 2013). Most recently, the office of US Trade Representatives explicitly emphasized the need to identify "steps to reduce unnecessarily burdensome requirements and delays at our borders".[2]

Average customs duties are generally low between the US and the EU. Nevertheless, tariffs are higher for agricultural products than for manufactured goods (Josling and Tangermann, 2015). In agri-food markets, non-tariff measures (NTMs) including the SPS measures are in generally more stringent in the EU than in the US. For instance, the EU adopts tougher food safety standards for aflatoxin residues in food items (Xiong and Beghin, 2012), pesticide residues in food products (Li and Beghin, 2014), and growth additives in livestock industries such as hormones and ractopamine (Bureau, Marette, and Schiavina, 1998; Alemanno

[2] See "U.S.-EU Joint Report on TTIP Progress to Date", Press Release from the Office of the United States Trade Representative in January, 2017, which is available at https://ustr.gov/about-us/policy-offices/press-office/press-releases/2017/january/us-eu-joint-report-t-tip-progress-0

and Capodieci, 2012).

3. An overview of MRLs across the Atlantic

Traditional trade barriers such as custom duties are generally low in both the US and the EU markets. The simple average tariff for plant products is about 4% in the US and 10% in the EU (Xiong and Beghin, forthcoming). However, sanitary and phytosanitary measures diverge substantially across the two markets and disrupt bilateral agri-food trade significantly (Bureau et al., 2014; Josling and Tangermann, 2015). In particular, the regulatory regime governing pesticide residues differs substantially between the two markets. The primary policy instrument is the Maximum Residue Limit, which sets the maximum permissible rate of concentration for a specific chemical residue in a specific product. The Codex Alimentarius, a body under the United Nations Food and Agriculture Organization and the World Health Organization, develops international MRLs based on science. However, the Codex standards are voluntary in nature, as the WTO acknowledges member countries' sovereign right in conducting risk assessments and setting their own standards. Nevertheless, The SPS Agreement of the WTO encourages its members to use CODEX MRLs whenever they are available. It is worth noting that neither the US nor the EU has aligned the national standards with the Codex counterparts.

In this article, we use the GlobalMRL database to investigate MRLs in eight agricultural products (i.e., cabbage, garden pea, papaya, peach, potato, soybean, strawberry, and tomato). [3] We select the above eight products for two reasons. First, these food products are prone to pesticide contamination. Second, we are able to collect US state-level bilateral trade records for those eight products.[4] Table 1 displays the number of MRLs imposed on the selected products

[3] The global MRL database is available at https://www.globalmrl.com/db#login.
[4] One exception is US soybean, for which the US export series are unavailable in 2016.

by the chemical type. In particular, we compare the number of regulated substances across the US, the EU, and the Codex.

Table 1. Number of MRLs on selected products, by chemical type

Codex		**United States**		**European Union**	
Active Ingredient	*MRL count*	*Active Ingredient*	*MRL count*	*Active Ingredient*	*MRL count*
2,4-D	4	1-Naphthaleneacetamide	1	1-Naphthaleneacetamide	1
Abamectin	6	1-Naphthaleneacetic acid	1	1-Naphthaleneacetic acid	1
Acephate	1	6-Diisopropylnaphthalene (2, 6-DIPN)	1	2,4-D	5
Acetamiprid	6	2,4-D	4	2,4-DB	2
Aldicarb	1	2,4-DB	1	Abamectin	8
Alpha-Cypermethrin	6	Abamectin	7	Acephate	2
Ametoctradin	4	Acephate	1	Acequinocyl	3
Azoxystrobin	9	Acequinocyl	3	Acetamiprid	11
Benalaxyl	2	Acetamiprid	8	Acetochlor	2
Bentazon	2	Acetochlor	1	Acibenzolar-S-methyl	4
Benzovindiflupyr	1	Acibenzolar-S-methyl	4	Alachlor	2
Beta-cyfluthrin	5	Acifluorfen	2	Aldicarb	3
Bifenazate	5	Alachlor	1	Alpha-Cypermethrin	9
Bifenthrin	8	Aldicarb	2	Ametoctradin	4
Boscalid	8	Alpha-Cypermethrin	6	Amisulbrom	2
Buprofezin	4	Ametoctradin	4	Azoxystrobin	12
Captan	5	Amisulbrom	2	Benalaxyl	2
Carbaryl	3	Aviglycine	1	Bentazon	5
Carbon disulfide	1	Azoxystrobin	9	Benthiavalicarb-isopropyl	2
Chlorantraniliprole	9	Benalaxyl	2	Benzovindiflupyr	5
Chlorothalonil	6	Benoxacor	7	Beta-cyfluthrin	10
Chlorpropham	1	Bensulide	3	Bifenazate	9
Chlorpyrifos	5	Bentazon	3	Bifenthrin	11
Clethodim	4	Benthiavalicarb-	2	Boscalid	12

		isopropyl			
Clofentezine	1	Benzovindiflupyr	4	Buprofezin	6
Clothianidin	6	Beta-cyfluthrin	7	Captan	11
Cyantranilipro le	7	Bifenazate	7	Carbaryl	8
Cyazofamid	4	Bifenthrin	8	Carbon disulfide	1
Cyflumetofen	3	Boscalid	9	Carboxin	2
Cyfluthrin	5	Buprofezin	6	Carfentrazone-ethyl	12
Cypermethrin	1	Captan	8	Chlorantranilip role	12
Cyproconazol e	1	Carbaryl	7	Chlorfenapyr	2
Cyprodinil	5	Carbon disulfide	1	Chlorothalonil	8
Cyromazine	2	Carboxin	1	Chlorpropham	1
Deltamethrin	4	Carfentrazone-ethyl	9	Chlorpyrifos	8
Diazinon	7	Chlorantraniliprole	9	Clethodim	11
Dicamba	1	Chlorfenapyr	2	Clofentezine	2
Dicloran	1	Chlorimuron-ethyl	1	Clomazone	6
Difenoconazol e	7	Chlorothalonil	7	Clopyralid	3
Diflubenzuron	1	Chlorpropham	1	Clothianidin	7
Dimethenamid	2	Chlorpyrifos	5	Cyantraniliprol e	9
Dimethenamid -P	2	Clethodim	8	Cyazofamid	4
Dimethoate	2	Clofentezine	2	Cyflufenamid	1
Dimethomorp h	5	Clomazone	3	Cyflumetofen	3
Dinotefuran	4	Clopyralid	3	Cyfluthrin	10
Diquat dibromide	6	Cloransulam-methyl	1	Cymoxanil	3
Dodine	1	Clothianidin	6	Cypermethrin	1
Emamectin	2	Cryolite	5	Cyproconazole	2
Esfenvalerate	2	Cyantraniliprole	7	Cyprodinil	7
Ethephon	2	Cyazofamid	4	Cyromazine	4
Ethoprop	1	Cyflufenamid	1	DCPA	4
Etofenprox	1	Cyflumetofen	3	Deltamethrin	5
Famoxadone	3	Cyfluthrin	7	Diazinon	9
Fenamidone	4	Cymoxanil	3	Dicamba	2
Fenbuconazol e	1	Cypermethrin	1	Dichlobenil	1
Fenbutatin-oxide	2	Cyproconazole	1	Dicloran	3

