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Effects of Tariffs and Sanitary Barriers on High- and Low-Value Poultry Trade

Everett B. Peterson and David Orden

A competitive partial-equilibrium spatial model with heterogeneous goods is constructed to evaluate effects of the removal of tariffs, tariff-rate quotas, and sanitary regulations on world poultry trade. The model distinguishes between "high-value" (mostly white meat) and "low-value" (mostly dark meat) poultry products and simulates the trade flows among eight exporting and importing countries and regions. Removing all barriers simultaneously has a larger impact on trade than removing only tariffs and tariff-rate quotas. Imposition of sanitary barriers against U.S. products by Russia shifts trade flows, but does not have large net impacts on U.S. producers.

Key words: poultry trade, sanitary barriers, tariffs

Introduction

World poultry markets represent one of the most rapidly growing sectors of the food industry. Poultry production has risen six-fold since 1965 to over 70 million tons. International trade has more than kept pace with this growth. World exports of poultry meat rose from approximately 380,000 mt in 1965 to over 8.7 million mt in 2002 (Food and Agriculture Organization of the United Nations, FAOSTAT database). Thus, trade accounts for about 10% of consumption.

The objective of this study is to evaluate the effects of sanitary barriers to poultry trade in the context of the economic incentives and other trade policy decisions that determine product flows in international markets. Poultry flocks are susceptible to diseases that can spread domestically and across borders. Microbial contamination of poultry for human consumption is also a serious problem in the sector, as with other meats, and is addressed by health regulations in exporting and importing countries. Thus, poultry markets are subject to a complex mix of national and trade sanitary regulations, together with nontechnical barriers in the form of tariffs and tariff-rate quotas (TRQs). The 1995 World Trade Organization (WTO) Agreement on Agriculture and on the Application of Sanitary and Phytosanitary (SPS) Measures has, to some extent, affected this mix, reducing levels of nontechnical border protection while tightening the rules for sanitary measures.

Everett B. Peterson is associate professor, Department of Agricultural and Applied Economics, Virginia Tech, Blacksburg, Virginia; David Orden is senior research fellow in the Markets, Trade, and Institutions Division, International Food Policy Research Institute, Washington, DC. The authors are grateful to Donna Roberts, ERS/USDA, Timothy Josling, Stanford University, and Mark Gehlhar, ERS/USDA, for comments and early contributions to this research. We also thank ERS/USDA for financial support through a cooperative agreement with Virginia Tech.

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To evaluate the policy effects on world poultry trade, a perfectly competitive, partial-equilibrium spatial model with heterogeneous goods is constructed to simulate the trade flows among six key non-composite exporting or importing regions (five countries and the European Union) and two rest-of-world region aggregates. The model incorporates several extensions of previous work. First, most previous analyses of the economic effects of technical barriers have examined bans on product shipments across a single border (e.g., Calvin and Krissoff, 1998; Paarlberg and Lee, 1998). Since alternative trade opportunities have not been evaluated in these case studies, assessment is precluded of arbitrage occurring through trade "deflection" when a bilateral ban leads other exporting countries to increase their sales to the specific importing region, with the blocked sales going elsewhere in world markets. As will be seen, there is a complex non-transitive set of existing bilateral poultry sanitary barriers between regions, indicating that trade deflection plays an important role in global poultry markets.

The second extension of previous work in our model is the separate identification of high-value (mostly white meat) and low-value (mostly dark meat) poultry products. Earlier poultry models have aggregated all products into a single category (e.g., Alston and Scobie, 1987; Kapombe and Colyer, 1998; Koo and Golz, 1994; Wang et al., 1998). Yet, bilateral trade data indicate that most often a country's imports and exports are concentrated in either high-value or low-value products. Maintaining this distinction significantly affects the benchmark model and simulated results of removing non-technical and sanitary trade barriers. Orden, Josling, and Roberts (2002) provide a simplified model with products differentiated by high and low value but assumed to be homogeneous between regions within each market category.

The Model

There are eight regions in the model: the United States (U.S.), Brazil, the European Union (EU), Japan, China, Russia, a rest-of-world poultry exporting region (ROWE), and a rest-of-world poultry importing region (ROWM). The non-composite regions were chosen because they account for a significant portion of world poultry production (approximately 70%) and poultry trade (approximately 90% of all exports and 75% of all imports).

Poultry Sector

All production, processing, and distribution activities within each region are merged into one industry. This level of aggregation is a simplifying assumption and reflects that for some regions, such as the United States, the production and processing activities are vertically integrated. A positive linear relationship is assumed between an aggregate poultry price and aggregate poultry production.

A wide range of poultry products are traded and are separated in the model into high-value and low-value products. The high-value poultry product includes white meat (breasts and wings) of chicken and turkey along with de-boned meat and specialty items. Low-value poultry is comprised of mainly dark meat (drumsticks and thighs) of chicken and turkey.[1] White and dark meats are produced in essentially equal (0.5 shares) and

[1] The distinction between white and dark meat product categories is consistent with industry characterizations of the poultry market (see Fuller, 2003).

fixed amounts per bird, and are thus treated as jointly produced goods. The distinction among trade flows in high-value and low-value products is important, because most countries mainly import (or export) dark (or white) meat due to the preferences of domestic consumers relative to production. For example, China and Russia import low-value poultry products, the EU imports high-value poultry products, and the U.S., as well as the EU, export low-value products. Brazil, in contrast, exports both high- and low-value poultry parts.

Because of the assumption of joint production, the supply responsiveness of the poultry sector depends on an aggregate poultry price, which is an average of the high-value and low-value prices. Joint production links the high- and low-value supplies and thus affects the simultaneous price determination in both markets. The relationship between the high-value and low-value poultry prices and the poultry supply response can be seen using the definition of the aggregate poultry price:

$$P_A = 0.5P_H + 0.5P_L, \tag{1}$$

where P_A is the aggregate poultry price, P_H is the high-value poultry price, and P_L is the low-value poultry price. Totally differentiating equation (1), converting to percentage changes, and multiplying each term on the right-hand side by q_A/q_A, where q_A is quantity of aggregate poultry production and $q_H = q_L = 0.5q_A$, yields:

$$\hat{P}_A = \frac{0.5q_A P_H}{P_A q_A}\hat{P}_H + \frac{0.5q_A P_L}{P_A q_A}\hat{P}_L = \frac{q_H P_H}{P_A q_A}\hat{P}_H + \frac{q_L P_L}{P_A q_A}\hat{P}_L = r_H\hat{P}_H + r_L\hat{P}_L, \tag{2}$$

where r_H and r_L are the revenue shares of high-value and low-value poultry products, respectively. The percentage change in the aggregate poultry price is a revenue share weighted average of the percentage changes in the individual poultry prices. Any combination of changes in high-value and low-value poultry prices that increase the aggregate poultry price will lead to an increase in both high-value and low-value poultry output.

