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Do Drug Residues Limits Affect International Trade in Beef?

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Abstract

There have been a number of high profile food safety disputes in trade over the past decade. These include the widely publicized dispute at the World Trade Organization between the U.S. and EU over hormone treated beef. Consumers in some industrialized countries have also expressed concern over imported beef produced with antibiotics and other artificial supplements. Developing countries are affected in a significant way in both how disputes are settled, as well as balance between risk and safety reflected in how standards are set. This paper examines the impact of drug residue standards on trade in beef and effect of setting harmonized international food safety standards. We find that if international standards set by Codex are followed in antibotics, global trade in beef would rise by over $3.2 billion. Among other developing countries, South Africa's exports would rise by $160 million, Brazil's by $200 million, and Argentina's by over $300 million.

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1. Introduction

Food safety regulations are motivated by public demand as well as the intention to protect domestic market. When regulations are set to protect public health, they are driven by a perception of risk in food consumption. In beef trade over the last decades, the outbreak of Foot-and-Mouth Diseases, and Bovine Spongiform Encephalopathy (BSE) has generated wide public attention to food safety risks. The use of veterinary drugs in livestock, such as growth hormones and veterinary medicines in beef has also been the subject of public debate and concern over the past decade.

The total elimination of risks associated with all animal diseases and drug residues is not economically and technologically feasible. Tightening food safety regulations on the use of veterinary drugs can induce significant additional costs to livestock producers because veterinary drugs are widely used to prevent infectious diseases caused by bacteria, to reduce the amount of feed needed for each animal, and to increase the rate of weight gain i.e. to stimulate growth. Tighter food safety standards consequently require producers to adopt alternative means to control animal diseases, if they are required to reduce the use of veterinary drugs.

The use of veterinary drugs in developing countries is likely to increase as a result of increased production and availability of veterinary drugs through imports from developed countries (FAO/IAEA Training and Reference Centre, 2002). In 1991, North America and Western Europe represented 56.8 percent of the world market for veterinary drugs with estimated sales at the level of 5.6 billion euro. In contrast, registered sales in Asia, Eastern Europe and Latin America were 1.7, 0.94 and 0.18 million euro, respectively, but are likely to grow, as veterinary drugs are an attractive input for animal-borne food production (Botsoglou and Fletouris, 2001). Food safety requirements imposed on developing country exports to the major OECD markets raise challenges for developing countries, given lack of capacity in technology, human resources, and infrastructure.

International standards are developed, in part, to mitigate the problems associated with discordances between importing and exporting countries related to differing food safety standards and attitudes toward food-borne risks and trade. The objective of the Codex Alimentarius Commission (Codex) is to develop international food safety standards that guarantee consumer health while not impeding trade – in support of goals referenced in the Sanitary and Phytosanitary Standards (SPS) Agreement of the World Trade Organization (WTO). In the case of veterinary drug residues, the Codex international maximum residue limits (MRLs) are supposed to be consistent with "(the) safe levels of Acceptable Daily Intakes (ADI) when veterinary drugs are used in accordance with good veterinary practice" (WTO, WT/DS48/R/CAN, 18 August 1997). Governments do not, however, generally accept Codex MRLs. Codex and the WTO have limited ability to encourage adoption of the MRLs (Wessel, 1992) and the differences in food safety standards across countries have often resulted in trade disputes (see, for example, IATRC (2001)).

In order to explore the impact of differing national standards and possible benefits of adopting Codex international standards to trade, this paper examines the impact of food safety standards on beef trade between sixteen exporting countries and five importing countries and the EU. We focus on the effect of a particular veterinary drug residue standard on trade flows of bovine meat. The drug for specific focus is tetracycline. Among veterinary drugs, tetracyclines are one of the most used around the world to promote animal health. About 58 percent of the antibiotics manufactured in the United States are tetracyclines and penicillin G. (Botsoglou and Fletouris, 2001).

The second section of this paper provides an overview of the use of veterinary drugs for growing livestock and their effect on food safety. The third section reviews regulatory measures of several countries on veterinary drug residues in beef. The fourth section reviews patterns of world trade in beef. The fifth section develops an empirical model to estimate the elasticity of trade flows with respect to tetracycline standards, and discusses the results. The final section summarizes our findings.