Fenhexamid	4	Cyprodinil	7	Difenoconazole	9
Fenpropathrin	3	Cyromazine	4	Diflubenzuron	3
Fenpyroximate	5	DCPA	4	Dimethenamid	3
Ferbam	1	Deltamethrin	4	Dimethenamid-P	3
Fipronil	1	Diazinon	7	Dimethoate	8
Flonicamid	4	Dicamba	1	Dimethomorph	6
Flubendiamide	6	Dichlobenil	1	Dinotefuran	1
Fludioxonil	8	Dichlormid	7	Diquat dibromide	11
Fluensulfone	2	Dicloran	3	Diuron	2
Flumioxazin	6	Diclosulam	1	Dodine	2
Fluopicolide	3	Difenoconazole	8	EPTC	6
Fluopyram	8	Diflubenzuron	2	Emamectin	3
Flutolanil	1	Dimethenamid	2	Esfenvalerate	10
Flutriafol	6	Dimethenamid-P	2	Ethalfluralin	6
Fluxapyroxad	9	Dimethoate	5	Ethephon	2
Folpet	3	Dimethomorph	6	Ethoprop	2
Gamma Cyhalothrin	6	Dinotefuran	6	Etofenprox	12
Glufosinate-ammonium	3	Diquat dibromide	8	Etoxazole	7
Glyphosate	1	Diuron	2	Etridiazole	2
Hexythiazox	4	Dodine	2	Famoxadone	3
Imazapic-ammonium	1	EPTC	4	Fenamidone	4
Imazapyr	1	Emamectin	3	Fenbuconazole	1
Imidacloprid	9	Endothall	1	Fenbutatin-oxide	3
Indoxacarb	6	Esfenvalerate	8	Fenhexamid	4
Iprodione	2	Ethalfluralin	3	Fenpropathrin	9
Lambda Cyhalothrin	7	Ethephon	2	Fenpyrazamine	1
Malathion	3	Ethoprop	2	Fenpyroximate	6
Maleic hydrazide	1	Etofenprox	9	Fentin hydroxide	1
Mancozeb	5	Etoxazole	6	Fipronil	1
Mandipropamid	4	Etridiazole	2	Flonicamid	6
Mesotrione	1	Famoxadone	3	Fluazifop-P-butyl	4
Metaflumizone	2	Fenamidone	4	Fluazinam	7

Metalaxyl	6	Fenbuconazole	1	Flubendiamide	10
Metalaxyl-M (Mefenoxam)	6	Fenbutatin-oxide	3	Fludioxonil	12
Methomyl	6	Fenhexamid	4	Flufenacet	2
Methoxyfenozide	8	Fenoxaprop-Ethyl	1	Flumioxazin	8
Methyl bromide	6	Fenpropathrin	7	Fluopicolide	4
Metiram	1	Fenpyrazamine	1	Fluopyram	11
Metrafenone	2	Fenpyroximate	6	Fluoride	5
Myclobutanil	4	Fentin hydroxide	1	Fluoxastrobin	6
Novaluron	6	Ferbam	1	Flupyradifurone	12
Oxamyl	3	Fipronil	1	Flutolanil	4
Paraquat dichloride	7	Flonicamid	6	Flutriafol	7
Pentachloronitrobenzene	4	Fluazifop-P-butyl	3	Fluxapyroxad	12
Penthiopyrad	9	Fluazinam	4	Folpet	3
Permethrin	6	Flubendiamide	7	Fomesafen	8
Phorate	2	Fludioxonil	9	Fosetyl-Al	7
Phosmet	2	Fluensulfone	5	Fosthiazate	2
Piperonyl Butoxide	3	Flufenacet	1	Glufosinate-ammonium	4
Propamocarb hydrochloride	2	Flufenpyr-ethyl	1	Glyphosate	12
Propargite	1	Flumetsulam	1	Halosulfuron-methyl	8
Propiconazole	3	Flumiclorac-pentyl	1	Hexythiazox	5
Prothioconazole	2	Flumioxazin	7	Imazapic-ammonium	2
Pyraclostrobin	8	Fluopicolide	4	Imazapyr	1
Pyrethrins	2	Fluopyram	8	Imazaquin	2
Pyrimethanil	4	Fluoride	2	Imazosulfuron	3
Quinoxyfen	1	Fluoxastrobin	5	Imidacloprid	12
Saflufenacil	4	Flupyradifurone	9	Indoxacarb	7
Sedaxane	2	Fluthiacet-methyl	1	Ipconazole	5
Spinetoram	3	Flutolanil	3	Iprodione	3
Spinosad	6	Flutriafol	6	Iprovalicarb	2
Spirodiclofen	2	Fluxapyroxad	9	Isofetamid	1
Spirotetramat	6	Folpet	3	Isoxaflutole	2
Sulfoxaflor	6	Fomesafen	5	Lactofen	4
Tebuconazole	3	Fosetyl-Al	5	Lambda Cyhalothrin	10

Tebufenozide	2
Thiabendazole	2
Thiacloprid	1
Thiamethoxam	8
Thiodicarb	1
Thiophanate-methyl	3
Thiram	2
Tolylfluanid	1
Trifloxystrobin	7
Triflumizole	1
Triforine	1
Zeta-Cypermethrin	7
Ziram	3
Zoxamide	2
Codex Total	**505**

Fosthiazate	2
Gamma Cyhalothrin	6
Glufosinate-ammonium	3
Glyphosate	10
Halosulfuron-methyl	5
Hexythiazox	5
Imazapic-ammonium	1
Imazapyr	1
Imazaquin	1
Imazethapyr	2
Imazosulfuron	3
Imidacloprid	9
Indaziflam	1
Indoxacarb	6
Ipconazole	2
Iprodione	3
Iprovalicarb	2
Isofetamid	1
Isoxaflutole	1
Kasugamycin	2
Lactofen	3
Lambda Cyhalothrin	7
Linuron	3
MCPA	2
MCPB	1
Malathion	9
Maleic hydrazide	1
Mancozeb	5
Mandipropamid	4
Mepanipyrim	3
Mesotrione	2
Metaflumizone	3
Metalaxyl	9

Linuron	6
MCPA	3
MCPB	3
Malathion	12
Maleic hydrazide	1
Mancozeb	5
Mandipropamid	4
Mepanipyrim	3
Mesotrione	3
Metaflumizone	3
Metalaxyl	12
Metalaxyl-M (Mefenoxam)	12
Metaldehyde	9
Metconazole	4
Methomyl	10
Methoxyfenozide	11
Methyl bromide	11
Metiram	1
Metolachlor	8
Metrafenone	3
Metribuzin	8
Myclobutanil	7
Napropamide	4
Novaluron	8
O-phenylphenol	3
Oryzalin	3
Oxamyl	3
Oxydemeton-methyl	2
Oxyfluorfen	5
Paraquat dichloride	12
Pendimethalin	11
Penoxsulam	1
Pentachloronit	6