Consumer Demand

Consumer demand for poultry products in each region is represented by a four-level nested constant elasticity of substitution (CES) demand system (see figure 1). At the bottom level, consumers choose among alternative sources of imported high-value poultry products or low-value poultry products, respectively. We have chosen to use an Armington specification due to the variation in unit value across exporters for a given importing region (see table 1). This price variation indicates there are some differences across countries in the specific types of high- or low-value products being traded. The low-value poultry products being exported from the United States, for example, are not exactly the same products as the low-value poultry from the EU or Brazil.

In the second level of the nested CES demand system (figure 1), consumers choose between a domestically produced and an aggregate imported high-value or low-value poultry product based on their relative prices. At the third level, consumers choose between aggregate high-value and low-value poultry products. If the aggregate price of high-value poultry, which is a function of the price of imports and the domestic price of high-value poultry, increases relative to the aggregate price of low-value poultry,

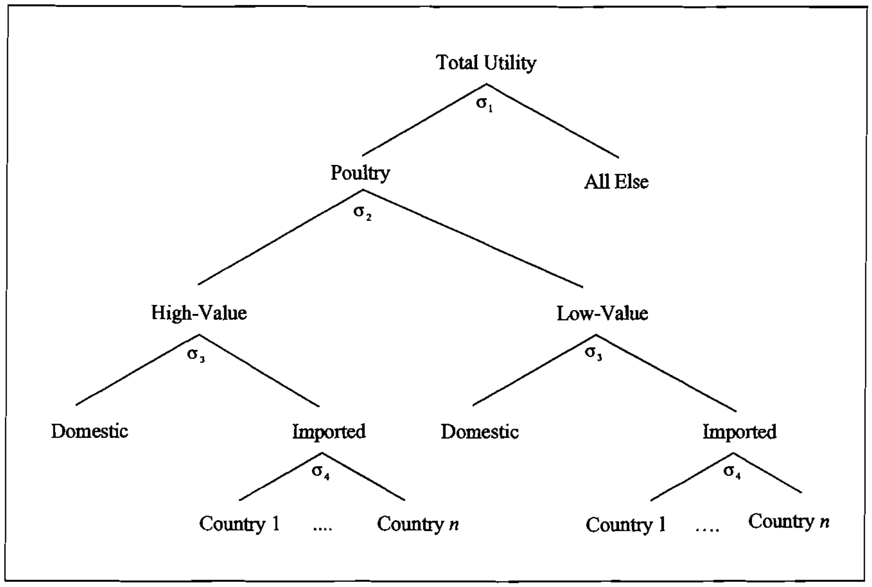

Figure 1. Structure of consumer preferences

consumers will increase their consumption of low-value poultry and decrease their consumption of high-value poultry. At the top level of the demand system, consumers choose between an aggregate poultry product and all other products. This allows for consumers to increase or decrease their overall consumption of poultry products as the aggregate relative price of poultry changes.

Government Policies

The base year of the model is 1998. During that year, all non-composite regions imposed tariffs on imported poultry products. The Japanese import market had the lowest tariffs (averaging 10%) of all of the non-composite regions. This in part reflects the Japanese government's encouragement of foreign investment by Japanese poultry firms in Brazil, Thailand, and China. The EU restricts poultry imports through TRQs, which are allocated to Brazil, Canada, Mexico, and countries in Central and Eastern Europe that have quota-restricted preferential access under the Europe Agreements. In-quota EU tariffs average 20%, and the EU over-quota tariffs are prohibitive. Russia imposes tariffs averaging 22.5%. Both the United States (average 25%) and Brazil (average 35%) use tariffs to protect their poultry markets even though these countries are relatively low-cost exporters.

Because poultry flocks are susceptible to infectious diseases and microbial contamination of poultry meat is a serious problem, many countries have sanitary (SPS) regulations that impose restrictions on exports from one or several countries. Table 2 summarizes whether binding SPS barriers exist between the six non-composite regions in the model.

One might expect that these regions would divide into two groups, those free of highly infectious poultry diseases and those not free of disease, with trade occurring within each group. However, this is not the case. The major importers of poultry products, China, Japan, and Russia, accept imports from all exporting regions in the model.

Table 1. Unit Value of 1998 World Poultry Trade, SITC Code 01235, "Poultry Cuts and Offal, Frozen" ($U.S. per metric ton)

	Importers						All Others	
Exporters	U.S.	Brazil	EU	China	Japan	Russia	High Value	Low Value
U.S.	—	—	—	647	1,112	719	—	808
Brazil	—	—	2,505	717	1,940	—	1,774	—
EU	—	—	—	936	—	712	—	710
China	—	—	—	—	1,890	—	1,563	—
All Others:								
High Value	—	—	3,264	—	2,060	—	—	—
Low Value	—	—	—	798	—	885	—	—

Source: International Bilateral Agricultural Trade database (USDA/ERS), developed from the United Nations Conference on Trade and Development bilateral SITC trade data.
Note: The trade data contained several instances of very small trade flows, generally less than 500 metric tons between regions in the model. Because of their small magnitudes and the likelihood that they represent trade in specialty poultry products, these trade flows are dropped from the benchmark trade flows.

Table 2. Bilateral SPS Barriers to Poultry Trade

	Importers					
Exporters	U.S.	Brazil	EU	China	Japan	Russia
U.S.	—	Banned	Banned	Allowed	Allowed	Allowed
Brazil	Banned	—	Allowed	Allowed	Allowed	Allowed
EU	Allowed	Allowed	—	Allowed	Allowed	Allowed
China	Banned	Banned	Banned	—	Allowed	Allowed

Source: Authors' review of trade-related regulations.