2. Beef Trade and Use of Veterinary Drugs

Overuse and inappropriate use of antibiotics in animals are giving rise to more drug-resistant bacteria, which is affecting the treatment of various life-threatening diseases in humans. The Institute of Medicine at the National Academy of Sciences has estimated the annual cost of treating antibiotic-resistant infections in the United States at $30 billion. Out of fifty million pounds of antibiotics produced in the United States each year, twenty million pounds are given to animals, of which 80 percent (16 million pounds) is used on livestock merely to promote more rapid growth. (Earth Times, July 1998).

Antibiotics and antimicrobial drug residues are present in animal bodies even after they are slaughtered. This is particularly true when sufficient time is not allowed for the residues to vanish. Cattle fed with antibiotics may result in the development of antibiotic resistant pathogens. There are several channels through which antibiotics and anti-microbial drug residues can cause adverse effects on human health through dietary intake of animal-borne products. Resistant pathogens might be directly transmitted from animals to humans, resulting in infections that are more difficult to treat (WHO/EMC/ZOO/97.4). Although resistant pathogens may not directly cause disease, they can transfer this resistance to pathogenic bacteria in the human body (WHO/EMC/ZOO/97.4; Prescott, 1997). In rare cases, the dietary intake of antibiotics and other veterinary drugs are also believed to cause a direct adverse health effect on humans.[1]

For example, salmonella infection occurs as a result of consumption of meat that is anti-microbial resistant. Ground beef originating from dairy cows is believed to transmit an antibiotic-resistant infection known as Salmonella Newport. Infected meat from the slaughtered cull dairy cows was used in the production of hamburger that has caused human illness (Franco et al, 1990). Eighty-four percent of isolates were resistant to at least 1 antibiotic, and 53 percent were resistant to at least 3. Eighty percent were resistant to tetracycline, 60 percent to sulfamethoxazole, 27 percent to ampicillin, and 16 percent to ceftriaxone.

Overall, however, the direct scientific evidence of risks associated with veterinary uses of antibiotic and antimicrobial drugs is very limited (Institute of Medicine, 1989; Swann report, 1969; U.S. Congress, Office of technology Assessment, 1995). A report from Institute of Medicine (1989) calculates that "the likeliest estimate of excess deaths attributable to subtherapeutic uses of penicillin and/or tertacyclines..... is in the range of 6 per year" and that "the likeliest estimate of deaths.....arising because of increased difficulty of treating is 20 per year."

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[1] Antibiotics known as chloramphenicol and a beta-2 agonist called clenbuterol are capable of having direct toxic effect. Chloramphenicol has been the cause of fatal aplastic anemia that results in death in approximately 70 percent of the cases and people recovering have high chances of experiencing acute leukemia. A veterinary drug known as clenbuterol has caused food poisoning in Spain affecting 135 people. Consumption of veal liver meals with clenbuterol residue caused food poisoning in France as well. In Italy 62 people had clenuterol intoxication after consuming beef. (Botsoglou and Fletouris, 2001).

3. Regulations on Veterinary Drug Residues

In the OECD countries, registration is typically required for veterinary drugs. As shown in Table 1, registration authorities are also in charge of setting drug residue standards in the United States and Japan. In Australia, New Zealand and Canada the registration authority and the authority responsible for setting veterinary drug standard are different. In the EU, a coordinating body exists for collectively setting common standards among the member countries, but registration authorities differ across countries. Authorities that monitor compliance with domestic or import standards are generally affiliated with agricultural ministries, such as the USDA, whereas registration and standard-setting authorities are affiliated with health ministries such as the USFDA. Testing facilities are used to determine maximum daily intake of the residues scientifically. These facilities conduct compliance monitoring in most cases.

