THE GRAVITY OF SPS RISK

Lesley Ahmed
Peter Herman
Caroline Peters
David Riker

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Abstract

As the frequency and magnitude of sanitary and phytosanitary (SPS) issues continues to grow worldwide, understanding the impact that these issues have on agricultural trade is becoming increasingly important. This paper uses a novel, product-centric approach to shed light on this topic. Using characteristics of products such as freshness or preparation method, we classify agricultural products as exhibiting either high or low SPS risk based on their relative likelihood of posing a danger to the human, animal, or plant health concerns that SPS measures address. This classification is then used within a collection of gravity trade models to estimate differences in trade patterns between high and low risk goods. We find that high risk goods exhibit higher trade costs based on several measures and that both types of goods face differing impacts from trade agreements providing for customs improvements or regulatory harmonization. Meanwhile, neither category of good experiences significant effects from trade facilitation efforts that either primarily lower tariffs or address indirectly-related aspects of trade such as intellectual property or services.

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Lesley Ahmed
Office of Industries
U.S. International Trade Commission

Peter Herman (Corresponding Author)
Office of Economics
U.S. International Trade Commission
peter.herman@usitc.gov

Caroline Peters
Office of Economics
U.S. International Trade Commission

David Riker
Office of Economics
U.S. International Trade Commission

1 Introduction

In recent years, non-tariff measures (NTMs) have gained considerable attention in international trade. As tariffs worldwide have largely disappeared, NTMs have grown both in the number of measures applied by countries as well as in relative effect as they become, in many cases, the most considerable barrier to trade faced by firms. This is especially true in the case of sanitary and phytosanitary (SPS) measures, which countries apply to ensure food safety; protect humans, animals, and plants from contaminants, diseases, disease-causing organisms, and pests; and to prevent damage from the entry and spread of pests. The number of SPS measures recorded by the World Trade Organization (2017) has grown by nearly 9.4 percent on average per year from 189 measures in 1995 to 936 measures in 2016.

Given this growth in SPS measures, understanding the effects of these measures on trade it is increasingly important. In this paper, we analyze the relationship between SPS issues and bilateral trade. Using a gravity modeling framework, we show that agricultural products that are especially sensitive to SPS risks exhibit different trading patterns than less sensitive agricultural products. High sensitivity goods exhibit higher trade costs with respect to several measures between trading partners. Similarly, high sensitivity products experience statistically different impacts from trade facilitating preferential trade agreements (PTA), particularly those that include provisions for regulatory harmonization and customs improvements. Meanwhile, other efforts to liberalize trade, such as those focusing primarily on tariff reductions or indirectly-related aspects of trade such as services or intellectual property provisions, exhibit limited impact on either high or low risk agricultural products, in general or relative to one another.

This paper is a new entry into the growing literature seeking to quantify the effects of non-tariff measures. Much of this literature has relied on gravity models to assess the extent to which NTMs may increase or decrease the cost or level of trade.[1] For example, Fontagné et al. (2011) infer the restrictiveness of NTMs using importer fixed effects to compare the relative openness of countries,

[1] In the past, NTMs have often been referred to as non-tariff barriers (NTBs). Although subtle, there is an important distinction between the terms NTM and NTB in modern convention. A measure can be put in place for a wide variety of reasons. Some of these reasons target important social objectives such as ensuring food safety or environmental protections. Other measures may be put in place for purely protectionist purposes similar to tariffs. A measure falling onto this latter category is generally considered an NTB. By comparison, the term NTM makes no such judgment regarding the protective nature of the measure and may be either protective or intended to provide a legitimate social benefit.

which they use to calculate a tariff-rate equivalent for each country. Kee et al. (2009) use a slightly different approach, employing data on the incidence of certain types of NTMs to identify the trade costs associated with the measures. For a more in-depth survey of different types of quantification methodologies, see Abbyad and Herman (2017).

Like NTMs more generally, SPS measures have the potential to be either trade-facilitating or trade-diminishing depending upon the nature of the measures themselves and the breadth of their implementation. Nimenya et al. (2012) find that SPS measures can be trade catalysts when they reduce information asymmetries in the market, allowing easier comparison of quality attributes across markets subject to different public and private SPS requirements. Doing so increases the impact of food product origin as a factor in product differentiation. Drogué and DeMaria (2012) and Winchester et al. (2012) have found the harmonization of SPS standards to be trade-increasing, although the effect on exports is not uniformly positive as some countries lose their differentiated edge when standards converge. Crivelli and Groeschl (2016) find that if exporters are able to overcome the fixed costs associated with compliance, SPS measures are trade increasing as consumers are reassured of the quality of foreign products.

On the other hand, SPS measures can act as a trade deterrent when they diverge from the general WTO principles of nondiscrimination, scientific evidence, risk assessment, and least-trade-restrictive alternatives. Exports from developing countries to high-income countries are the most negatively impacted by the implementation of SPS measures, as the costs of compliance are relatively steeper in countries with weaker institutions and less developed agrofood supply chains (see, for example, Disdier et al. (2008), Li and Beghin (2011), Melo et al. (2014), and Henson and Jaffee (2008)). With regards to the intensive margin, the multiple sets of standards imposed by various regulatory bodies - large private sector actors in the agrofood supply chain, public sector actors in destination markets, and governing authorities within multilateral organizations - present barriers to market entry for new exporters and make full harmonization of SPS measures difficult overall, as identified by Henson and Jaffee (2008). Moenius (2006) and Tothova and Oehmke (2008) argue that the trade-diminishing impact of SPS measures can also work at the extensive margin, with harmonization efforts restricting the number of varieties available overall, limiting consumer choice and welfare. Work by Fontagné et al. (2015) using firm level data provides supporting evidence that both the intensive and extensive margins of trade are negatively affected by the presence of

SPS measures and that this effect is more severe for smaller firms.

Work by Nimenya et al. (2012), Rickard and Lei (2011), and Calvin and Krissoff (1998) has revealed that that the magnitude of welfare gains from removing SPS measures depend largely on the commodity being traded and whether the risk that measures are protecting against is transferable. Calvin and Krissoff (1998) in particular, find that unlike with tariffs, policymakers must consider both scientific and economic consequences with the imposition of new SPS measures, weighing the decrease in food safety risk against the potential losses to consumers and producers.

The work presented here builds off of this research by studying the relationship between bilateral trade determinants and SPS concerns. Unlike most of this research that uses the incidence of SPS measures to identify trade impacts, we take a product-centric approach that identifies goods that are most prone to the types of issues that SPS measures attempt to mitigate. We divide agricultural product categories into two groups depending on whether the product category faces high or low SPS risks. High risk goods are those that are especially susceptible to the health and disease risks covered by SPS measures. Using this grouping, we analyze the trade implications for each group using gravity models to infer differences in trading behavior. A key benefit of this alternative, product-centric approach is that our results are more closely connected to the health and safety aspects of SPS policies because there is no ex-ante need to determine if a measure is inefficiently distortionary as identification is not directly based on the policies in place.

The paper proceeds as follows. Section 2 describes our approach to SPS risk and the categorization of agricultural goods. Section 3 describes the data and gravity methodology used for the analysis and presents our findings. Section 4 concludes.