		robenzene	
Metalaxyl-M (Mefenoxam)	9	Penthiopyrad	11
Metaldehyde	6	Permethrin	8
Metconazole	3	Phorate	3
Methomyl	7	Phosmet	5
Methoxyfenozide	8	Phosphine	8
Methyl bromide	8	Picoxystrobin	2
Metiram	1	Prohexadione calcium	1
Metolachlor	5	Propamocarb hydrochloride	2
Metrafenone	3	Propargite	1
Metribuzin	6	Propiconazole	5
Myclobutanil	6	Propyzamide	1
Naled	6	Prothioconazol e	3
Napropamide	4	Pymetrozine	3
Norflurazon	2	Pyraclostrobin	11
Novaluron	7	Pyraflufen-ethyl	4
O-phenylphenol	3	Pyrethrins	6
Oryzalin	3	Pyridaben	4
Oxamyl	3	Pyridalyl	2
Oxathiapiprolin	6	Pyridate	1
Oxydemeton-methyl	2	Pyrimethanil	4
Oxyfluorfen	4	Pyriproxyfen	11
Oxytetracycline	1	Quinoxyfen	3
Paraquat dichloride	9	Quizalofop-ethyl	5
Pendimethalin	8	Rimsulfuron	5
Penflufen	3	S-metolachlor	9
Penoxsulam	1	Saflufenacil	6
Pentachloronitrobenze ne	5	Sedaxane	2
Penthiopyrad	8	Sethoxydim	10
Permethrin	7	Simazine	2
Phorate	2	Spinetoram	11
Phosmet	4	Spinosad	11
Phosphine	5	Spirodiclofen	2
Picoxystrobin	1	Spiromesifen	7
Piperonyl Butoxide	5	Spirotetramat	11
Prohexadione calcium	1	Spiroxamine	1
Propamocarb	2	Sulfoxaflor	7

hydrochloride	
Propargite	1
Propiconazole	4
Propyzamide	1
Prothioconazole	2
Pymetrozine	3
Pyraclostrobin	8
Pyraflufen-ethyl	3
Pyrethrins	4
Pyridaben	4
Pyridalyl	2
Pyridate	1
Pyrimethanil	4
Pyriofenone	1
Pyriproxyfen	8
Pyroxasulfone	1
Quinoxyfen	3
Quizalofop-ethyl	3
Rimsulfuron	4
S-metolachlor	6
Saflufenacil	3
Sedaxane	2
Sethoxydim	7
Simazine	2
Spinetoram	8
Spinosad	8
Spirodiclofen	2
Spiromesifen	5
Spirotetramat	8
Spiroxamine	1
Streptomycin	2
Sulfentrazone	6
Sulfoxaflor	6
Sulfuryl fluoride	2
Tebuconazole	3
Tebufenozide	2
Teflubenzuron	3
Tepraloxydim	1

Sulfuryl fluoride	5
Tebuconazole	4
Tebufenozide	2
Teflubenzuron	4
Tepraloxydim	2
Tetraconazole	4
Thiabendazole	9
Thiacloprid	1
Thiamethoxam	11
Thifensulfuron-methyl	2
Thiodicarb	3
Thiophanate-methyl	5
Thiram	2
Tolylfluanid	1
Tri-Allate	3
Tribenuron Methyl	2
Trifloxystrobin	11
Triflumizole	4
Trifluralin	9
Zeta-Cypermethrin	10
Zinc phosphide	1
Ziram	3
Zoxamide	2
EU Total	**1,124**

Terbacil	2
Tetraconazole	3
Thiabendazole	6
Thiacloprid	1
Thiamethoxam	8
Thifensulfuron-methyl	1
Thiodicarb	2
Thiophanate-methyl	4
Thiram	2
Tioxazafen	1
Tolfenpyrad	3
Tolylfluanid	1
Tri-Allate	2
Tribenuron Methyl	1
Trifloxystrobin	8
Trifloxysulfuron	1
Triflumizole	4
Trifluralin	6
Triforine	1
Uniconazole-P	1
Zeta-Cypermethrin	7
Zinc phosphide	1
Ziram	3
Zoxamide	2
US Total	**970**

As shown in Table 1, the Codex commission has developed international standards for 505 MRLs that govern the application of 135 active chemicals. Both the number of MRLs and the coverage of chemicals are low in Codex, probably due to the lack of scientific consensus on the risk assessments of other active ingredients. In the US market, there are 970 MRLs governing the use of 251 chemicals. Both numbers are much higher than the Codex counterparts, suggesting that developed countries tend to take the lead on food safety in the policy space. The EU currently adopts 1124 MRLs pertaining to 213 substances. The coverage of regulated ingredients is lower in the EU than in the US presumably because the EU bans certain chemicals altogether.

While Table 1 highlights the frequency of MRLs across the Atlantic, Table 2 below shows the stringency of MRLs, in the measurement of ppm , across the US, the EU, and the Codex. It is worth noting that a lower MRL corresponds to a more restrictive standard.

Table 2. Stringency of MRLs in the US, the EU, and Codex

MRL in ppm	Obs	Mean	Std. Dev.	Min	Max
Codex	505	2.99	23.33	0.005	500
United States	970	2.10	8.71	0.01	200
European Union	1,124	1.21	6.01	0.005	100

As shown in Table 2, the Codex MRLs are averaged at nearly 3 ppm, with a wide range from 5 ppb to 500 ppm. The US MRLs take the average of 2.1 ppm, which is more stringent than the Codex average standard. Similar to Codex, US MRLs vary substantially from one chemical to another. In the case of EU, the average MRL is 1.21 ppm, which is substantially more restrictive than either the US or Codex. This is consistent with the anecdotal evidence that the EU is a leading advocate for food safety and other public health policies.

4. An econometric analysis of state-level food trade between the US and the EU

4.1. The econometric specification

In this section, we provide an econometric model to explain the cross-Atlantic trade in selected food products. Specifically, we deploy the MRL stringency index, proposed by Li and Beghin (2014), as the measurement the restrictiveness of MRLs by product and by market. In particular, the MRL stringency index is averaged across MRLs targeting all ingredients applicable to a given product in a given market. A higher MRL stringency index indicates a higher MRL standard in general. If a country defers its MRLs to Codex, the stringency index takes the value of one.[5]

The econometric specification takes the following form:

$$\ln(T_{sijt}) = \beta_0 + \beta_1 \cdot \ln(MRL_{sjt}) + \beta_2 \cdot \ln(dist_{ij}) + \sum_i \alpha_i \cdot IM_i + \sum_j \chi_j \cdot EX_j + \sum_t \delta_t \cdot Q_t + \sum_s \gamma_s \cdot P_s + \varepsilon_{sijt},$$

(1)

where T_{sijt} is the trade value of product *s* in quarter *t* from the exporting market *i* to the importing market *j*. Note that the term market refers to either a non-US country or a US state. The variable MRL_{sjt} is MRL stringency index imposed by market *j* for product *s* in quarter *t*. The estimated coefficient for this stringency index provides an indication of whether MRLs impede or promote agricultural trade. The variable $dist_{ij}$ measures the bilateral distance between the two trading partners. In particular, either the largest port or the capitol of a US state is used to compute the geographical distance from other markets.

Furthermore, we include importers' fixed effect, or IM_i, and exporter's fixed effects, or EX_j, to account for the multilateral trade resistance terms (Anderson and van Wincoop, 2003). In addition, we deploy quarterly dummy variables, or Q_t, to control for any seasonal effects that could contribute to agricultural production and trade. Finally, we use product-level fixed effects, or P_s, to account for unobservable characteristics that are specific to each product. It is worth noting that, although tariffs are not explicitly included in equation (1), the combination of importers' fixed effects and products' fixed effects has the capacity to absorb the potential impacts of tariffs.

4.2. Data sources and the estimation procedure

As discussed in Section 3, the MRL data are sourced from the GlobalMRLs database of

[5] See Li and Beghin (2014) for the detailed discussions of the properties of the MRL stringency index.