Table 1 Regulating Authorities of Veterinary Drugs in Selected Countries

Country or Grouping	*Drug registration*	*Setting veterinary drug standard*	*Monitoring compliance with drug standard (Domestic)*	*Monitoring compliance with drug standard (Imports)*
EU		Committee for Veterinary Medicinal Products (CVMP)	Each country has its own surveillance scheme. To oversee this surveillance, there exists a Community Reference Laboratories that supports and advises the national laboratories.	Same as domestic scheme
U.S.	Center for veterinary medicine of Food and Drug administration (FDA)	FDA	Food safety and Inspection service (FSIS) of U.S. Department of Agriculture (USDA)	FSIS of USDA
Australia	National Registration Authority (NRA)	The Australian Quarantine and Inspection Service (AQIS), the Australian Customs Service (ACS) and Australia New Zealand Food Authority (ANZFA)	National Residue Survey (NRS), of the National Office of Food Safety of the Department of Agriculture, Fisheries and Forestry, Australia (AFFA)	NRS of AFFA
New Zealand	Agricultural compounds and veterinary medicines group (ACVM) of Ministry of Agriculture and Forestry (MAF)	Australia New Zealand Food Authority (ANZFA)	MAF	MAF

Table 1 Regulating Authorities of Veterinary Drugs in Selected Countries

Country or Grouping	*Drug registration*	*Setting veterinary drug standard*	*Monitoring compliance with drug standard (Domestic)*	*Monitoring compliance with drug standard (Imports)*
Canada	Bureau of Veterinary Drugs, Health Protection Branch, Federal Department of Health	Health Canada of Agriculture and Agri-Food Canada (AAFC)	Health Canada of AAFC	Canadian Food Inspection Agency (CFIA) of AAFC
Japan	Pharmaceutical and Food Safety Bureau of (PFSB) Ministry of Welfare (former Ministry of Health, Labor and Welfare)	PFSB of Ministry of Welfare	Agricultural Production Bureau, and General Food Policy Bureau of Ministry of Agriculture, Forestry and Fishery (MAFF), and PFSB of Ministry of Welfare	National Veterinary Assay Laboratory (NVAL) of MAFF

Source: Authors' research

In the United States, the Center for Veterinary Medicine (CVM) of the FDA is responsible for drug registration. A tolerance level of antibiotic residues has been determined for each antibiotic used in animal feed based on the results of extensive tests for toxicity and carcinogenicity (Franco et al, 1990). The National Residue Program of Department of Agriculture's Food and Safety Inspection Service (FSIS) conducts laboratory test of samples and reports the results of the analysis of the samples to CVM. At the completion of the investigation recommendations are made or appropriate steps are taken to prevent future violation.

In Canada, there has been a rapid growth in the regulation of animal antibiotics since 1990. Canada passed the Health of Animals Act in 1990. The registration of veterinary drugs is the responsibility of the Bureau of Veterinary Drugs, Health Protection Branch, and Federal Department of Health, acting under the Food and Drugs Act and Regulations. The food-control procedures in Canada rest with four departments: Health Canada, Agriculture and Agri-Food Canada, Department of Fisheries and Ocean and Industry Canada. Drug monitoring is conducted at the slaughter plants by veterinary meat inspectors. Canadian Federal Meat Inspection system of the Food Production and Inspection Branch, Federal Department of agriculture and Agri-Food deal with drug monitoring.

In the European Union (EU) maximum residue limits (MRLs) for veterinary drugs are established within the Committee for Veterinary Medical Products (CVMP) after taking into account all publicly available relevant scientific information (including opinions of the Scientific Committee on Veterinary Measures relating to Public Health, reports from the Joint FAO/WHO Expert Committee on Food additives (JECFA) or reports from internationally renowned research organizations) concerning the safety of residues of the drug concerned for the consumer of animal-borne food. In the event of any disagreement among the member states about the quality, safety or efficacy of a veterinary drug, the matter can only be resolved by a binding Community decision within a European regulatory framework. The European Agency for the Evaluation of Medicinal Product is responsible for this task. Since January 1992 a new regulation was passed that does not authorize a new pharmacologically active substance for use in veterinary medicine unless a union wide MRL has been established. The Commission has also published a timetable for establishing these MRLs. The EU passed three regulations in the 1990s with regard to

veterinary drugs. Council Directive 96/23/EC regulates the monitoring of residues in animals and animal products. Commission Directive 97/6/EC requires resistance monitoring for feed additive antibiotics and related substances in animal bacteria. Currently there is no veterinary medicine that is allowed to be used as growth-promoting agent in the EU.