2 SPS Risk

Some products pose greater risk to human, plant, and animal health than other products because of their inherent characteristics and tendency to carry pests, diseases, or organisms. Similarly, the nature of how a product is consumed or used can make it susceptible to SPS risk, such as whether it is for direct human consumption or undergoes heat treatment before it is consumed. In this paper, we define SPS risk based on whether a product is inherently sensitive to these concerns. Specifically, a product is considered high SPS risk if it is:

1. a living plant or animal, hence with greater risk of spreading diseases or pests;

2. a meat product—whether fresh, frozen or processed—because of risk of spreading human and animal diseases that are not mediated by processing (e.g. foot and mouth disease or bovine spongiform encephalopathy); or

3. fresh or perishable and intended for human consumption, thereby exhibiting a greater risk to human health.

A few examples of high SPS risk products are dairy products, beef, live plants, and fresh cut flowers. A few examples of lower SPS risk products are vegetable oils, pasta, wool, and dried vegetables. A full list of the HS 4-digit codes used in the analysis and their respective risk categorization can be found in table 5. Of the 210 agricultural product categories, 56 are classified as high risk; the remaining are considered low risk.

Traditionally, researchers examining the trade effects of SPS measures and technical barriers to trade (TBT) categorize products based on the number of SPS measures or other NTMs they face. These categorizations, while different from our inherent risk classification, unsurprisingly feature some considerable similarities because products that pose greater SPS risk tend to have more SPS measures applied by importing countries. Prior research on this topic has employed several different strategies to identify products subject to SPS measures. Disdier et al. (2008) summarize some common measures to identify potential barriers, using a simple dummy and frequency index along with calculated AVEs to estimate their effect. Fontagné et al. (2005) examine the number countries that had made WTO SPS notifications for products at the HS 4-digit level. Not surprisingly, the products they label as "sensitive," with at least 40 countries notifying SPS measures to the WTO, are similar to the group of products we categorize as high risk—including meat products, milk products, flowers, and fresh fruits and vegetables. The products not labeled as "sensitive" exclude many processed food products and are also similar to our SPS risk categorization. Grant and Arita (2017), who examine the incidence and length of specific trade concerns raised at the WTO SPS committee meetings, find the highest incidence of SPS specific trade concerns were in meat and edible offal, fresh fruits and nuts, live animals, dairy products, and edible vegetables, roots and tubers. They find no SPS specific trade concerns for gums, resins and vegetable saps, preparation

of cereals, flour, starches, and pastry; and tobacco and tobacco products. These, again, are in line with our classification.

3 Gravity Analysis

3.1 Data Description

In addition to the SPS sensitivity data that we produced, several other data sources were combined in order to create the gravity dataset used in the analysis.

Trade data was downloaded from COMTRADE.[2] We utilize a cross section consisting of 55 countries for the year 2015. For each country pair, the data includes all reported trade flows belonging to 210 HS2007, 4-digit codes, representing all agriculture products. Any codes not exhibiting positive trade flows between a given country pair is assumed to be an untraded sector and is included as a zero so that the panel is square. As described above, each of these products was designated as being high or low SPS risk using a dummy variable taking the value of one if a product is deemed to be high risk. Recall that a high risk product or sector is one that, because of its inherent nature or general use, poses greater risk to human, animal, and/or plant health. Of the 210 HS 4-digit categories considered, 56 are identified as having high SPS risk.

Gravity variables were primarily sourced from the Gurevich et al. (2017) extension to the CEPII database.[3] These variables include GDPs, shared common language, population weighted distance, contiguity, colonial relationships, and preferential trade agreements (PTA). In later specifications, additional preferential trade agreement data from the World Bank's *Content of Deep Trade Agreements* dataset was integrated (see Hofmann et al. (2017)).[4] This additional data provides more granular information on the type of trade agreements that country pairs belong to as well as the numerous types of provisions they may or may not exhibit. Specifically, we utilize variables indicating provisions in trade agreements that target the liberalization of agricultural trade restrictions, customs transparency, the affirmation and harmonization of SPS measures, trade-related aspects of

[2] https://comtrade.un.org/data/

[3] Available for download from https://www.usitc.gov/sites/default/files/publications/332/grav_data_1948to2015_for_posting.zipx

[4] Available for download from https://data.worldbank.org/data-catalog/deep-trade-agreements

intellectual property, and trade in services.[5] Additionally, we include data that divides the general PTA indicator into three specific types of agreements: customs unions (CU), economic integration agreements (EIA), and free trade agreements (FTA).

3.2 Gravity Models

The objective of this research is to identify the ways in which sensitivity to SPS risks impacts aspects of trade. Given its strength in quantifying the bilateral determinants of trade, the gravity model represents an ideal tool for doing so. To identify these SPS influences, we employ several gravity specifications that highlight differences in trade patterns between high and low SPS risk agriculture products. These specifications thoroughly explore these relationships by testing the robustness of the identified differences with respect to both aggregation and several fixed effect strategies. In total, four specifications were considered.

Each of the specifications was estimated using a Poisson Pseudo Maximum Likelihood estimator.[6] PPML procedures have become standard in gravity research due to their ability to incorporate zero-value trade flows and superior treatment of heteroskedasticity.

The first specification follows traditional methods employed in gravity modeling in which trade flows are aggregated at the country pair level. That is, a single observation reflects aggregate trade between two partners in the agriculture products considered. In this case, we differentiate between high and low sensitivity goods by constructing two aggregations. One aggregation includes only those goods listed as being high risk, the other includes only low risk. Once aggregated according to risk, the following gravity specification was estimated:

$$X_{ij} = \beta z_{ij} + I_i + I_j \tag{i}$$

Indexes i and j denote exporter and importer respectively. The variable X_{ij} denotes the trade value of exports from j to i while z_{ij} denotes the following collection of gravity variables: contiguity, common language, distance, colony, and PTA. Identification of differences between high and low risk goods is determined by comparing the respective coefficients for the trade determinants.

[5] These provisions correspond to the variables *wto_p_ftaag*, *wto_p_cust*, *wto_p_sps*, *wto_p_trips*, and *wto_p_gats*, respectively.

[6] See Santos Silva and Tenreyro (2006)

The remaining specifications utilize disaggregated data in an effort to better identify the nuances present at the product or sector level. For this purpose, we consider three different specifications. The first of these specifications does not attempt to control for sector-level variation, including only importer and exporter fixed effects. The second specification includes an additional set of product level fixed effects corresponding to each of the HS 4-digit codes included in our sample. Specifically, these two specifications take the following forms, respectively:

$$X_{ijs} = \beta z_{ij} + \gamma_0 sps\_risk_s + \gamma(sps\_risk_s * z_{ij}) + I_i + I_j \tag{ii}$$

$$X_{ijs} = \beta z_{ij} + \gamma_0 sps\_risk_s + \gamma(sps\_risk_s * z_{ij}) + I_i + I_j + I_s \tag{iii}$$

The additional index s denotes the product and sps_risk_s denotes the dummy variable reflecting SPS risk for product s. In these two cases, the effects of SPS sensitivity are identified through the inclusion of the dummy for SPS risk that takes the value of one if a product is high risk and its interaction with the other bilateral determinants.

The fourth specification controls for importer-sector and exporter-sector variation by estimating a separate model for each of the products considered. By estimating each s separately, the fixed effects are allowed to vary across sectors.[7] Because products are estimated separately, the identification of differences between high and low risk products relies on non-parametric methods. Specifically, we report Kolmogorov-Smirnov statistics for each variable that determines if the distribution of coefficients, conditional on risk type, differs in a statistically significant way.

3.3 Results

3.3.1 Baseline Gravity Variables

The results for specifications (i)-(iii) are presented in table 1. A summary of the results for specification (iv) over all sectors is presented in table 2. Additionally, kernel-density plots of the estimated coefficients for each sector are provided in figure 1.