The two major exporters, the United States and Brazil, do not accept imports from each other and also ban imports from China, based on recurrent outbreaks of Newcastle Disease. The EU also bans imports from the U.S. and from China. The main point of disagreement between the U.S. and the EU is on the use of end-of-line chlorine decontamination in U.S. processing facilities. The EU does not consider this to be equivalent to trisodiummonophosphate or lactic acid decontamination, and therefore has banned poultry imports from the United States. Imports of poultry from Brazil into the U.S. are banned based on intermittent outbreaks of poultry diseases in Brazil, but the EU does not block imports from Brazil due to disease problems. Finally, Brazil's SPS barrier against imports from the United States is based on the decision that the inspection system for poultry processing plants in the U.S. is not equivalent to its own. Thus, diverse sanitary barriers applied differently among countries lead to a complex set of trade opportunities.

Data

The benchmark bilateral trade flows are obtained from the USDA's International Bilateral Agricultural Trade Database, which is adopted from trade data of the United Nations and contains information on the quantity (in metric tons) and the value of poultry trade in each category.[2] The UN trade data identify six, five-digit SITC categories for trade in poultry products. These SITC categories separate poultry into whole birds, cuts, and livers, as well as distinguish between fresh or chilled and frozen. The dominant SITC category is 01235, "poultry cuts and offal (other than livers), frozen," which accounts for nearly 70% of world (excluding intra-EU) poultry trade. Because of our interest in differentiating the distinct markets for high-value and low-value poultry products, our analysis is focused specifically on these frozen poultry cuts. The next largest category (SITC 01232), "poultry not cut in pieces, frozen," accounts for approximately 20% of world poultry trade—but to retain tractability in our differentiated-product model, we exclude this and the four remaining SITC categories.

The bilateral trade flows within the category of frozen poultry cuts were assigned to either high-value or low-value products based on the unit values computed from the data (see table 1). For example, Brazilian exports to Japan and the EU (with unit values of $1,940 and $2,505, respectively) are assumed to consist of high-value poultry products, while Brazilian and U.S. exports to China, or U.S. exports to Russia (with unit values of $717, $647, and $719, respectively) are assumed to consist of low-value poultry products. Table 3 reports quantities of the benchmark bilateral trade flows in high-value and low-value products on this basis. The only gray area in this dichotomy is U.S. exports to Japan, whose unit value does not closely match either category. In examining the U.S. trade data at the 10-digit Harmonized System (HS) level, approximately 70% of U.S. exports to Japan are in the category "0207140090" which is defined as "frozen other cuts/edible offal (inc. livers)." Because nearly all of U.S. exports to China and Russia also fall in the same category, and to avoid creating a second low-value products classification in the model, we assume U.S. exports to Japan are low-value products.[3] Given the relatively small amount of U.S. poultry exports to Japan (76,100 mt), this abstraction should not substantially affect the model results.

The level of poultry production for each region is given in the first column of table 3. It is the 1998 estimate of poultry meat production (obtained from the Food and Agriculture Organization FAOSTAT database). The level of poultry production in the two composite regions is determined by first identifying which countries (other than those already in the model) are net poultry exporters in FAO trade data. Then, the level of poultry production in the ROWE region is the sum of production in these exporting countries. Poultry production for the ROWM region is obtained by subtracting the quantity of poultry meat produced in all other regions in the model from world poultry production.

Data on domestic prices of high- and low-value poultry products by region were not available. However, the general magnitude of many of these prices can be inferred from the reported unit trade values and estimates of transportation costs.[4] Exact benchmark domestic prices for each region were determined as part of the model calibration process.

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[2] The authors are grateful to Mark Gehlhar, ERS/USDA, who provided access to the trade data.

[3] Comparing the unit export values within the 10-digit HS category between Japan, China, and Russia indicates that even within this narrow HS category there are product or quality differences.

[4] Our estimates of transportation costs were made from limited available ocean freight rates and are available from the authors on request.

Table 3. Benchmark Data (1998)

Country	Production	Price	U.S.	Brazil	ROWE	EU	China	Japan	Russia	ROWM	Net Trade
			Domestic Consumption (+), Exports (+), or Imports (–)								
High Value:	(mil. mt)	($/mt)	<---------- (million metric tons) ---------->								
U.S.	7.619	1,950	7.619	—	—	—	—	—	—	—	0.000
Brazil	2.485	1,850	—	2.328	—	0.043	—	0.067	—	0.047	0.157
ROWE	2.841	1,800	—	—	2.654	0.062	—	0.125	—	—	0.187
EU	4.446	2,900	—	-0.043	-0.062	4.552	—	—	—	—	-0.105
China	5.675	1,750	—	—	—	—	5.428	0.194	—	0.054	0.247
Japan	0.606	2,200	—	-0.067	-0.125	—	-0.194	0.991	—	—	-0.385
Russia	0.345	2,205	—	—	—	—	—	—	0.345	—	0.000
ROWM	7.206	2,000	—	-0.047	—	—	-0.054	—	—	7.306	-0.101
Total High Value:	31.222										
Low Value:	(mil. mt)	($/mt)	<---------- (million metric tons) ---------->								
U.S.	7.619	485	5.581	—	—	—	0.491	0.076	0.683	0.789	2.038
Brazil	2.485	545	—	2.349	—	—	0.136	—	—	—	0.136
ROWE	2.841	600	—	—	2.715	—	0.126	—	—	—	0.126
EU	4.446	600	—	—	—	3.871	0.139	—	0.145	0.292	0.576
China	5.675	1,100	-0.491	-0.136	-0.126	-0.139	6.565	—	—	—	-0.891
Japan	0.606	750	-0.076	—	—	—	—	0.682	—	—	-0.076
Russia	0.345	925	-0.683	—	—	-0.145	—	—	1.172	—	-0.827
ROWM	7.206	800	-0.789	—	—	-0.292	—	—	—	8.287	-1.081
Total Low Value:	31.222										
Total HV + LV:	**62.444**										

Sources: Production derived from Food and Agriculture Organization FAOSTAT database; trade flow data taken from International Bilateral Agricultural Trade Database (USDA/ERS), developed from the United Nations Conference on Trade and Development bilateral SITC trade data; domestic prices derived from model calibration by the authors.

Note: Due to rounding errors, totals may not add.