The Commonwealth National Registration Authority (NRA) is in charge of registration of veterinary drugs in Australia. When the usage of a particular drug is likely to leave residues, the Australia New Zealand Food Authority (ANZFA) assesses the impact of dietary intake. National residue Survey (NRS) in the National Office of Food safety of the Department of Agriculture, Fisheries and Forestry, Australia (AFFA) is responsible for monitoring edible animal products for residues. During 1997-1998, NRS implemented a surveillance testing program called national Antibacterial Residue Minimization program on veterinary drug residue that focused on minimization of antibiotics in cattle. Australia enacted the Agricultural & Veterinary Chemicals Act (Agvet) in 1994. ANZFA is also responsible for setting drug standard in New Zealand whereas Agricultural Compounds and Veterinary Medicines group (ACVM) of Ministry of Agriculture and Forestry (MAF) is responsible for drug registration in New Zealand. Since 1994, New Zealand has passed ten regulations that address antibiotics.

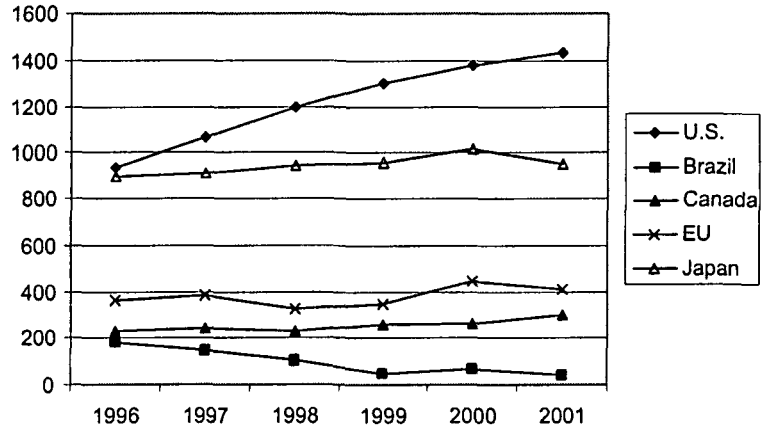
In Japan, the principal legal regulation dealing with veterinary drugs is the Pharmaceutical Affairs Law established in 1960. Based on these legal regulations foodstuff is analyzed for residues of antibiotics. Samples are sent for analysis to Government laboratories, including Meat inspection offices and Institutes of public health. To prevent the occurrence of drug residues, law prescribes that animals cannot be slaughtered shortly after the drugs are administered.

At the international level, the World Health Organization (WHO) along with the Food and Agriculture Organization (FAO) provide the Secretariat of the Codex. Codex is responsible for the implementation of the Food Standard Programs designed by WHO and FAO jointly. A subsidiary body of the Codex known as Codex Committee on Residues of Veterinary Drugs in Foods (CCRVDF) deals with the development of standards, guidelines and recommendation for veterinary drug residues in food. The work of this committee is supported by the Joint FAO/WHO Expert Committee on Food Additives (JECFA). Risk assessment, risk management and risk communication are the three basic elements of risk analysis that are considered by the Codex for setting MRLs of veterinary drug residues in food.

4. World Beef Trade

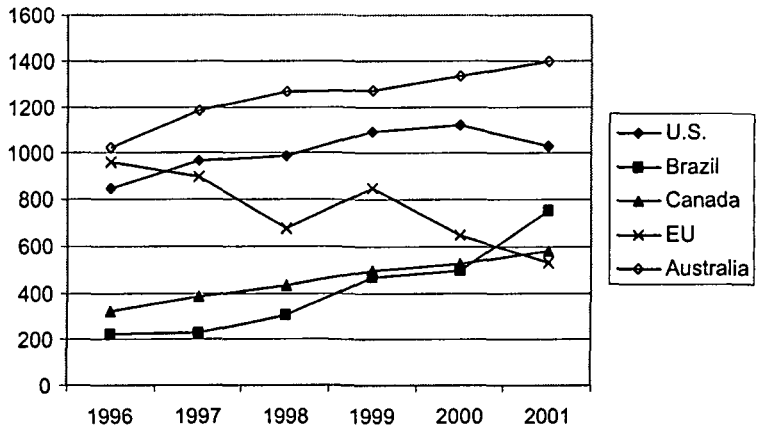
Figures 1 and 2 present the volumes of bovine meat traded between major exporters and importers from 1996 to 2001. The figures suggest that beef exports have generally fluctuated more than imports, reflecting the higher volatility of the exports to public information regarding beef trade. It is also apparent that large exporters are also large importers in the world. Table 2 presents bilateral trade values between the sixteen exporting countries and six importing countries as the annual average between 1995 and 2000. The data indicate that among importing countries, there has been a shift in the share of imports from exporting countries. The empty cells indicate that values are missing.