In each specification, the results are generally consistent with previous literature. As is typically expected, contiguity, common language, and PTAs are trade facilitating while geographic distance

[7] Alternatively, a specification including importer-sector and exporter-sector fixed effects would control for mostly the same variation but was computationally infeasible given the sample.

Table 1: Gravity estimates for specification (i)-(iii)

	(i) (High SPS Risk)		(i) (Low SPS Risk)		(ii)		(iii)	
Contiguity	0.452***	(0.120)	0.349***	(0.102)	0.394***	(0.094)	0.394***	(0.094)
Common Language	0.442***	(0.108)	0.187	(0.111)	0.200	(0.104)	0.200	(0.104)
Log Distance	-0.868***	(0.066)	-0.821***	(0.054)	-0.798***	(0.052)	-0.798***	(0.052)
Colony	-0.045	(0.160)	0.239	(0.131)	0.193	(0.145)	0.193	(0.145)
PTA	0.767***	(0.105)	0.230**	(0.084)	0.260**	(0.086)	0.260**	(0.086)
SPS Risk					0.236	(0.522)	5.792***	(0.697)
Contiguity * SPS Risk					-0.049	(0.150)	-0.049	(0.150)
Language * SPS Risk					0.120	(0.128)	0.120	(0.128)
Distance * SPS Risk					-0.056	(0.059)	-0.056	(0.059)
Colony * SPS Risk					-0.044	(0.203)	-0.044	(0.203)
PTA * SPS Risk					0.547***	(0.142)	0.547***	(0.142)
Constant	5.065***	(0.837)	8.797***	(0.562)	3.295***	(0.550)	-2.691***	(0.649)
Importer, Exporter F.E.	yes		yes		yes		yes	
Sector F.E.	no		no		no		yes	
N	2886		2886		606060		606060	

Standard errors clustered at the country pair level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 2: Summary of the estimation results for individual sectors (iv)

Variable	Low Risk		High Risk		K-S test stat.	K-S p-value
	Mean β	S.D.	Mean β	S.D.		
Distance (log)	-1.223	(0.855)	-1.596	(1.451)	0.274	0.003
Contiguity	0.332	(0.908)	0.244	(0.797)	0.115	0.605
Common Language	0.205	(0.827)	0.554	(0.835)	0.164	0.197
Colony	-0.101	(1.303)	0.131	(0.638)	0.170	0.164
PTA	0.518	(1.296)	0.972	(1.170)	0.305	0.001

is trade deterring. With regards to the relationships between trade determinants and SPS risk, we find several consistent results. First, when accounting for sector-specific fixed effects in specification (iii), we find that high SPS risk goods trade more on average than low SPS risk goods. There are several possible explanations for this trend. By their nature, high risk goods tend to be fresh and seasonal, relying to a higher degree on seasonal trade for year-round availability than other agricultural products. Similarly, the fresh nature of these goods likely implies that they are generally of a higher quality and more prone to trade than their preserved or otherwise prepared, low risk counterparts in the vein of the so-called "Washington Apples" effect. Finally, the SPS risks of the goods may themselves be a reflection of the fact that they trade more; the high risk goods may be characterized as high risk because of past SPS incidences encountered during trade.

Second, specification (iv) finds that high risk goods are particularly sensitive to distance. Increased distance, which is often interpreted as being representative of transport time and costs, are especially impactful to high risk goods. This is likely a reflection of the relatively greater risk of rot and and other quality degradations inherent in the higher SPS risk products.

Finally, we find that under all four specifications, PTAs are significantly more influential in increasing trade among high risk goods. This finding suggests that policies put in place by countries that restrict trade are especially onerous to goods that face higher sensitivity to SPS issues. Because the existence of a PTA between countries is a rather blunt measure of trade facilitation, there are several possible explanations for why these agreements have a stronger influence on high risk goods. Because of the added complexity of trading high risk goods, efforts to reduce barriers to trade likely affect these goods more significantly because there is a larger potential gain from doing so. Additionally, many trade agreements—particularly in recent years—focus increasingly on NTMs, which will affect SPS sensitive goods more significantly.[8] An outcome of this trend is a general reduction in the burden of NTMs, a mitigation on the delays faced at borders, and an improvement in the efficiency of achieving the desired SPS safety measures.

3.3.2 Expanded Trade Agreement Variables

In light of these findings, we considered an additional sequence of specifications that aim to decompose the effect of PTAs on trade—and SPS sensitive goods in particular—into more granular

[8] See Neufeld (2014) for a discussion of these recent trends in trade agreements.

measures of preferential treatment. Specifically, we replace the PTA variable in the original specifications with a collection of eight variables characterizing aspects of trade agreements. Three of these variables represent special types of provisions included in agreements covering agriculture, customs procedures and transparency, and SPS concerns, respectively. These types of provisions were selected due to their anticipated direct effects on the trade of agricultural products. Two of the variables represent membership of both trading parties to the multi-party Agreement on Trade-Related Aspects of Property Rights (TRIPS) and General Agreement on Trade in Services (GATS), respectively. These agreements were selected in order to identify potential spillovers from other trade liberalization efforts that may indirectly support the trade of certain agricultural products. The remaining three variables identify membership to a specific class of PTA—namely CU, EIA, or FTA—that may each have their own unique impacts on trade. By introducing these eight additional variables, we are able to better identify some of the specific aspects of trade agreements that drive the effects of PTAs observed in the previous collection of estimates.

The gravity results corresponding to this second collection of variables are presented in table 3 for specifications (i)-(iii). Summary statistics for the results of the individual sector estimates of specification (iv) are presented in table 4 and as kernel density plots in figures 2 and 3.[9] As before, the standard gravity components exhibit the expected effects. Of the added PTA variables, several exhibit interesting relationships with agricultural goods in general and high or low risk goods in particular.

Of the three types of special provisions included in the model specification—agriculture, customs, and SPS—each exhibits some specific influence on agricultural trade.

First, agricultural provisions facilitate trade in high risk agricultural products significantly more than low risk products within the frameworks of specifications (ii) and (iii).[10] However, when controlling for country-sector specific effects under specification (iv), there is limited statistical difference between high and low risk goods. Agricultural provisions, which reflect both tariff and non-tariff liberalizations on agricultural products, represent a slightly complicated case to analyze due to how common they are. According to Hofmann et al. (2017), agricultural provisions are

[9]There are several sectors for which there is an insufficient amount of observed trade or variation for estimation to be possible using the added PTA variables. In these cases, the unestimated coefficients are omitted from the reported statistics.

[10]The results of specification (i) are also suggestive of this but much less significantly so.