Bryant Christie Inc. The database is frequently updated to reflect currently effective MRLs in a wide range of markets. Unfortunately, there are no archives in the database for the retrieval of historical MRLs. The extraction of MRLs in this article is as of May, 2017. The transformation of raw MRL data to MRL stringency index follows the procedure used in Li and Beghin (2014). In essence, the transformation amounts to averaging MRLs over all active ingredients at the product level in each market. In Appendix A, we display the MRL stringency indices for the eight selected products. The overall pattern is that the US MRL policy is slightly weaker than the Codex counterparts, whereas the EU MRL policy is substantially tougher than the Codex recommendations.

We also collect quarterly bilateral agricultural trade series from HIS/GTA inc. that pertain to 50 US states and 12 EU members (See Appendix B for the list of markets).[6] Our selection of products is defined by the following product codes in the WTO Harmonized System: cabbage (070490), garden pea (070810), papaya (080720), peach (200870), potato (070110), soybean (120110), strawberry (081010), and tomato (070200). Since the extraction of MRLs is as of May 2017, we match the MRL data with the quarterly trade data from the second quarter of 2016 to the first quarter of 2017. The implicit assumption is that these MRL policies have been in effective for at least twelve months.

The distance variable is based on port-to-port measurement. In particular, we use the capitol or the largest port in a US state or EU member country as the representative trading hub in that market. Different from a conventional gravity equation analysis, we exclude GDP, population, and other commonly used trade determinants because their effects will be fully absorbed by importers' and exporters' fixed effects in our cross-sectional setting.

[6] Note that we also include some third countries that the US or the EU have trade partnership with, in order to facilitate the empirical identification.

A prominent feature of bilateral trade records at disaggregated product levels is that zero trade flows are pervasive. This problem is more significant in our analysis as we utilize bilateral trade data pertaining to individual US states. To account for the large portion of missing trade, we follow Xiong and Beghin (2014) and use the two-step Heckman procedure to estimate the regression equation. For the purpose of identification, we create an indicator variable that equals one if the MRL policy is more stringent in the exporting market than in the importing market. This variable is to be included in the selection equation but excluded from the outcome equation. The underlying assumption is that exporters who have experience meeting tough standards at home are more likely to penetrate foreign markets.

5. Results and discussions

5.1. Estimation results

One major advantage of the Heckman two-step procedure is that the statistical inference can be drawn along the *intensive margin of trade* and the *extensive margin of trade*. Specifically, the intensive margin refers to the impacts of trade barriers on the volume of trade, while the extensive margins points to the impacts of trade determinants on the likelihood of trading occurring or not. From a policy perspective, the analysis along the extensive margin is equally important as some trade barriers can be prohibitive in nature. We present the estimations of equation (1) in Table 3.

Table 3. Econometric results from the Heckman two-step model

Heckman two-step model	Estimated Coefficient	Standard Error
Outcome equation		
Log-scaled distance	-0.863*	0.462
Log-scaled MRL score	-0.544**	0.266
Inverse Mill's ratio[a]	2.726*	1.614
Product fixed effects	Yes	
Quarter fixed effects	Yes	
Importer fixed effects	Yes	
Exporter fixed effects	Yes	
Number of Observations	1,819	
Selection equation		
Log-scaled distance	-0.344***	0.033
Log-scaled MRL score	-0.049	0.059
Excluded variable[b]	-0.046	0.043
Product fixed effects	Yes	
Quarter fixed effects	Yes	
Importer fixed effects	Yes	
Exporter fixed effects	Yes	
Number of Observations	81,912	

Note: a. The Inverse Mill's Ratio is statistically different from zero, which suggests that the decision to trade is a self-selection process. b. The excluded variable is an indicator variable that equals one if MRL is tougher in the exporting market than in the importing market. The notations *, **, and *** represent the 10%, 5%, and 1% levels of significance respectively.

We first attend to the outcome equation in Table 3. We find that trading partners that are further apart trade less with each other. Specifically, we estimate that a 10% increase in distance diminishes bilateral trade by over 8%. This order of magnitude is consistent with previous findings (e.g., Disdier and Head, 2008). More importantly, we find that MRLs impede agri-food trade significantly. In particular, we estimate that a 10% increase in the MRL stringency reduces bilateral trade by more than 6%. This finding lends support to the general argument that food safety standards amount to barriers to trade, even among developed nations. In addition, we find that the Inverse' Mill's ratio is statistically different from zero, which suggests that the decision to trade is a self-selection process. In other words, it is critical to formally model zero trade records and correct for the potential selection bias. It is also worth noting that only 2.2% (or 1819) of bilateral trade records correspond to positive trade flows. This percentage is lower than any counterpart in previous studies because our data set covers bilateral trade at the state level instead of the national level.

We now discuss the estimation results in the selection equation in Table 3. We find that distance diminishes the likelihood of trade. That is, markets that are further apart are less likely to establish trading partnership with each other. Furthermore, we find that the probability of trade is inversely related to the MRL stringency in the importing market. However, this negative impact is not statistically significant. For the purpose of empirical identification, the selection equation includes one extra variable which is an indicator variable that equals one if MRL is more restrictive in the exporting market than in the importing market. The underlying hypothesis is that exporters with experience meeting home standards are better equipped to comply with foreign requirements. The estimated coefficient for this excluded variable carries an unexpected sign. Nevertheless, the counter-intuitive effect is not statistically significant.

Another caveat in equation (1) is that the impact of MRLs may vary across exporters. One possibility is that US states facing the Atlantic are more affected by the stringency food safety policies in the EU. To test this hypothesis, we create a dummy variable which equals one if the US state belongs to the East Coast of America. There are a total of 14 states meeting this definition. We then create an interaction term, which is the product of the MRL variable and this dummy variable. We subsequently include the interaction term in equation (1) and re-estimate the model. We find that the coefficient of the extra variable is not statistically significant (even at 10% level). Therefore, there is no empirical evidence that MRLs are more (or less) trade impeding when agri-food trade is from the East Coast.

5.2. Simulation results and policy implications

Although the cooperation on NTMs is a high priority in the ongoing TTIP negotiations, it remains to be seen if the negation outcome leads to a mutual recognition or potential harmonization of different food safety standard across the Atlantic. For the purpose of economic simulation, we propose the scenario in which both the US and the EU defer their MRLs to the Codex counterparts. Under this scenario, the TTIP agreement would be in compliance with the relevant WTO provisions such as the SPS Agreement and Technical Barriers to Trade Agreement.

In order to project the impacts of TTIP on cross-Atlantic agricultural trade, we conduct a simulation analysis that is based on the econometric results in the previous section. Specifically, we assume that the sample of the selected products is representative of all agricultural products, which implies that the empirical findings in Table 3 carry over to US-EU agricultural trade in general. Furthermore, we explore the scenario in which the TTIP agreement endorses the Codex MRLs so as to be in compliance with WTO provisions.

We simulate the changes in cross-Atlantic agricultural trade, state by state, via the following formula:

(2) $\Delta T_k = \beta_1 \cdot \%\Delta MRL \cdot T_k$,

where ΔT is the change in agricultural exports from US state *k* to the EU. The notation $\%\Delta MRL$ is the percentage change in MRL stringency indices if the EU defers its MRLs to Codex levels. The notation T_k is the current value of agricultural exports from US state *k* to the EU. It is worth noting that the adherence to Codex means a relaxation of standards from EU's perspective. Therefore, we expect US agricultural exporters to expand their sales in the EU under the proposed reform. We display the simulated trade effects in Table 4.