Figure 1 Bovine Meat Imports from the Major Importers (in 1,000 tons)



Source: USDA, FAS (2002)

Figure 2 Bovine Meat Exports from the Major Exporters (in 1,000 tons)



Source: USDA, FAS (2002)

Australia is the world's largest beef exporter, followed by the United States. Australia's beef exports grew by more than 40 percent from 1996 to 2001. The EU was the world's second largest beef exporter in 1996, but turned out to be the fifth largest in 2001 mainly due to large number of BSE detection.

The United States was the world's largest beef importer between 1996-2001, and it is the largest exporting partner for Canada, New Zealand, Mexico, and Nicaragua. Japan is the second largest beef importer and is the largest importing partner for the United States and Australia. The EU is the largest importing partner for South Africa and several Latin American countries such as Argentina, Brazil and Uruguay. While most large beef exporters are also large beef importers others, Brazil's beef exports dominated imports by far. Brazil became the world's third largest beef exporter in 2001, surpassing the EU and Canada.

Table 2 Bilateral Beef Export

US$1,000, average of 1995-2000

Exporting countries	*Importing countries*					
	Australia	*Canada*	*EU15*	*Japan*	*New Zealand*	*U.S.*
Argentina		22,008	310,079	30		33,960
Australia		70,926	45,168	981,059	5,349	497,574
Brazil			208,745	13		
Canada	31		1,859	42,694	23	673,631
Switzerland		26	1,200			28
Chile			49			30
China			74	59		
Hungary			17,120			
Mexico				472		8,488
Nicaragua			147	73		24,605
New Zealand	6,947	77,784	22,785	68,581		389,534
Thailand			70	12		
Ukraine		63	35	66		37
Uruguay		17,026	99,591	7,606		33,613
U.S.	594	260,157	27,085	1,558,123	112	
South Africa			80,160	31		39

Source: United Nations Comtrade records

5. The Econometric Model and Results

The Econometric Model

We examine the hypothesis of the effect of tetracycline standards imposed by importing countries on the bilateral trade flows of beef in the period 1995-2000. A gravity model is used to analyze the effects of tetracycline standards of the five importing countries and EU on bilateral trade flows from the sixteen exporting countries. A gravity model was first developed by Tinbergen (1962) and Pöyhönen (1963) to explain bilateral trade flows by trading partners' GNP and geographical distance between countries. Among the recent application, Moenius' (2000) gravity model provides a framework for estimating the effect of product standards on trade flows. His model includes measures of standards in a gravity model. He additionally employs a fixed-effects estimation to control for unobserved country (and industry) specific characteristics. Otsuki et al. (2001) apply the fixed-effects estimation to the case of food safety standards. Maskus and Wilson (2001) provides a comprehensive overview of the analytical framework for analysis of the impact of technical regulations on trade.

We study here pairs of six importing countries (Australia, New Zealand, United States, Canada, the EU and Japan) and sixteen exporting countries (Australia, Argentina, Brazil, Canada, Chile, China, Hungary,

Mexico, New Zealand, Nicaragua, South Africa, Switzerland, Thailand, Ukraine, Uruguay and the United States). Among the sixteen exporting countries, the five OECD countries have the highest per capita GNP. Ukraine, China and Nicaragua are categorized as the low-income countries according to the United Nations classification in 1999. The per-capita income of China and Ukraine was slightly below US$ 900, and that of Nicaragua was lowest at US$ 468.