Table 3: Gravity estimates for specification (i)-(iii) with added PTA variables

	(i) (High SPS Risk)		(i) (Low SPS Risk)		(ii)		(iii)	
Contiguity	0.494***	(0.113)	0.338***	(0.098)	0.393***	(0.092)	0.393***	(0.092)
Common Language	0.436***	(0.107)	0.261*	(0.107)	0.221*	(0.104)	0.221*	(0.104)
Log Distance	-0.770***	(0.064)	-0.710***	(0.055)	-0.753***	(0.056)	-0.753***	(0.056)
Colony	0.062	(0.148)	0.373**	(0.122)	0.335*	(0.134)	0.335*	(0.134)
Agricultural Provisions	0.533	(0.470)	-0.633	(0.359)	-0.478	(0.292)	-0.478	(0.292)
Customs Provisions	0.110	(0.232)	0.910**	(0.329)	0.664**	(0.230)	0.664**	(0.230)
SPS Provisions	0.387*	(0.193)	-0.194	(0.201)	-0.073	(0.155)	-0.073	(0.155)
TRIPS	0.096	(0.168)	-0.010	(0.190)	-0.045	(0.156)	-0.045	(0.156)
GATS	-0.724**	(0.230)	0.376	(0.225)	0.269	(0.214)	0.269	(0.214)
Customs Union	0.901*	(0.377)	0.493	(0.262)	0.475	(0.250)	0.475	(0.250)
EIA	0.096	(0.211)	0.027	(0.218)	-0.037	(0.195)	-0.037	(0.195)
FTA	0.261	(0.363)	-0.152	(0.207)	-0.038	(0.189)	-0.038	(0.189)
High SPS Risk					-1.575*	(0.667)	3.981***	(0.780)
Contiguity * High Risk					0.011	(0.145)	0.011	(0.145)
Language * High Risk					0.244	(0.131)	0.244	(0.131)
Distance * High Risk					0.138	(0.077)	0.138	(0.077)
Colony * High Risk					-0.112	(0.187)	-0.112	(0.187)
Ag. Prov. * High Risk					1.456**	(0.562)	1.456**	(0.562)
Cust. Prov. * High Risk					-0.406	(0.360)	-0.406	(0.360)
SPS Prov. * High Risk					0.369	(0.246)	0.369	(0.246)
TRIPS * High Risk					0.489*	(0.229)	0.489*	(0.229)
GATS * High Risk					-0.762**	(0.270)	-0.762**	(0.270)
CU * High Risk					-0.181	(0.414)	-0.181	(0.414)
EIA * High Risk					0.190	(0.209)	0.190	(0.209)
FTA * High Risk					-0.601	(0.374)	-0.601	(0.374)
Constant	8.121***	(0.706)	8.172***	(0.646)	3.806***	(0.617)	-2.662***	(0.749)
Importer, Exporter F.E.	yes		yes		yes		yes	
Sector F.E.	no		no		no		yes	
N	2886		2886		606060		606060	

Standard errors clustered at the country pair level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: Summary of the estimation results for individual sectors using expanded trade agreement data (iv)

Variable	Low Risk		High Risk		K-S test stat.	K-S p-value
	Mean β	S.D.	Mean β	S.D.		
Distance (log)	-1.140	(1.027)	-1.531	(1.462)	0.244	0.013
Contiguity	0.354	(0.855)	0.274	(0.738)	0.125	0.502
Common Language	0.233	(0.961)	0.523	(0.858)	0.143	0.339
Colony	-0.052	(1.400)	0.215	(0.673)	0.213	0.042
Agriculture Provision	-0.504	(7.817)	-1.282	(5.716)	0.138	0.380
Customs Provision	0.649	(6.401)	0.017	(2.343)	0.185	0.106
SPS Provision	-0.589	(5.967)	0.240	(2.125)	0.185	0.106
TRIPS	0.496	(4.419)	0.113	(1.343)	0.091	0.855
GATS	0.328	(2.708)	0.025	(2.769)	0.096	0.810
Customs Union	0.892	(5.466)	3.107	(5.963)	0.192	0.086
EIA	0.025	(4.835)	-0.165	(2.128)	0.149	0.289
FTA	-0.039	(5.396)	1.864	(5.255)	0.162	0.206

present in 99.6 percent of trade agreements covered by the World Bank's database. Thus, it is likely that the variable is only identifying general trade facilitation effects, which are also being picked up in other variables, potentially explaining the inconsistencies between specifications (i)-(iii) and (iv).

By comparison, customs provisions appear to be effective at increasing the trade of agricultural goods in general but do not exhibit a statistical difference in their effects on high or low risk goods under most specifications. However, specification (iv) suggests that customs provisions are relatively more trade facilitating for low risk goods at close to a ten percent significance level. This relatively stronger impact for low risk goods may suggest that high risk goods, for which long clearance times tend to result is substantial depreciation of value such as rot, already experience special customs consideration outside of those identified by the variable. Thus, the broad provisions for customs transparency and clearance improvements controlled for here may largely represent improvements for non-fresh agricultural products not already covered.

Finally, SPS provisions, which reflect the harmonization of measures targeting the types of risks inherent to the studied products, exhibit limited influence on trade in agricultural goods generally or goods of a specific risk. The exception to this is specification (iv), which suggests that SPS provisions are more influential to high risk goods, again at a nearly ten percent confidence level.

This provides some support for the idea that NTM harmonization is trade facilitating.

The two measures representing membership to the TRIPS and GATS largely reinforce the initial observations that agricultural goods benefit from general trade facilitation. Both agreements represent efforts to improve trade by reducing costs, alleviating barriers, and addressing other frictions faced by IP sensitive goods and cross-border services. TRIPS, which targets intellectual property issues in trade, is relatively more facilitating for high risk goods than low risk goods under specifications (ii) and (iii). This relationship may be reflective of more sophisticated and proprietary IP embedded in the high risk goods, which tend to be fresh and of higher quality. Meanwhile, the GATS appears to be more facilitating for low risk goods under specifications (ii) and (iii). This observation may be related to that made above with regards to the effects of customs provisions. It may well be the case that the general services considerations have limited additional impact on high risk goods because they already exhibit special considerations due to the sensitivity of the goods. However, under specification (iv), neither TRIPS nor GATS exhibits significant differences across risk types when sectoral effects are permitted to vary across importers and exporters. This suggests that when controlling for variations in the types of products countries import and export, such as technology intensity in the case of TRIPS, these indirectly related trade agreements no longer disproportionately benefit high or low SPS risk goods. This observation provides further evidence that it is the specific provisions addressing aspects of certain high or low risk goods rather than general or indirect trade facilitation because the interaction between the country fixed effects and the sectors will have diluted the varying role of technology or services highlighted above.

The remaining three variables characterizing the type of agreement that both partners belong to—CU, EIA, and FTA—exhibit slightly curious results. Under most specifications, none of these types of agreements appear to be significant determinants of trade or exhibit large differences between high and low risk goods. This observation suggests that much of the trade facilitating behavior identified using the broadly defined PTA variable from the initial collection of gravity variables, which included agreements in all three categories, is specific to certain types of provisions rather than general trade facilitation. That is, the positive effects of trade agreements are more closely tied to specific cases in which provisions address the goods being traded rather than spillovers resulting from increased economic cooperation. This observation also provides support for the first of the two effects described above with respect to the TRIPS and GATS. If it is generally the case

that specific types of provisions are what cause increases in trade flows, it is likely that the positive effect that these two agreements have is reflective of their provisions for IP and services rather than more general, indirect liberalization. The one exception to this observation is that under specification (iv), customs unions are significantly more trade facilitating for high risk goods. This observation is consistent with much of the other results in that a customs union reflects general regulatory cooperation in addition to tariff reductions. As a result, it is not surprising that customs unions exhibit stronger effects on regulation-sensitive, high SPS risk goods when estimated at the sector level and controlling for country effects at that level.

These results, all taken together, provide strong evidence for several aspects of trade and SPS risk. High risk goods appear to be consistently affected by aspects of trade that slow the flow of goods from exporter to importer. The shortening of distances between trading partners and the introduction of policies that mitigate regulatory burdens through transparency and cooperation tend to increase the trade of high risk goods significantly more than low risk goods. These results suggest that policymakers with specific industries in mind ought to consider intrinsic characteristics of their goods when they design trade policy as not all goods are affected equally. Furthermore, the observed evidence suggests that increasing trade in specific types of products requires the introduction of agreements and provisions that directly target the products in question. Broad agreements representing general and indirect liberalizations do not appear to consistently increase trade in a specific subsets of products, namely high and low SPS risk agricultural goods.