Calibration

The calibration process for the CES demand system begins at the high- and low-value import sub-utility functions because this is the level where both initial quantities and expenditure are observed. The CES utility and sub-utility functions, for each region i, for each level of the demand system in figure 1 can be expressed as:

$$U = \left\{ \sum_{j=1}^{n} \alpha_j^{1/\sigma} x_j^{(\sigma-1)/\sigma} \right\}^{\sigma/(\sigma-1)}, \quad \sum_{j=1}^{n} \alpha_j = 1, \tag{3}$$

where α_j is a shift parameter to be determined during calibration, x_j is the quantity of good j consumed, n is the number of goods consumed, σ is the elasticity of substitution for that level in the nested CES demand structure, and the regional subscript i is suppressed for simplicity. The resulting demand function and true cost-of-living price index for each level are then denoted by:

$$x_j = \frac{\alpha_j p_j^{-\sigma} I}{\sum_j \alpha_j p_j^{1-\sigma}} \tag{4}$$

and

$$P_M = \left\{ \sum_{j=1}^{n} \alpha_j p_j^{1-\sigma} \right\}^{1/(1-\sigma)}, \tag{5}$$

where I is total or group expenditures, p_j is the price of good j, and P_M is the price index.

Import Sub-utility

Typically, equation (4) is calibrated by rescaling all prices to equal one and setting the values of α_j equal to the associated import share of that good from region j into region i. A problem with this approach at the level of the import sub-utility functions is that if region j does not export to region i in the initial equilibrium, α_j is set equal to zero, which then bars the possibility of region j exporting to region i after reform of trade policies occurs. Because removing trade barriers, especially SPS barriers, could alter the observed pattern of trade, this method of calibrating the α_j is clearly constraining.

In our calibration, we assume instead that all $\alpha_j = \alpha$ for those countries exporting to a given region in a given scenario. Assuming all α's are equal allows them to be removed without altering the preference structure of the utility function, eliminating the α_j also from equations (4) and (5). The implication of this assumption is that imports from each region with which trade is considered feasible are consumed in equal amounts if all import prices are the same. As long as a given region imports high- or low-value poultry from at least one source in the benchmark, our assumption provides a systematic basis for evaluating trade of that product occurring with other regions under alternative scenarios. A limitation of the assumption that all α_j's are equal is that the calibrated prices cannot be made to exactly match the data-derived export unit values for all regions. This is because the differences in relative import quantities are strictly due to relative price differences, whereas choice of unique α_j's for each exporting region reflects other demand factors affecting relative import levels. A second limitation of this approach is that it does not provide a systematic basis for counter-factual scenarios in cases when there are no benchmark imports. In some cases, technical barriers might be thought likely to block imports from all sources. A number of disputes over technical barriers to poultry trade have been addressed through the WTO informal dispute consultation process (Josling, Roberts, and Orden, 2004). But these cases, as well as other disputes on technical barriers brought up at the WTO, generally involve bilateral issues, not barriers that preclude all trade.

Using equation (4) under our assumption on the α_j's, the prices of imported high-value or low-value poultry products are determined in calibration to replicate the benchmark trade flows and total expenditures on imports by each region. The values of the calibrated import prices are also a function of the value of the elasticity of substitution between import sources (σ_4 in figure 1). The smaller the value of this elasticity, the larger will be the calibrated import price differentials between regions. Various values for the import elasticity of substitution were tried during the calibration process. Values of less than 10 resulted in much larger price differentials than the observed differentials in unit export values, while values over 10 did not reduce the price differentials substantially. Therefore, the elasticity of substitution between imports is assumed equal to 10 for all regions.[5]

To illustrate the price calibration process, consider the imports of high-value poultry into Japan. In the benchmark, three regions—Brazil, China, and the ROWE—export 385,100 mt of high-value poultry to Japan at a value of $752.4 million. A system of three equations, representing the quantity of high-value poultry imported from each region, in three unknowns (the import prices), is then solved. The resulting import prices are assumed to be cost + insurance and freight (c.i.f.) prices. Continuing with the Japan example, the calibrated high-value import prices per metric ton for the base model scenario are $2,102 for Brazil, $1,889 for China, and $1,974 for ROWE. Subtracting the international transportation costs determines the corresponding domestic price for each of the exporting countries (see table 3). The domestic price of high-value poultry in Japan is estimated to approximately equal the average tariff-inclusive c.i.f. import price.

For low-value poultry, the domestic prices for the U.S. and the EU are averages of the calibrated c.i.f. prices for China and Russia less transport costs (ROWM is excluded from the averages because transportation costs are not known). For Brazil, the domestic low-value price is based on the calibrated c.i.f. price for China. For China, Russia, and ROWM, the domestic low-value poultry price is set equal to the average tariff-inclusive c.i.f. import price in each region. For Japan, the import price and domestic price of low-value poultry are set at the domestic U.S. price plus transportation costs and tariffs.

While most high-value and low-value domestic prices can be determined from the calibrated import prices, tariffs, and estimated transport costs, alternative methods must be used for regions that do not export or import a given poultry product. For the United States, the high-value poultry price is set equal to an average wholesale price of chicken breast, chicken wings, and turkey breast (USDA/ERS). For Russia, the domestic high-value price is set equal to the average domestic high-value price in Brazil, China, and ROWE plus the 22.5% tariff rate. Thus, the domestic high-value price in Russia would be less than the domestic price of the potential exporters plus transport cost. This assumption is made because Russia does not import any high-value poultry, and a domestic price less than the exporter's price plus transport cost would discourage high-

[5] Alston and Scobie (1987) considered two different values for this parameter, 3 and 36, in their analysis. A value of 5.0 is used in conducting a sensitivity analysis of our results.

value exports to Russia. Finally, because of the TRQ in the EU, the calibrated high-value import prices are not considered accurate reflections of the EU domestic prices. In 1998, the average wholesale price for young chickens was approximately \$1,750/mt (European Commission, 2002). Hence, the EU high-value poultry price was computed such that the simple average of the domestic high-value and low-value price equals \$1,750.

Remaining Demand Parameters

Once domestic prices for all products have been calculated, the parameters in the remaining CES utility and sub-utility functions can also be determined. Since all the remaining groups in the nested CES have only two goods, equation (4) simplifies with the α_j replaced by α and $(1 - \alpha)$. For example, consider the sub-utility functions governing the substitution between domestic and imported high-value (low-value) poultry products. Then x_j is the quantity of the domestic poultry product consumed, p_j is the domestic price, p_m is an import price index determined using equation (5) at the bottom-level import sub-utility function, σ is the elasticity of substitution between domestic and imported products (i.e., the Armington elasticity, or σ_3 in figure 1), and I is expenditure on high-value (low-value) poultry products. Once an elasticity of substitution is chosen, the only unknown parameter that needs to be chosen is the shift parameter α.