Table 4. Agricultural export expansion to EU due to MRL harmonization

	Export value in 2016 (1000 US dollars)	Increase in exports (1000 US dollars)
Increase in exports by US state		
California	$3,285,971	$501,548
Louisiana	$2,146,941	$327,694
Alaska	$452,836	$69,118
Texas	$419,764	$64,070
Washington	$377,478	$57,616
Tennessee	$335,730	$51,244
North Carolina	$283,916	$43,335
Florida	$270,190	$41,240
Illinois	$205,170	$31,316
Wisconsin	$172,631	$26,349
Kentucky	$152,429	$23,266
New York	$151,091	$23,061
New Jersey	$135,416	$20,669
Nebraska	$118,006	$18,012
Virginia	$117,721	$17,968
Pennsylvania	$109,760	$16,753
South Carolina	$106,592	$16,269
Massachusetts	$106,423	$16,244
Arizona	$106,372	$16,236
Georgia	$105,402	$16,088
Kansas	$99,046	$15,118
Ohio	$96,987	$14,803
Minnesota	$91,257	$13,929
Iowa	$82,435	$12,582
Oregon	$78,814	$12,030
Arkansas	$75,320	$11,496
Indiana	$55,460	$8,465
Idaho	$44,236	$6,752
Utah	$41,771	$6,376
Maryland	$30,233	$4,615
Missouri	$29,760	$4,542
Colorado	$25,971	$3,964
Montana	$24,270	$3,704
New Mexico	$20,495	$3,128
Maine	$20,059	$3,062
Michigan	$19,103	$2,916
New Hampshire	$18,614	$2,841
North Dakota	$10,528	$1,607
Connecticut	$8,397	$1,282
Rhode Island	$8,090	$1,235

Alabama	$7,115	$1,086
Oklahoma	$3,598	$549
Nevada	$2,086	$318
Hawaii	$1,913	$292
Vermont	$1,749	$267
South Dakota	$1,585	$242
Mississippi	$1,274	$194
Delaware	$698	$107
Wyoming	$218	$33
West Virginia	$216	$33
All 50 states	**$10,061,139**	**$1,535,663**

As shown in Table 4, US agricultural exports to the EU reached $10 billion in 2016. Coastal states with large bases of farm production contribute most to the cross-Atlantic trade. Specifically, California's agri-food exports to the European market reached $3 billion in 2016, leading all other states. The high value of Californian exports is most likely attributable to the high-value specialty crops and animal products in California. Louisiana turns out as the second largest exporter, probably because its ports are frequently used by farmers and exporters in neighboring states as well. As the priori of our simulation analysis, we expect large exporting states to benefit more from the harmonization of MRLs triggered by a potential TTIP agreement.

The last column in Table 4 displays the additional exports to be gained by US states if the potential TTIP agreement endorses the Codex standards. Since the Codex standards are less restrictive than the EU standards, the TTIP reform effectively reduces barriers faced by US exporters that target the European market. Overall, we find that the harmonization of MRL standards has the potential to boost US agricultural exports to the EU by more than $1.5 billion a year. Furthermore, the simulation results at the US state level suggest that the gains from the TTIP reform are unequally shared by individual states. Specifically, we find that large exporting states tend to benefit more from the potential trade liberalization. For instance, the top exporter California is projected to gain half of billion more from exports to the European market. In contrast, inland states with less dependency on agriculture are expected to make modest gains from a TTIP agreement that addresses regulatory differences in food safety.

6. Conclusions

Despite the political developments across the Atlantic, the TTIP negotiations between the US and the EU remain in progress and ambitious in reforms. If successful, the resulting TTIP agreement would not only eliminate conventional border barriers but also foster regulatory coherence across the Atlantic. In particular, the agricultural sectors on both sides would be deeply affected by a comprehensive agreement that addresses the regulatory divergence in terms of food safety and other sanitary and phytosanitary issues.

In this article, we provide the first economic analysis of the possible TTIP agreement and draw policy implications for individual US states. Specifically, we utilize the quarterly trade series pertaining to major ports in the US and the MRLs that exemplify the differences in food safety standards across the Atlantic. Deploying a state-of-the-art gravity equation model that addresses the high frequency of missing trade, we find that MRLs significantly diminish agri-food trade. In particular, we estimate that a 10% reduction in MRL stringency would promote trade by nearly 6%. If the final provisions endorse the Codex MRLs, the TTIP agreement would boost US agricultural exports to the EU by more than one billion dollars a year. Finally, coastal states with large agricultural sectors would benefit most from the reforms induced by a TTIP agreement.

Several extensions can be made to the current research. First, the product coverage can be further expanded to cover animal products for which across-Atlantic trade is believed to be constrained by differences in antibiotic drug policies. Second, a general equilibrium model can be coupled with the current simulation in order to further investigate the economic gains that could be trickled down to local land owners and farm workers. Third, it is promising to pursue a normative approach that identifies the socially optimal food safety policy that strikes a balance between free trade and public health or other social welfare objectives.