Curiously, many of the results are sensitive to the model specification. In light of this, it is important to reassess these specifications in terms of model selection. Due to the important influences of sector specific fixed effects within the model, specification (iv) is our preferred specification. Of the four specifications, (iv) is the one the best controls for sector specific idiosyncrasies. There are many reasons for which a particular country may not import or export a particular HS 4-digit category that are unrelated to either SPS risk or trade costs. For example, a country in a temperate climate will likely never be a large exporter of certain agricultural products, regardless of their trade agreements or other trade costs. Specification (iv) with the additional trade agreement variables provides for the best control of this type of effect and the strongest identification strategy.

As such, our preferred interpretation of the results follows those reflecting the specification (iv) estimates. In summary, distance and colonial ties, which both represent proxies for trade costs

between partners, indicate that high risk goods benefit from cost reductions relatively more than low risk goods. Similarly, trade facilitation efforts in the form of trade agreements generally affect high risk goods more when they address issues that directly affect aspects of the goods being traded. More broadly defined, indirectly-related trade facilitation measures, or those that primarily lower tariffs rather than address regulatory harmonization, do not exhibit statistical differences in their effects when comparing high and low risk goods.

In addition to the specific results regarding the trade determinants of high and low SPS risk agricultural goods, these findings provide interesting insight into the ways in which economic research studies SPS issues and NTMs more broadly. As discussed in the introduction, most research assesses the effects of NTMs on trade by studying the effects of the measures themselves rather than by directly studying the product characteristics that have inspired the measures. Our findings provide evidence that this alternative, product-focused approach can return economically interesting policy implications while foregoing any need to ex-ante differentiate between non-tariff measures that address socially desirable issues and those that are either domestic protection efforts veiled as NTMs or unnecessarily burdensome due inefficiently designed measures (i.e. NTBs). Assuming that the trade agreements that countries enter into and the provisions included within tighten regulatory efficiency rather than concede socially desirable measures, the policy effects identified by our results are related only to protectionism or the inefficient application of NTMs. As such, this product-focused approach represents a promising strategy for future NTM research.

4 Conclusion

SPS concerns and the measures put in place to address them significantly influence trading patterns. Using a novel approach of identifying SPS issues by noting the agricultural goods for which SPS human, plant, and animal health risks are highest, we have observed several consistent trends. The estimates from several gravity model specifications suggest that high risk goods experience higher standards costs to trade as measured by distance between partners and, under the preferred specification, colonial relationships. Similarly, high risk goods tend to benefit more from trade facilitation in the form of preferential trade agreements broadly or specific types of facilitation such as customs unions or SPS provisions specifically. Likewise, high risk goods tend to be less affected

by specific customs provisions than low risk goods. Neither category of goods appears to exhibit significant differences with respect to other trade facilitation efforts that primarily lower tariffs or address indirectly-related aspects of trade, such as the TRIPS or GATS.

This work provides evidence that the risks underlying SPS measures exhibit specific nuances that ought to be considered when designing trade policies and, more specifically, SPS measures. In general, it appears that high risk SPS agricultural goods rely to a greater degree on trade facilitation policies than do lower risk goods. Furthermore, increasing trade in these high risk goods tends to require the introduction of policies that target specific issues related to SPS sensitivity rather than spillovers from broader liberalization efforts. Efforts to facilitate (or deter) trade in specific types of agricultural products ought to be composed of these types of attributes in order to be most effective.

In addition to providing insight into the trading patterns around SPS issues, this work also shows that a product-centric approach to the analysis on NTM issues can generate useful perspective on the ways in which NTMs prohibit trade. Unlike most research, which studies these issues through the lens of applied measures that may exist with multiple underlying motives, the presence of SPS risk in a product is not subject to politicking, rent-seeking, protectionism, or administrative inefficiency. The trends identified here are those associated only with actual health SPS concerns, bypassing any need to pass judgment on the scientific validity of any measures. For this reason, analysis of trade determinants using similar product-centric approaches can provide valuable information for designing measures that effectively provide the desired social protections while avoiding the introduction of inefficient barriers to trade.

This work opens the door for several promising avenues for further research extending the findings here. First, the incorporation of a panel dataset covering more years would provide better identification of the effects of preferential trade relationships by taking advantage of variation in membership overtime. A longer time series would also help answer lingering questions about the effects of longer-lived trade agreements. Second, the estimates could be used to parameterize general equilibrium experiments, such as those described in Baier and Bergstrand (2009), in order to simulate the effects of policy changes. Such work could, for example, better describe or predict the impacts of signing "deeper" trade agreements on specific markets by incorporating their SPS risk characteristics into the assessment.

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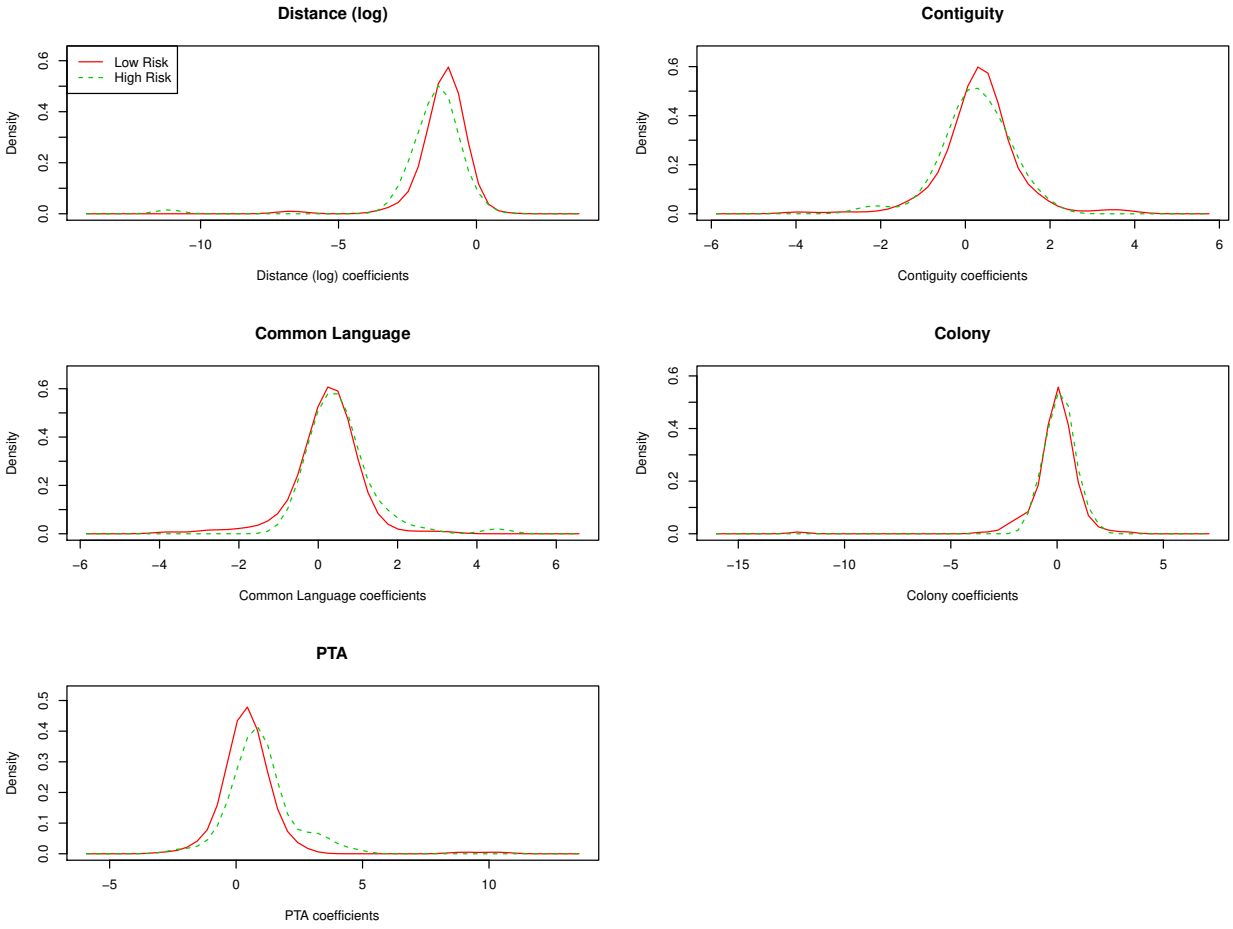