Values for σ_1 and σ_3 in each region are obtained from the Global Trade Analysis Project (GTAP) database (Center for Global Trade Analysis, 2001). The elasticity of substitution between poultry and all else (σ_1) is set equal to the Allen partial elasticity of substitution between the GTAP commodity "other meat products" (which includes poultry meat) and an all-other-commodity aggregate for each region (see table 4). Given that the budget share for all poultry products is small, the value of σ_1 basically determines the aggregate own-price demand elasticity for poultry.[6] The Armington elasticities in the GTAP database vary across products, but not across regions. We use a value of $\sigma_3 = 2.5$, which is an average between the two GTAP commodities that include live and processed poultry products.

No estimates of the elasticity of substitution between high-value and low-value poultry products (σ_2) were available. Because of the strong consumer preferences for either white or dark meats in various regions, such as the preference for white meat versus dark meat in the United States and the converse in Brazil and Russia, it is assumed that substitution possibilities in demand between high-value and low-value products are limited. Therefore, we assumed an elasticity value of 0.5 for all regions. Based on the assumed values of the elasticities of substitution and the initial consumption budget shares, all poultry products are gross substitutes for one another in all regions.

The implied own-price uncompensated demand elasticities for high-value and low-value poultry for all regions are given in table 4. In general, the demand elasticities for domestically produced products are inelastic, while the elasticities for imports are elastic. This difference is due to much smaller consumption shares for imports. The relatively larger demand elasticities for domestic product in Japan are due to smaller poultry consumption shares. These demand elasticities are within the ranges used by previous studies.[7]

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[6] The aggregate demand elasticity for poultry is equal to $s_A(\sigma_1 - 1) - \sigma_1$, where s_A is the budget share for all poultry products.

[7] Koo and Goltz (1994) assume perfectly inelastic demand; Alston and Scobie (1987) use a demand elasticity of -0.5 for all regions; Beck, Hoskins, and Mumey (1994) use demand elasticities of -0.56 for broilers and -1.09 for turkey; and Wang et al. (1998) use poultry demand elasticities of -1.33 and -0.53 for urban and rural consumers in China.

Table 4. Demand Elasticities at Initial Prices

Region	σ_1 [a]	Own-Price Demand Elasticity [c]			
		DHV [b]	IHV	DLV	ILV
U.S.	0.30	-0.33	—	-0.47	—
Brazil	0.20	-0.27	—	-0.43	—
ROWE	0.15	-0.24	—	-0.41	—
EU	0.20	-0.30	-2.45	-0.46	—
China	0.25	-0.36	—	-0.60	-2.30
Japan	0.40	-1.17	-1.75	-0.80	-2.18
Russia	0.10	-0.32	—	-1.72	-1.06
ROWM	0.20	-0.32	-2.47	-0.68	-2.23

[a] Elasticity of substitution between poultry products and all other products in consumers' utility function in figure 1. The other elasticities of substitution in figure 1 do not vary across countries. The assumed values of σ_2, σ_3, and σ_4 are 0.5, 2.5, and 10, respectively.

[b] The abbreviations DHV, IHV, DLV, and ILV stand for domestic high-value poultry products, imported high-value poultry products, domestic low-value poultry products, and imported low-value poultry products. Cells without an entry represent zero consumption in the benchmark data set.

[c] The unconditional own-price elasticities for a nested CES utility function are derived based on the formula from Keller (1980) for the own-price Allen partial elasticities of substitution. For example, the own-price Allen partial elasticity of substitution for domestic high-value poultry products is:

$$\sigma_{DHV} = -\left[\sigma_3\left(c_{DHV}^{-1} - c_{HV}^{-1}\right) + \sigma_2\left(c_{HV}^{-1} - c_P^{-1}\right) + \sigma_1\left(c_P^{-1} - 1\right)\right],$$

where c_{DHV}, c_{HV}, and c_P are the initial budget shares of domestic high-value poultry, all high-value poultry, and all poultry, respectively. Then, the unconditional own-price demand elasticity for domestic high-value poultry, noting that the CES utility function is homothetic, is defined as $\varepsilon_{DHV} = c_{DHV}(\sigma_{DHV} - 1)$. The same procedure is utilized for the other poultry products.

Supply Response

Little empirical evidence exists on poultry supply elasticities across regions. Wang et al. (1998) assumed a supply elasticity of 1.175 for China. Kapombe and Colyer (1998) estimated a supply response of 0.13 for U.S. broiler production. Because of the lack of supply elasticity estimates across regions, we consider two values. The first value represents a long-run effect where regions have time to build more production and processing facilities. For this case, we follow Alston and Scobie (1987) and assume an aggregate supply elasticity of 5 across regions. The second value represents the short run, where an aggregate supply elasticity of 0.5 is assumed for all regions.

Results

The model developed in the previous section is used to analyze the impacts on the global poultry sector of four alternative policy changes. First, we remove all tariffs and the EU TRQ among the six non-composite regions but leave any SPS barriers in place. Second, we remove only the SPS barriers. Third, we remove all trade barriers among the six non-composite regions, a "free trade" case for these regions. The final policy change is drawn from recent events, a Russian ban on low-value imports from the United States [see Ames (1998) for the chronology of one recent dispute]. Results using the long-run supply response are reported in table 5. The base case model production, domestic prices, and trade flows correspond with table 3.