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Appendix A

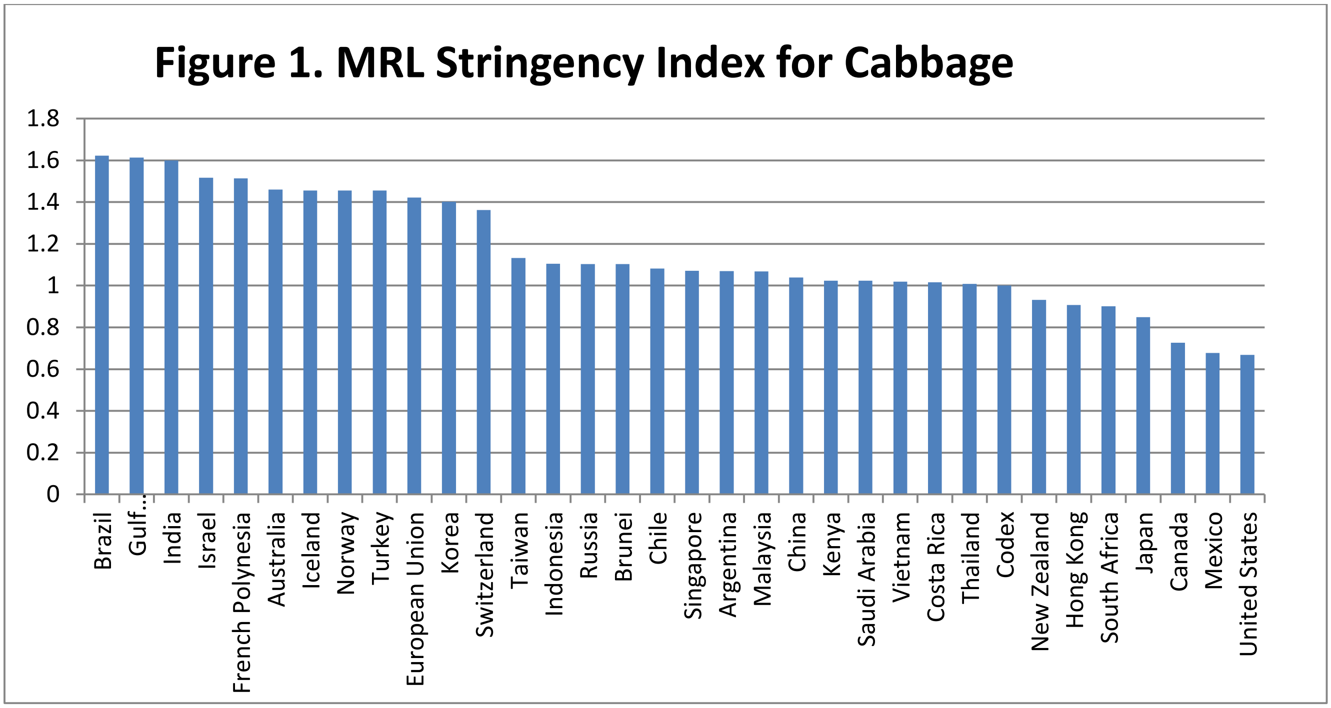


Figure 1. MRL Stringency Index for Cabbage
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Brazil
Gulf...
India
Israel
French Polynesia
Australia
Iceland
Norway
Turkey
European Union
Korea
Switzerland
Taiwan
Indonesia
Russia
Brunei
Chile
Singapore
Argentina
Malaysia
China
Kenya
Saudi Arabia
Vietnam
Costa Rica
Thailand
Codex
New Zealand
Hong Kong
South Africa
Japan
Canada
Mexico
United States

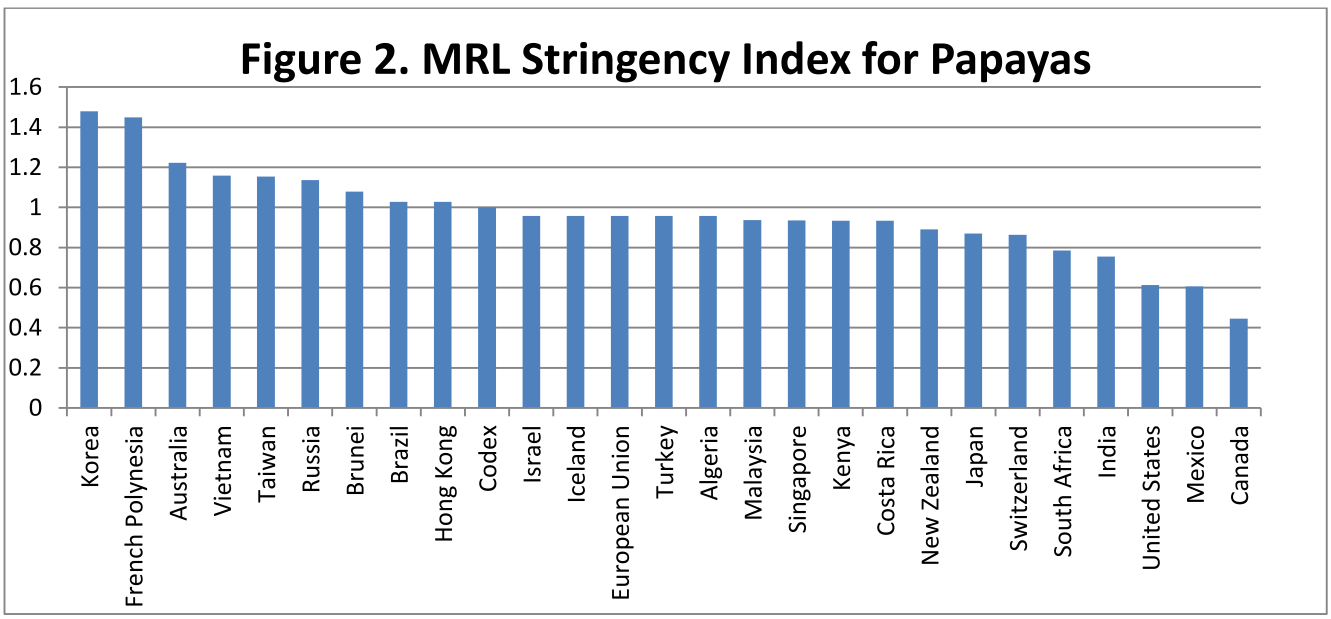


Figure 2. MRL Stringency Index for Papayas
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Korea
French Polynesia
Australia
Vietnam
Taiwan
Russia
Brunei
Brazil
Hong Kong
Codex
Israel
Iceland
European Union
Turkey
Algeria
Malaysia
Singapore
Kenya
Costa Rica
New Zealand
Japan
Switzerland
South Africa
India
United States
Mexico
Canada