Figure 1: Kernel density plots of coefficient estimates in each sector using the initial set of gravity variables

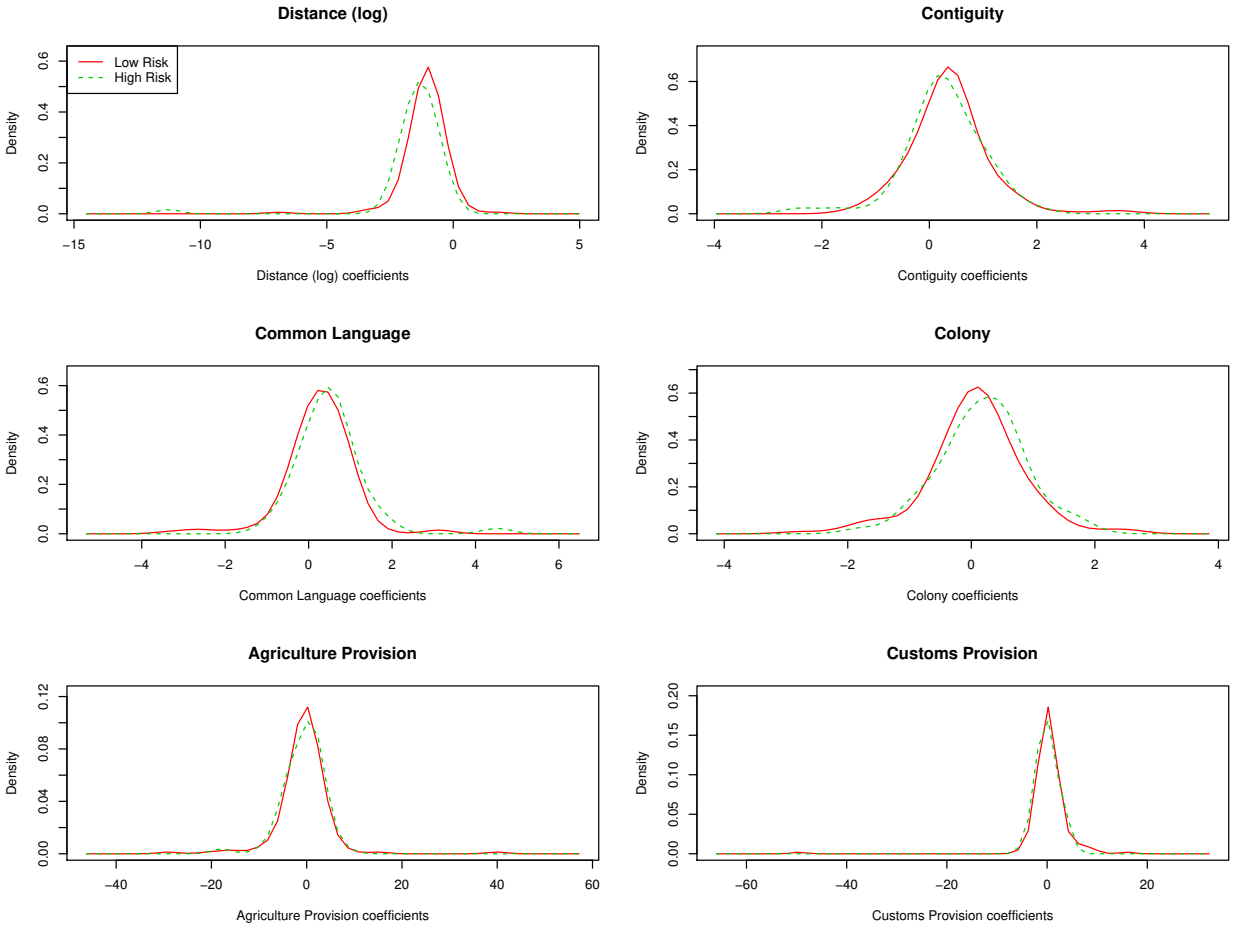

Figure 2: Kernel density plots of coefficient estimates in each sector using the expanded set of PTA variables