Table 5. Long-Run Model Results

Variable	Base	Remove Tariffs and TRQs		Remove All Barriers		Russian Ban on U.S. Exports	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Poultry Production:	(mil. mt)	<--------------	Percentage	Change (%)		-------------->	
U.S.	15.238	0.86	0.52	2.12	1.65	-0.67	-0.73
Brazil	4.969	6.09	10.08	4.68	8.61	-0.12	3.69
ROWE	5.682	4.99	4.39	3.80	3.41	-0.11	-0.32
EU	8.893	-3.66	-4.10	-4.18	-4.54	1.33	0.33
China	11.349	-3.18	-3.34	-3.24	-3.41	-0.15	-0.36
Japan	1.212	-3.18	-3.68	-3.38	-3.85	-0.24	-0.72
Russia	0.690	-3.88	-4.93	-3.98	-4.97	8.51	3.79
ROWM	14.411	0.40	0.02	0.37	0.01	-0.10	-0.24
Total:	62.444	0.04	0.02	0.03	0.01	0.05	0.04
HV Poultry Prices:	($/mt)	<--------------	Percentage	Change (%)		-------------->	
U.S.	1,950	-1.81	-1.10	-1.29	-0.68	1.42	1.57
Brazil	1,850	1.76	-1.28	1.06	-1.88	0.26	-4.22
ROWE	1,800	1.62	1.29	0.96	0.76	0.26	0.02
EU	2,900	-2.64	-2.27	-2.79	-2.43	-2.67	-0.66
China	1,750	4.70	4.54	4.63	4.49	0.24	-0.03
Japan	2,200	-1.81	-1.92	-1.89	-1.99	0.32	0.04
Russia	2,205	2.92	3.72	3.00	3.74	-6.26	-2.82
ROWM	2,000	-0.43	0.03	-0.41	0.02	0.15	0.24
LV Poultry Prices:	($/mt)	<--------------	Percentage	Change (%)		-------------->	
U.S.	485	8.13	4.96	7.33	4.39	-6.39	-7.04
Brazil	545	2.52	16.40	3.65	17.13	-0.76	17.51
ROWE	600	2.28	2.79	3.29	3.57	-0.62	-0.29
EU	600	8.48	6.18	8.62	6.43	14.45	3.59
China	1,100	-9.13	-8.95	-9.04	-8.90	-0.47	-0.14
Japan	750	2.80	2.72	2.88	2.81	-1.13	-0.68
Russia	925	-9.58	-12.19	-9.84	-12.29	20.69	9.29
ROWM	800	1.36	-0.05	1.28	-0.05	-0.44	-0.76
Total HV Exports:	(mil. mt)	<--------------	Percentage	Change (%)		-------------->	
U.S.	0.000	0.00	0.00	—[a]	—[a]	0.00	0.00
Brazil	0.157	100.90	138.46	74.73	111.97	-0.10	23.63
ROWE	0.187	78.51	67.62	56.91	49.98	-0.04	-4.49
China	0.247	-8.37	-13.71	-10.60	-15.64	-0.03	-7.80
Total:	0.591	48.12	52.42	52.26	55.69	-0.05	1.60
Total LV Exports:	(mil. mt)	<--------------	Percentage	Change (%)		-------------->	
U.S.	2.038	13.87	8.59	17.43	11.96	-11.79	-13.03
Brazil	0.136	123.39	299.27	108.37	278.85	-8.93	199.45
ROWE	0.126	123.89	116.48	109.17	103.94	-9.46	-10.05
EU	0.576	3.94	-6.15	0.97	-8.23	54.55	14.39
Total:	2.874	21.85	24.05	22.43	24.51	1.73	2.61
Total HV Imports:	(mil. mt)	<--------------	Percentage	Change (%)		-------------->	
EU	0.105	243.71	259.90	264.25	275.81	0.00	0.00
Japan	0.385	9.19	10.16	9.71	10.61	-0.01	0.99
ROWM	0.101	-7.34	-2.71	-6.45	-1.85	-0.28	5.58
Total:	0.591	48.12	52.42	52.26	55.69	-0.05	1.60

(continued . . .)

Table 5. Continued

	Base	Remove Tariffs and TRQs		Remove All Barriers		Russian Ban on U.S. Exports	
Variable	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Total LV Imports:	(mil. mt)	<--------------		Percentage Change (%)		-------------->	
China	0.891	72.59	75.68	73.17	76.49	6.07	7.14
Japan	0.076	14.71	20.16	16.26	21.37	8.93	10.93
Russia	0.827	8.00	5.91	8.39	6.24	-9.26	-8.88
ROWM	1.081	-8.87	-4.33	-8.20	-4.11	6.05	7.07
Total:	2.874	21.85	24.05	22.43	24.51	1.73	2.61

Note: Due to rounding errors, totals may not add.
Column Definitions:
[1] = Base scenario.
[2] = Maintains bilateral trade patterns from base case.
[3] = Allows Brazil to export low-value poultry products to Russia and the ROWM.
[4] = Maintains bilateral trade patterns from base case, but removal of barriers opens EU market to U.S. exports.
[5] = Allows U.S. entry into EU and Brazil to export low-value poultry products to Russia and the ROWM.
[6] = Maintains bilateral trade patterns from base case, but eliminates U.S. access to Russian market.
[7] = Eliminates U.S. access, but allows Brazil to export low-value poultry products to Russia.
[a] Percentage change cannot be calculated, but exports expand to 111,000 mt and 99,000 mt, respectively, in columns [4] and [5].

Removal of Tariffs and TRQs (with SPS barriers still in place)

In analyzing this policy change, we consider two long-run scenarios. In the first, the nontechnical trade barriers are removed with the bilateral trade patterns remaining the same as in the base case. A scenario is then considered where liberalization could change the existing trade patterns, even with SPS barriers in place. In particular, a scenario is analyzed where Brazil becomes an exporter of low-value poultry to Russia and the ROWM region. Given the growth of the Brazilian sector into a major player in poultry export markets, there is some potential for Brazil to enter these two markets. Finally, given the uncertainty of the magnitude of poultry supply elasticities, these two experiments are conducted using the short-run supply responses.

Long-Run Results

The removal of all tariffs and TRQs results in the reduction of the relative price of imported poultry products in all importing regions. This causes an increase in the demand for imported poultry products in those regions. Trade in high-value and low-value poultry products increases by 48.1% and 21.8%, respectively (see table 5, column 2), representing an increase of 913,000 mt, or 26.3%, in the total volume of trade. Because low-value poultry products account for the majority of poultry trade in the base case, approximately two-thirds of the increase in trade volume is in low-value products.

The regional impacts depend on import and export patterns of that region and on the magnitude of liberalization. For example, the United States is a large exporter of low-value products, but does not trade high-value products. Tariff liberalization results in an increase in U.S. low-value exports by 13.8%, or 282,000 mt (table 5, column 2). The largest increase in exports is to China, which has the largest tariff reduction, followed by an increase in exports to Russia.[8] To satisfy the increase in export demand for low-

[8] Bilateral trade flows are not shown for the scenarios in table 5, but are available from the authors on request.

value products, the United States must increase poultry production and/or decrease domestic consumption of low-value products. The U.S. low-value poultry price increases by 8.1%, achieving both an expansion in production and a shift in domestic demand from low-value products to high-value products. With the joint nature of poultry production, if the expansion in production is greater than the substitution effect in demand, then the price of high-value products will fall. This is the case for the United States, with the price of high-value poultry declining by 1.8%. Note that this decrease in the U.S. high-value price limits the expansion in U.S. poultry production because it offsets much of the increase in the U.S. low-value price, leaving a smaller increase in the revenue-share weighted U.S. aggregate poultry price. When taking these two effects into account, U.S. poultry production increases by 0.9%, or 130,000 mt.