Figure 3. MRL Stringency Index for Garden Peas

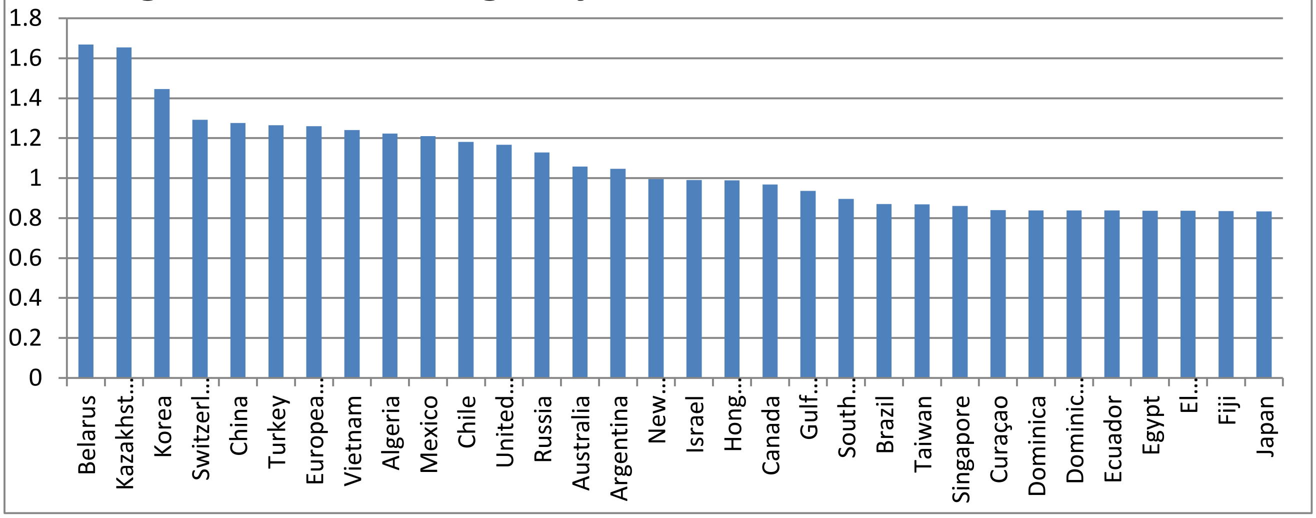


Figure 4. MRL Stringency Index for Peach

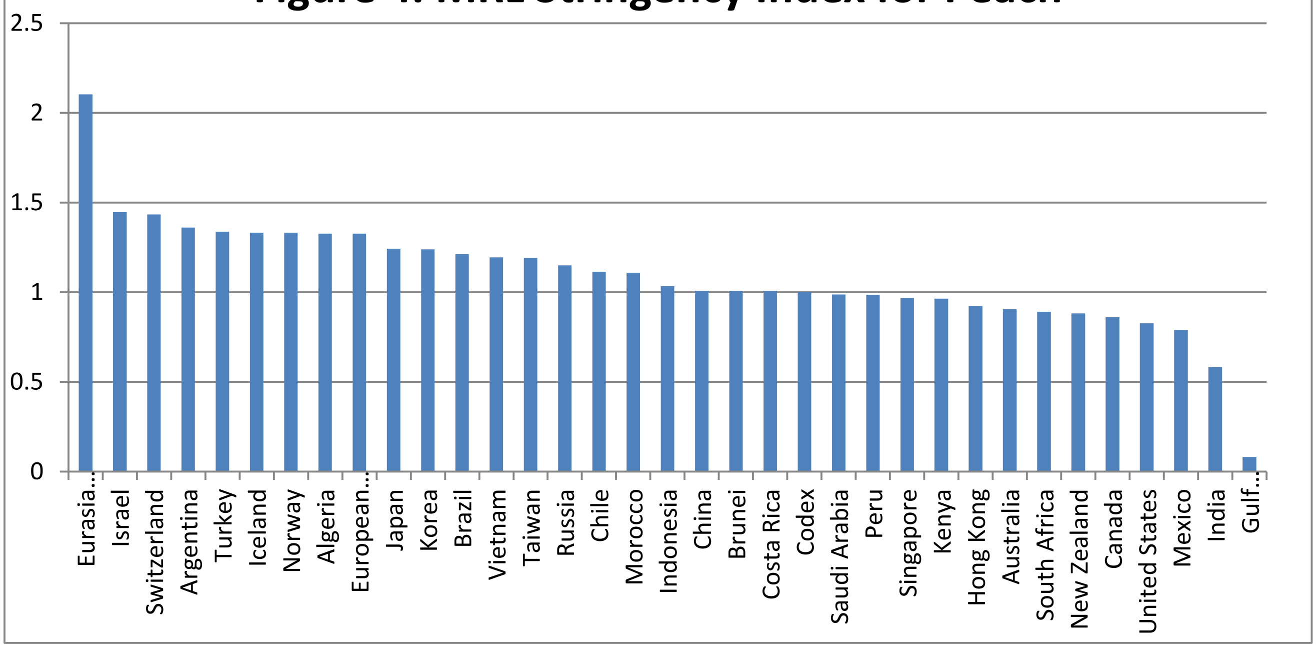


Figure 5. MRL Stringency Index for Potato

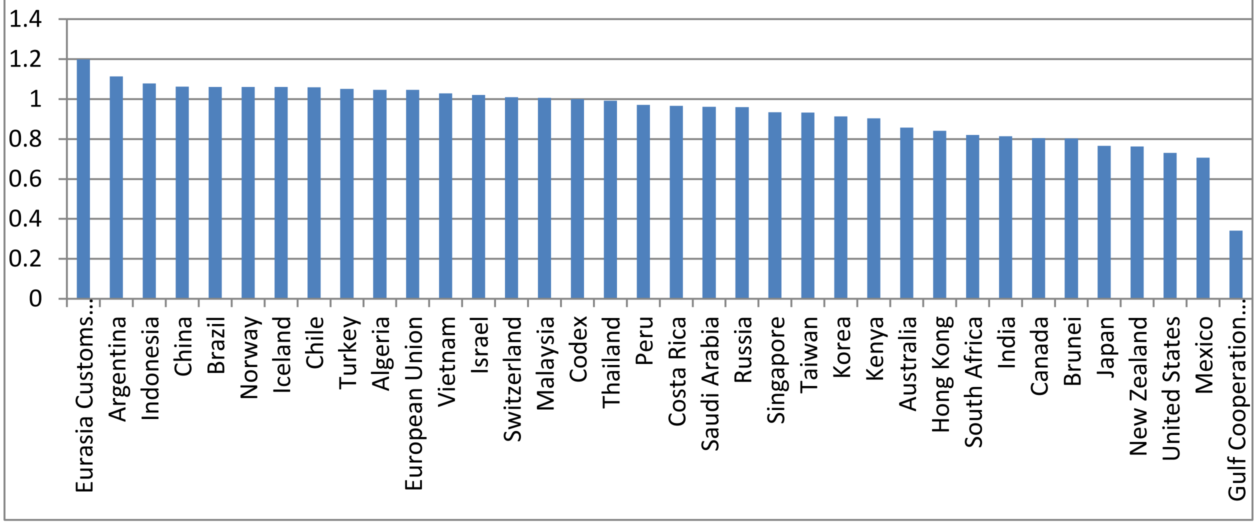
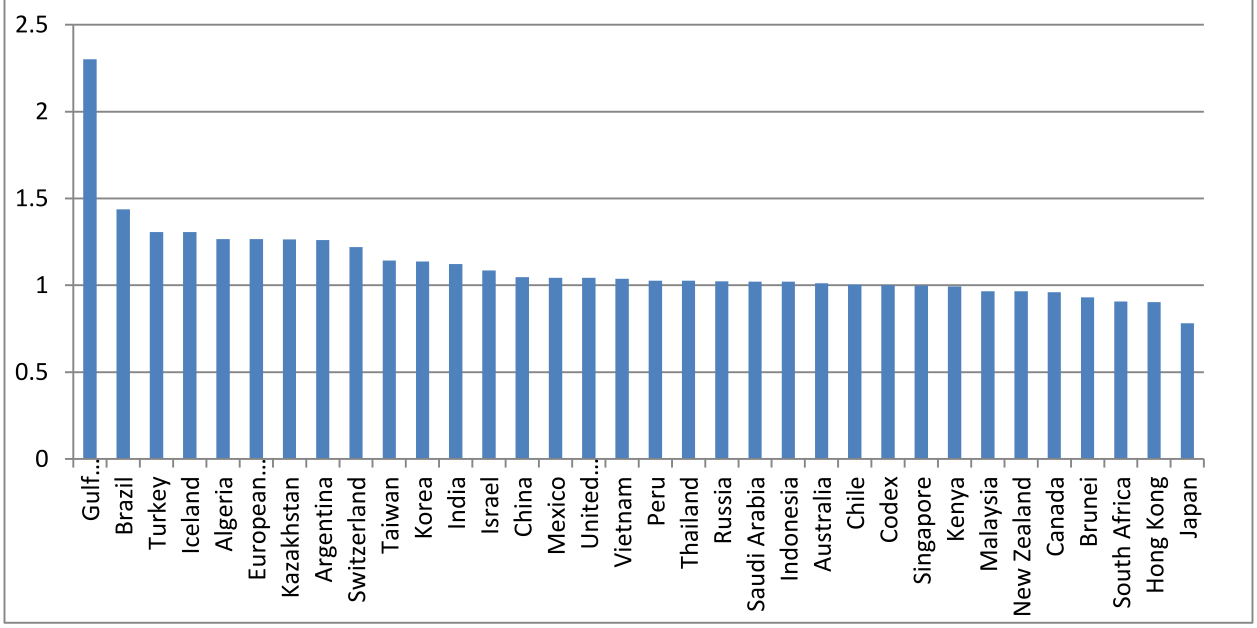