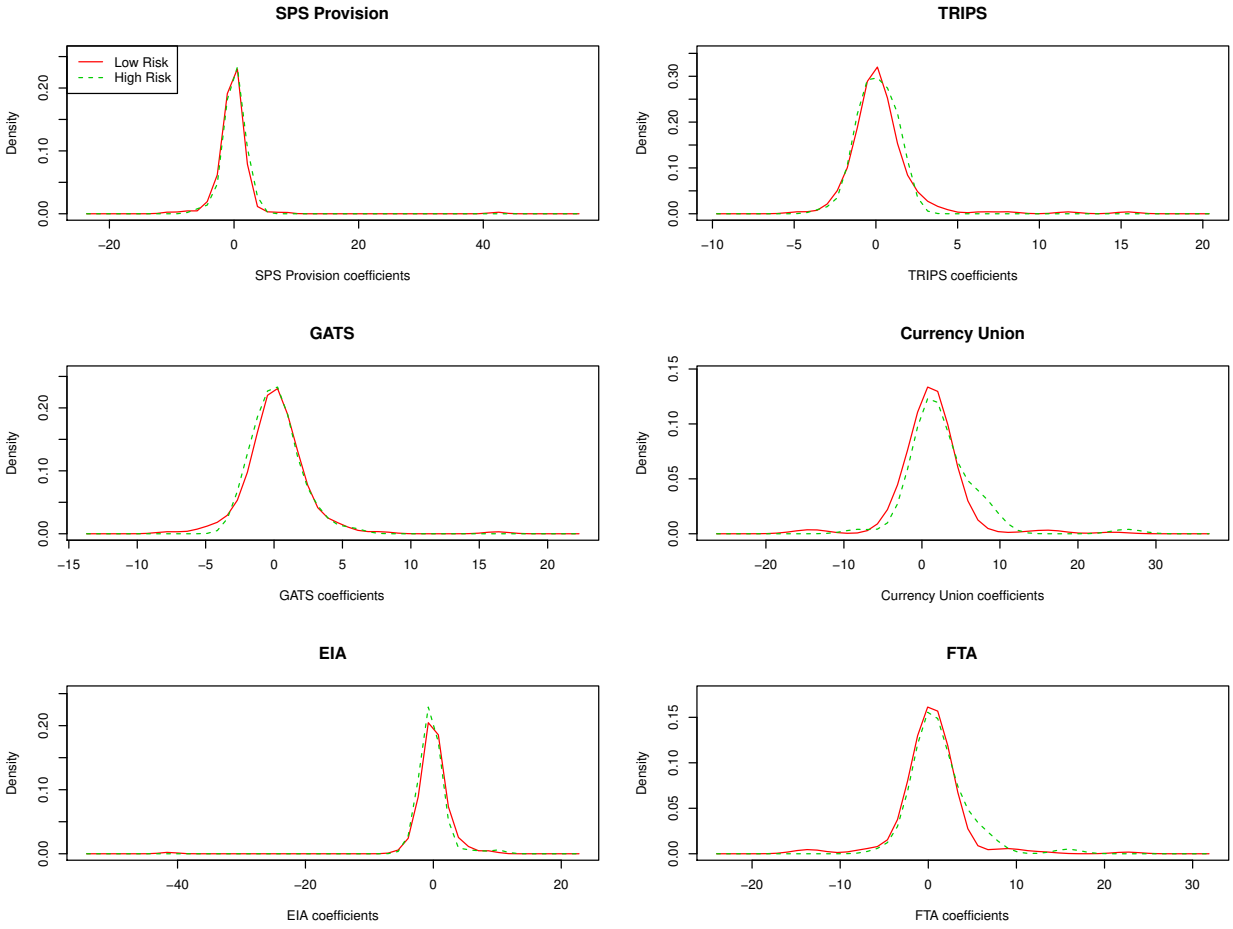

Figure 3: Kernel density plots of coefficient estimates in each sector using the expanded set of PTA variables

Table 5: List of agricultural, HS 4-digit codes and risk classification

High Risk	HS 4-digit	Product Description
x	0101	Live horses, asses, mules and hinnies.
x	0102	Live bovine animals.
x	0103	Live swine.
x	0104	Live sheep and goats.
x	0105	Live poultry
x	0106	Other live animals.
x	0201	Meat of bovine animals, fresh.
x	0202	Meat of bovine animals, frozen.
x	0203	Meat of swine.
x	0204	Meat of sheep or goats.
x	0205	Meat of horses, asses, mules or hinnies.
x	0206	Edible offal of animals.
x	0207	Meat and edible offal of the poultry.
x	0208	Other meat and edible meat offal.
x	0209	Pig fat.
x	0210	Meat and offal, salted, in brine, dried or smoked; edible flours and meals of meat or meat offal.
x	0401	Milk and cream, not concentrated or sweetened.
x	0402	Milk and cream, concentrated orsweetened.
x	0403	Buttermilk, curdled milk and cream, yogurt, kephir and other fermented or acidified milk and cream.
x	0404	Whey and products consisting of natural milk constituents.
x	0405	Butter and other fats and oils derived from milk; dairy spreads.
x	0406	Cheese and curd.
x	0407	Birds' eggs, in shell.
x	0408	Birds' eggs, not in shell, and egg yolk.
	0409	Natural honey.
x	0410	Edible products of animal origin, n.e.s.
	0501	Human hair.
	0502	Pigs', hogs' or boars' bristles and hair; badger hair and other brush making hair.
x	0504	Guts, bladders and stomachs of animals.
	0505	Skins and other parts of birds.
	0506	Bones and horn-cores.
	0507	Ivory, tortoise-shell, whalebone and whalebone hair, horns, antlers, hooves, nails, claws and beaks.
	0510	Ambergris, castoreum, civet and musk; cantharides; bile, whether or not dried; glands and other animal products for pharmaceuticals.
	0511	Animal productsn.e.s; dead animals, unfit for human consumption.
x	0601	Bulbs, tubers, tuberous roots, corms, crowns and rhizomes; chicory plants and roots.
x	0602	Other live plants (including their roots), cuttings and slips; mushroom spawn.
x	0603	Cut flowers and flower buds for ornamental purposes.
x	0604	Foliage, branches and other parts of plantsfor ornamental purposes.
x	0701	Potatoes, fresh or chilled.
x	0702	Tomatoes, fresh or chilled.
x	0703	Alliaceous vegetables, fresh or chilled.
x	0704	Edible brassicas, fresh or chilled.
x	0705	Lettuce and chicory, fresh or chilled.
x	0706	Carrots, turnips, and similar edible roots, fresh or chilled.
x	0707	Cucumbers and gherkins, fresh or chilled.
x	0708	Leguminous vegetables, fresh or chilled.
x	0709	Other vegetables, fresh or chilled.
	0710	Vegetables, frozen.
	0711	Vegetables provisionally preserved but unsuitable for immediate consumption.

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Table 5 – Continued from previous page

High Risk	HS 4-digit	Product Description
	0712	Dried vegetables.
	0713	Dried leguminous vegetables.
	0714	Roots and tubers with high starch or inulin content.
x	0801	Coconuts, Brazil nuts and cashew nuts, fresh or dried.
x	0802	Other nuts, fresh or dried.
x	0803	Bananas, including plantains, fresh or dried.
x	0804	Dates, figs, pineapples, avocados, guavas, mangoes and mangosteens, fresh or dried.
x	0805	Citrus fruit, fresh or dried.
x	0806	Grapes, fresh or dried.
x	0807	Melons and papaws (papayas), fresh.
x	0808	Apples, pears and quinces, fresh.
x	0809	Apricots, cherries, peaches, nectarines, plums and sloes, fresh.
x	0810	Other fruit, fresh.
x	0811	Fruit and nuts, frozen.
	0812	Fruit and nuts, provisionally preserved but unsuitable for immediate consumption.
	0813	Fruit, dried; mixtures of nuts or dried fruits
	0814	Peel of citrus fruit or melons.
	0901	Coffee.
	0902	Tea.
	0903	Mat.
	0904	Pepper of the genus Piper;fruits of the genus Capsicum or of the genus Pimenta.
	0905	Vanilla.
	0906	Cinnamon and cinnamon-tree flowers.
	0907	Cloves (whole fruit, cloves and stems).
	0908	Nutmeg, mace and cardamoms.
	0909	Seeds of anise, badian, fennel, coriander, cumin or caraway; juniper berries.
	0910	Ginger, saffron, turmeric (curcuma), thyme, bay leaves, curry and other spices.
	1001	Wheat and meslin.
	1002	Rye.
	1003	Barley.
	1004	Oats.
	1005	Maize (corn).
	1006	Rice.
	1007	Grain sorghum.
	1008	Buckwheat, millet and canary seeds; other cereals.
	1101	Wheat or meslin flour.
	1102	Cereal flours other than of wheat or meslin.
	1103	Cereal groats, meal and pellets.
	1104	Cereal grains otherwise worked; germ of cereal.
	1105	Flour, meal, powder, flakes, granules and pellets of potatoes.
	1106	Flour, meal and powder of dried leguminous vegetables, of sago, or of roots or tubers.
	1107	Malt.
	1108	Starches; inulin.
	1109	Wheat gluten.
	1201	Soya beans.
	1202	Ground-nuts, not roasted or otherwise cooked.
	1203	Copra.
	1204	Linseed.
	1205	Rape or colza seeds.
	1206	Sunflower seeds.
	1207	Other oil seeds and oleaginous fruits.
	1208	Flours and meals of oil seeds or oleaginous fruits.
	1209	Seeds, fruit and spores, of a kind used for sowing.
	1210	Hop cones; lupulin.