The impacts of liberalization on Brazil and the aggregate exporting region (ROWE) are similar because these regions export both high-value and low-value products in relatively equal proportions; hence the increase in exports can be accomplished with an expansion in production without requiring large relative poultry price changes. The prices of high-value poultry increase by 1.8% and 1.6%, respectively, in Brazil and the ROWE, while low-value poultry prices increase by 2.5% and 2.3%, respectively (table 5, column 2). Because the prices of high-value and low-value poultry products both increase, the aggregate poultry price increases by a larger percentage in Brazil and ROWE compared to the United States. Thus, there is a larger expansion in poultry products in these regions (6.1% for Brazil and 5.0% for ROWE) than in the U.S. (0.9%).

China and the EU experience different effects from liberalization because they are importers and exporters of poultry products. Consequently, liberalization will result not only in an increase in demand for each region's exports, but an increase in import demand by each region as imports become relatively cheaper than domestic poultry (table 5, column 2). The impact on poultry production and prices in China and the EU depends on the relative strength of the increase in exports versus imports. China is a much larger importer of low-value poultry than an exporter of high-value products. Coupled with the largest decrease in tariffs, low-value imports increase by 72.6% (646,000 mt). The decrease in the demand for Chinese low-value poultry results in a 9.1% drop in the price of this product. This price reduction in turn leads to a reduction in Chinese poultry production, and therefore a reduction in supply of both high-value and low-value products. The decrease in the supply of Chinese high-value poultry is greater than the decrease in demand, which is due to Chinese consumers substituting relatively lower price low-value poultry for high-value poultry. Thus, the Chinese high-value poultry price increases by 4.7% and exports fall by 8.4% (20,000 mt). In the EU, the removal of the TRQ results in an increase in high-value imports of 243.7%, or 257,000 mt. This is larger than the increase in low-value exports (3.9%, or 22,000 mt). The EU high-value poultry price declines, reducing the aggregate EU poultry price and therefore EU poultry production. The increase in export demand coupled with a decrease in supply leads to an increase in the price of EU low-value poultry.

Russia is an importer of low-value poultry products. The removal of tariffs on imported low-value poultry products reduces the price of imports versus domestically produced low-value poultry for Russian consumers. This causes consumers to substitute imported low-value poultry for domestically produced low-value poultry. As observed from table 5 (column 2), the decrease in demand for Russian low-value poultry leads to a 9.6% price reduction and a 3.9% reduction in Russian poultry production. The demand for Russian high-value poultry also decreases as consumers substitute to the relatively less expensive low-value products. However, this decrease in demand is less than the decrease in Russian high-value poultry supply, causing the price of Russian high-value poultry to increase by 2.9%.

Japan as well as the aggregate importing region (ROWM) import both high-value and low-value poultry products. However, we did not include the ROWM in the assumed reduction of trade barriers because of limited information about trade policies of these countries. Therefore, the effects of the liberalization modeled are different for these two regions. In the initial benchmark, Japan imports roughly five times more high-value poultry products than low-value poultry products. Thus, the removal of Japanese tariffs has a larger impact on Japanese high-value product volume. Due to the decrease in the relative price of imports, Japanese purchases of imported high-value products increase by 35,000 mt (9.2%) while the purchases of low-value products increase by 11,000 mt (14.7%). The substitution of imported for domestic poultry products decreases the demand for Japanese poultry, leading to a 3.2% reduction in Japanese poultry production and a 1.8% decrease in the Japanese price of high-value products. The drop in the production of low-value Japanese poultry is greater than the decrease in demand, so its price increases by 2.8% (table 5, column 2). In the ROWM region, liberalization by other countries results in the prices of imported poultry increasing relative to domestically produced poultry. This causes consumers in the ROWM to substitute domestically produced poultry for imports. There is a much larger increase in the demand for ROWM low-value poultry versus high-value poultry (because the ROWM region imported approximately 10 times more low-value poultry in the base case). Thus, the net expansion in ROWM poultry production results in the price of ROWM low-value poultry increasing (1.4%) and the price of ROWM high-value poultry decreasing (-0.4%).

Entry of Brazil into New Markets

The third column in table 5 reports the results for the scenario where tariffs and the EU TRQs are removed and Brazil enters new markets to export low-value poultry to Russia and the ROWM, becoming a direct competitor with the U.S. and the EU. This new entry leads to both a substitution and expansion effect (stemming from the assumed demand structure) in those markets. Holding expenditures on imported low-value poultry products constant, new entry leads to a reduction in market share for all incumbents. However, since the CES demand structure is "variety loving," the price index of imported products decreases with new entry leading to an expansion in imports. For the U.S. and the EU, the substitution effect dominates the expansion effect, with exports to Russia and the ROWM declining compared to the base case. For Brazil, the substitution and expansion effects in Russia and the ROWM reinforce one another, leading to a 300% increase in Brazilian low-value exports. This is a much larger increase in Brazilian low-value exports compared to the previous scenario.

The main impact from the larger increase in Brazilian low-value exports is that the price of Brazilian low-value poultry increases relative to the U.S. and EU low-value poultry prices—an opposite result compared to the previous scenario. This helps the U.S. and the EU increase their sales of low-value poultry to China, due to the substitution effect, and allows both countries to stem some of the loss of sales in Russia and the ROWM. However, compared to the previous scenario, the U.S. and the EU experience smaller increases in the price of low-value products. The U.S. has a smaller overall increase in poultry production (0.5%), while the EU experiences a larger overall decrease in poultry production (-4.1%).

Short-Run Results

In the short run, because poultry producers cannot respond as much to changes in poultry prices, trade liberalization would be expected to have smaller effects on production and trade, compared to those shown in table 5 for the long run.[9] All regions experience a smaller increase or smaller decrease in poultry production in the short run. Because of the smaller production expansion in poultry exporting countries, in the short run there is a 10%–15% smaller increase in high-value poultry trade and approximately 5% smaller increase in low-value poultry trade.

With an inelastic supply response, one would also expect trade liberalization to have larger impacts on price changes compared to the longer-run scenario. However, due to the joint production of high-value and low-value poultry products, this is not always the case. For example, the decrease in the price of U.S. high-value poultry is smaller in the short run than in the long run. This is because a smaller increase in U.S. poultry production in the short run puts less downward pressure on the U.S. high-value price. Similarly, there is a smaller increase in the Chinese high-value price and the EU low-value price. Smaller reductions in poultry production in both regions in the short run imply relatively larger supplies and smaller price increases. Finally, a smaller reduction in Russian poultry production in the short run provides enough additional high-value poultry whereby the price decreases in the short run compared to a price increase in the long run.