Figure 6. MRL Stringency Index for Soybeans



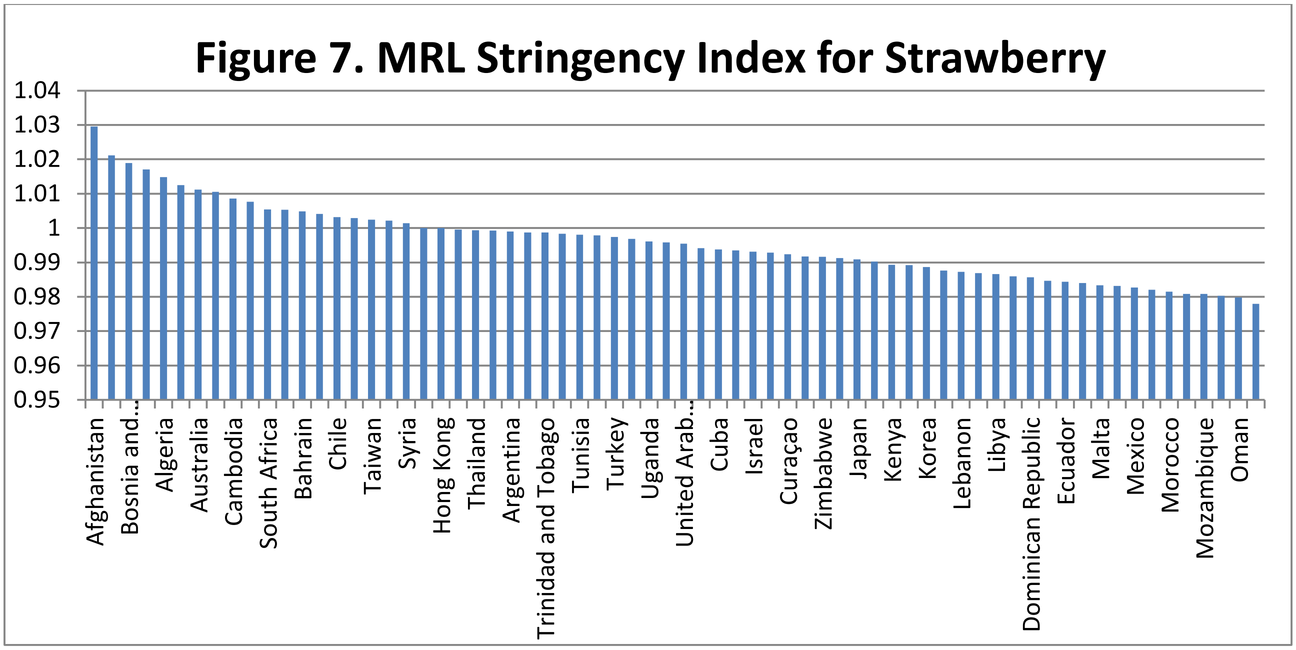


Figure 7. MRL Stringency Index for Strawberry
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
Afghanistan
Bosnia and…
Algeria
Australia
Cambodia
South Africa
Bahrain
Chile
Taiwan
Syria
Hong Kong
Thailand
Argentina
Trinidad and Tobago
Tunisia
Turkey
Uganda
United Arab…
Cuba
Israel
Curaçao
Zimbabwe
Japan
Kenya
Korea
Lebanon
Libya
Dominican Republic
Ecuador
Malta
Mexico
Morocco
Mozambique
Oman

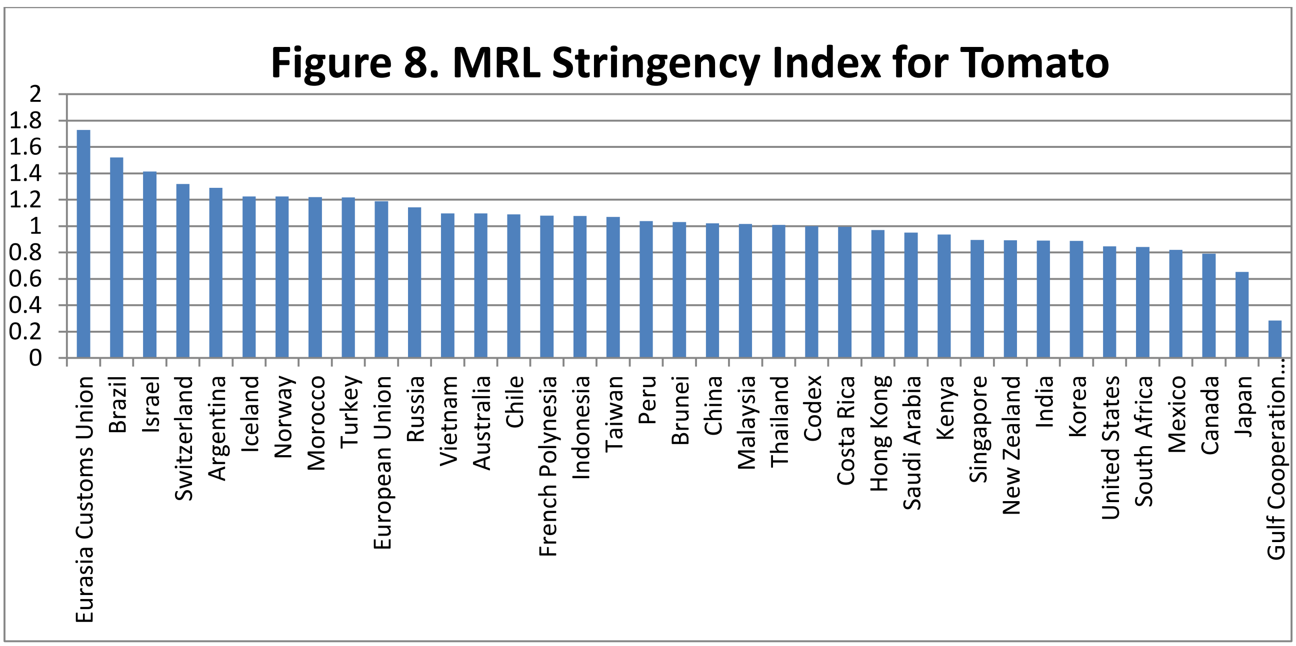


Figure 8. MRL Stringency Index for Tomato
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Eurasia Customs Union
Brazil
Israel
Switzerland
Argentina
Iceland
Norway
Morocco
Turkey
European Union
Russia
Vietnam
Australia
Chile
French Polynesia
Indonesia
Taiwan
Peru
Brunei
China
Malaysia
Thailand
Codex
Costa Rica
Hong Kong
Saudi Arabia
Kenya
Singapore
New Zealand
India
Korea
United States
South Africa
Mexico
Canada
Japan
Gulf Cooperation…

Appendix B

Table B. List of U.S. states and EU members

U.S. states				**EU members**
Alabama	Kansas	New Mexico	Virginia	Belgium
Alaska	Kentucky	New York	Washington	Denmark
Arizona	Louisiana	North Carolina	West Virginia	France
Arkansas	Maine	North Dakota	Wisconsin	Germany
California	Maryland	Ohio	Wyoming	Greece
Colorado	Massachusetts	Oklahoma		Ireland
Connecticut	Michigan	Oregon		Italy
Delaware	Minnesota	Pennsylvania		Luxemburg
Florida	Mississippi	Rhode Island		Netherlands
Georgia	Missouri	South Carolina		Portugal
Hawaii	Montana	South Dakota		Spain
Idaho	Nebraska	Tennessee		United Kingdom
Illinois	Nevada	Texas		
Indiana	New Hampshire	Utah		
Iowa	New Jersey	Vermont		