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High Risk	HS 4-digit	Product Description
	1211	Plants and parts of plants used primarily in perfumery, in pharmacy or for insecticidal, fungicidal or similar purposes.
	1212	Locust beans, seaweeds and other algae, sugar beet and sugar cane; fruit stones and kernels and other vegetable products
	1213	Cereal straw and husks.
	1214	Swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products.
	1301	Lac; natural gums, resins, gum-resins and oleoresins.
	1302	Vegetable saps and extracts; pectic substances, pectinates and pectates; agar-agar and other mucilages and thickeners.
	1401	Vegetable materials of a kind used primarily for plaiting.
	1404	Vegetable products n.e.s.
	1501	Pig fat and poultry fat.
	1502	Fats of bovine animals, sheep, or goats.
	1503	Lard stearin, lard oil, oleostearin, oleo-oil and tallow oil.
	1504	Fats and oils and their fractions, of fish or marine mammals.
	1505	Wool grease and fatty substances.
	1506	Other animal fats and oils and their fractions.
	1507	Soya-bean oil and its fractions.
	1508	Ground-nut oil and its fraction.
	1509	Olive oil and its fractions.
	1510	Other oils and their fractions, obtained solely from olives.
	1511	Palm oil and its fractions.
	1512	Sunflower-seed, safflower or cotton-seed oil and fractions thereof.
	1513	Coconut (copra), palm kernel or babassu oil.
	1514	Rape, colza or mustard oil and fractions thereof.
	1515	Other fixed vegetable fats and oils.
	1516	Animal or vegetable fats and oils and their fractions, partly or wholly hydrogenated.
	1517	Margarine; edible mixtures of animal or vegetable fats or oils.
	1518	Animal or vegetable fats and oils and their fractions, chemically modified.
	1520	Glycerol, crude; glycerol waters and glycerol lyes.
	1521	Vegetable waxes, beeswax, other insect waxes and spermaceti.
	1522	Degras; residues resulting from fatty substances or animal or vegetable waxes.
x	1601	Sausages and similar meat products.
x	1602	Other prepared or preserved meat products.
	1701	Cane or beet sugar and chemically pure sucrose, in solid form.
	1702	Other sugars, in solid form; sugar syrups; artificial honey; caramel.
	1703	Molasses.
	1704	Sugar confectionery.
	1801	Cocoa bean.
	1802	Cocoa shells, husks, skins and other cocoa waste.
	1803	Cocoa paste.
	1804	Cocoa butter, fat and oil.
	1805	Cocoa powder, not containing added sweetening.
	1806	Chocolate and other food preparations containing cocoa.
	1901	Malt extract; food preparations of flour, groats, meal, starch or malt extract, not containing minimal or no cocoa.
	1902	Pasta.
	1903	Tapioca and substitutes therefor prepared from starch.
	1904	Foods prepared with cereals or cereal products .
	1905	Bread, pastry, cakes, biscuits and other bakers' wares.
	2001	Vegetables, fruit, nuts and other edible parts of plants, prepared or preserved by vinegar or acetic acid.
	2002	Tomatoes prepared or preserved otherwise than by vinegar or acetic acid.

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High Risk	HS 4-digit	Product Description
	2003	Mushrooms and truffles, prepared or preserved otherwise than by vinegar or acetic acid.
	2004	Other vegetables prepared or preserved otherwise than by vinegar or acetic acid, frozen.
	2005	Other vegetables prepared or preserved otherwise than by vinegar or acetic acid, not frozen.
	2006	Vegetables, fruit, nuts, fruit-peel and other parts of plants, preserved by sugar.
	2007	Jams, fruit jellies, marmalades, fruit or nut pure and fruit or nut pastes.
	2008	Fruit, nuts and other edible parts of plants, otherwise prepared or preserved n.e.s.
	2009	Fruit juices (including grape must) and vegetable juices.
	2101	Extracts, essences and concentrates, of coffee, tea or mat.
	2102	Yeasts ; other single-cell micro-organisms; prepared baking powders.
	2103	Sauces; mixed condiments and seasonings; mustard flour and meal and prepared mustard.
	2104	Soups and broths and preparations therefor; homogenised composite food preparations.
x	2105	Ice cream and other edible ice.
	2106	Food preparations not elsewhere specified or included.
	2201	Waters, not containing sweetening nor flavoured; ice and snow.
	2202	Waters, containing sweetening, and other non-alcoholic beverages, not including fruit or vegetable juices.
	2203	Beer made from malt.
	2204	Wine of fresh grapes.
	2205	Vermouth and other wine of fresh grapes flavoured with plants or aromatic substances.
	2206	Other fermented beverages.
	2207	Undenatured, 80\% or higher ethyl alcohol; ethyl alcohol and other spirits, denatured, of any strength.
	2208	Undenatured, 80\% or less ethyl alcohol; spirits, liqueurs and other spirituous beverages.
	2209	Vinegar and substitutes for vinegar obtained from acetic acid.
	2301	Flours, meals and pellets, of meat or meat offal, of fish or other aquatic animals.
	2302	Bran, sharps and other residues, derived from the working of cereals or of leguminous plants.
	2303	Residues of starch manufacture and similar residues, beet-pulp, bagasse and other waste of sugar manufacture, brewing or distilling dregs and waste.
	2304	Oil-cake and other solid residues resulting from the extraction of soyabean oil.
	2305	Oil-cake and other solid residues resulting from the extraction of ground-nut oil.
	2306	Oil-cake and other solid residues resulting from the extraction of vegetable fats or oils.
	2307	Wine lees; argol.
	2308	Vegetable materials and vegetable waste, used in animal feeding, n.e.s.
	2309	Preparations of a kind used in animal feeding.
	2401	Unmanufactured tobacco; tobacco refuse.
	2402	Cigars, cheroots, cigarillos and cigarettes, of tobacco or of tobacco substitutes.
	2403	Other manufactured tobacco and manufactured tobacco substitutes.
	2905	Acyclic alcohols and their halogenated, sulphonated, nitrated or nitrosated derivatives.
	3301	Essential oils (terpeneless or not).
	3501	Casein, caseinates and other casein derivatives; casein glues.
	3502	Albumins.
	3503	Gelatin.
	3504	Peptones and other protein substances n.e.s.; hide powder, whether or not chromed.
	3505	Dextrins and other modified starches; glues based on starches, dextrins, or other modified starches.
	3809	Finishing agents and accelerating dye carriers
	3823	Industrial monocarboxylic fatty acids; acid oils from refining; industrial fatty alcohols.
	3824	Prepared binders for foundry moulds or cores; chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products), n.e.s.
x	4101	Raw hides and skins of bovine or equine animals.
x	4102	Raw skins of sheep or lambs.
	4103	Other raw hides and skins.

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High Risk	HS 4-digit	Product Description
x	4301	Raw furskins.
	5001	Silk-worm cocoons suitable for reeling.
	5002	Raw silk (not thrown).
	5003	Silk waste (including cocoons unsuitable for reeling, yarn waste and garnetted stock).
	5101	Wool, not carded or combed.
	5102	Fine or coarse animal hair, not carded or combed.
	5103	Waste of wool or of fine or coarse animal hair, including yarn waste but excluding garnetted stock.
	5201	Cotton, not carded or combed.
	5202	Cotton waste (including yarn waste and garnetted stock).
	5203	Cotton, carded or combed.
	5301	Flax, raw or processed but not spun; flax tow and waste (including yarn waste and garnetted stock).
	5302	True hemp (Cannabis sativa L.), raw or processed but not spun; tow and waste of true hemp.