Removal of SPS Barriers Only

In this scenario, all of the SPS barriers listed in table 2 are removed.[10] With the EU's TRQs still in place, removal of the SPS barriers on U.S. and Chinese imports is moot because these countries do not have quota rights. Thus, only the U.S.'s ban on Brazilian and Chinese poultry products and Brazil's ban on U.S. and Chinese poultry products are effectively removed. Since the United States is a large exporter of low-value poultry, it is only likely that Brazil or China would export high-value poultry products to the U.S. But given the size of the U.S. poultry sector and the differences in the base prices plus

[9] Because the base value of 10 for the elasticity of substitution among import sources (σ_4 in figure 1) may be considered too high, we also examined each long-run and short-run scenario using an elasticity of substitution of 5 among import sources. The effect of reducing this parameter is to lessen the substitution effect between competing imports relative to the expansion effect due to lower import prices after the removal of existing tariffs. Because the majority of poultry trade is in low-value products and the United States is the least cost low-value producer, a smaller substitution effect means smaller increases in U.S. low-value exports. When the existing trade patterns are maintained, the gains in U.S. low-value exports are 40% to 50% lower (long run and short run) than reported in the text. If Brazil enters the Russian and ROWM low-value poultry markets, then U.S. low-value exports do not significantly increase. Again, these results are available from the authors on request.

[10] This does not necessarily imply that all such regulations are unnecessary or protectionist in intent. Full risk-based evaluations of the impact of alternative sanitary regulations and the consequences of their modification are needed to inform judgments about whether a particular regulatory barrier is an efficient and effective way of controlling health dangers. Here, we limit our analysis to the effects of removing these barriers between our aggregated regions, without providing an assessment of whether doing so would raise sanitary risks among these trading partners.

transportation costs, lifting of the U.S. SPS barriers is unlikely to generate a significant amount of export sales. The same is true for U.S. or Chinese exports to Brazil. Thus, removing these barriers alone does not really create the potential for increased trade. These are not the strongest results from our model because, in the absence of any imports by Brazil or the United States in the benchmark data, a preference for imports would have to be arbitrarily specified to induce any trade. For the reasons given above, we chose not to set a nonzero value of this parameter.

Free Trade

In this scenario, all nontechnical and SPS barriers are simultaneously removed. The most important effect comes from the removal of the EU's TRQs and SPS barriers which we assume allows for access to the EU high-value poultry market for U.S. poultry producers.[11] The main impact of this policy change, seen by comparing the results in columns 4 and 5 in table 5 with those in columns 2 and 3, is an expansion of U.S. high-value and low-value exports relative to other exporters. With new market access to its high-value poultry market, the United States exports around 100,000 mt of high-value poultry to the EU. The drop in the U.S. high-value poultry price is less when all trade barriers are removed than with only the nontechnical trade barriers removed. This leads to a greater expansion in U.S. poultry production. With more U.S. low-value poultry produced, the low-value price increase is smaller when all trade barriers are removed and the U.S. is able to further expand its low-value poultry exports.

Russian Ban on U.S. Low-Value Poultry Imports

Russia is a major market for U.S. low-value poultry products, accounting for nearly one-third of all U.S. low-value poultry exports in 1998. An import ban on U.S. low-value poultry by Russia would reduce the demand for U.S. low-value poultry products while increasing the demand for these products from U.S. competitors. Consequently, the price of U.S. low-value poultry falls while the prices of low-value poultry from Brazil and the EU increase. As shown in the last two columns of table 5, the U.S. low-value poultry price decreases by 6.4% to 7.0% compared to the base price. The changes in Brazilian and EU low-value poultry prices depend on whether or not Brazil is assumed to export to Russia. Without access to the Russian market, the Brazilian price remains virtually unchanged, and the EU price increases 14.5%. With access to the Russian market, the Brazilian low-value price increases 17.5%, while the EU low-value price increases 3.6%. With either change in relative prices, the United States increases its low-value exports to China and the ROWM. Increased U.S. exports to these regions offset some of the loss of exports to Russia, yielding an overall reduction in U.S. low-value exports of 11.8% to 13.0%. The change in U.S. poultry production is much smaller (-0.7%) because the lower price of low-value poultry products leads to increased domestic consumption.

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[11] Simultaneous removal of the tariff-rate quota and SPS barriers might also give China access to the EU market, but exports from China are mostly labor-intensive processed products targeted at the Japanese market. Consequently, we did not include EU access by China in the reported model.

Summary and Conclusions

This study has utilized a competitive partial-equilibrium spatial model with heterogeneous goods to examine the effects of nontechnical and sanitary barriers that impede world poultry trade. The model draws a key distinction between high- and low-value poultry products, which are jointly produced but have distinct patterns of trade among the eight countries and regions in the model. On the demand side, a four-level nested CES system is specified in which imported poultry products in the high- and low-value categories compete with the similar goods produced domestically. The model is calibrated under the assumption that imports by a region would be consumed in equal amounts if all import prices were the same. From this calibration, we replicate observed trade flows, and derive import and domestic prices consistent with the benchmark data.

The simulation results suggest that nontechnical barriers to trade among the eight countries and regions have significant effects on world markets. Under our long-run elasticities, global trade would expand by more than 25% if nontechnical trade barriers were removed by the major importers. Removing nontechnical and sanitary barriers simultaneously creates additional trade opportunities compared to removing only nontechnical barriers—in our case, primarily from the additional access the United States gains to the EU market.

The disaggregated results for high- and low-value poultry products also yield insights about the effects of trade policies on each of these poultry markets. Production falls in the major importing regions with removal of trade barriers, but the joint production of high- and low-value poultry, as well as increased trade flows, determine the effects on specific prices (and marketed quantities) within each country. When Brazil is assumed to enter low-value poultry markets of Russia and the ROWM region as new markets, effects on production and exports resulting from trade policy reform are reduced for the U.S. and EU, and their exports are partly diverted to China. Similarly, if U.S. products are excluded from Russia, as has occurred several times based on ostensible sanitary concerns, arbitrage opportunities partially ease the impact on the U.S. poultry sector. Thus, our results show that both nontechnical and sanitary barriers matter to world poultry markets, as do market arbitrage possibilities.

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