In our gravity model, the key economic variables of the gravity model such as Gross National Product (GNP) and the geographical distance between corresponding pair of importing and exporting countries are used. In the general specification of the gravity model, the logarithm of bilateral trade flows in real value is regressed on logarithms of GNP of the exporters and the importers, of geographical distance between each pair of importers and exporters, and the variables that can account for the rest of the variation (Maskus and Wilson, 2001). In our study, such variables include standards for tetracycline residue standards in the importing country, year dummies, and other dummies for free trade agreement and colonial ties.

A fixed-effects model is estimated assuming that country-specific effects vary systematically among the exporting countries. Moenius (2000) employed a fixed-effects model to control for unobserved characteristics specific to importing and exporting countries as well as industries. The incorporation of fixed effects causes a technical problem, however, when at least one of the explanatory variables is invariant within groups for which cross section panel is formed (Wooldridge, 2002). We assume that tetracycline residue standards are constant across time since the information is available for a single year in our sample. This makes it necessary to exclude the importing country fixed-effects, but it will still allow for the exporting country fixed-effects to be incorporated since tetracycline residue standards vary across importing country for a given exporting country.

The specification of the gravity model is as follows:

$$ln(V_{ij}^t) = b_0 + b_1 ln(GNP_i^t) + b_2 ln(GNP_j^t) + b_3 ln(POP_i^t) + b_4 ln(POP_j^t) + b_5 ln(DIST_{ij})$$

$$+b_6 ln(VST_i^t) + b_7 D_{hormone} + b_8 D_{FMD} + b_9 D_{APEC} + b_{10} D_{NAFTA} + b_{11} D_{1995} + b_{12} D_{1996} + b_{13} D_{1997} +$$

$$b_{14} D_{1998} + b_{15} D_{1999} + b_{16} D_{COL} + \varepsilon_{ij}^t$$

where i and j stand for the importer and exporter respectively, and t denotes time. Parameter b's are coefficients, and ε_{ij} is the error term that is assumed to be normally distributed with mean zero. The data used here is for the time period 1995 to 2000. V_{ij} denotes the value of trade from country j to country i. It is obtained from the trade database of the United Nations Statistical Office. The product included in this analysis is beef (SITC Revision 1 code 0111 that includes fresh, chilled or frozen beef). GNP_i, POP_i, GNP_j, and POP_j are the real Gross National Products (expressed in 1995 U.S. dollars) and populations for the importing and exporting countries, respectively. Data on these basic gravity model variables are obtained from the World Development Indicators of the World Bank for the period of 1995-2000. The data for EU is obtained by aggregating the data for 15 EU member countries. $DIST_{ij}$ is the geographical distance between country i and j. VST_i is the maximum residue limit of tetracycline, imposed on imports by the importing country i. The maximum residue limit (MRL) is expressed in parts per million (ppm), and was obtained from the Department of Agriculture, Fisheries and Forestry, Australia (AFFA) (2002). The U.S. standard was obtained from Center for Veterinary Medicine (CVM) of FDA. A higher (lower) value of the standard implies more lax (stringent) regulation of the veterinary drug standard. The MRL is lowest in the EU and New Zealand at 0.1 ppm, second lowest is Japan at 0.2 ppm, followed by Australia

and Canada at 0.25 ppm, and least stringent in the United States at 2.0 ppm. Table 3 lists the tetracycline standard of the importers.

Table 3 Tetracycline Standards in beef followed by the Importing Countries

Importers	*Standard*
EU, New Zealand	0.10 ppm
Japan	0.20 ppm
Australia, Canada	0.25 ppm
Codex	0.60 ppm
U.S.	2.00 ppm

Source: Department of Agriculture, Fisheries and Forestry, Australia. The Center for Veterinary Medicine of FDA.

A dummy variable, $D_{hormone}$ is added to control for the effect of the EU ban on the U.S. and Canadian beef that are hormone-treated. The EU banned the export of U.S. beef treated with growth hormones in 1989.[2] The ban has been extended to Canadian beef. The BSE outbreak in Europe may have affected beef trade within Europe and with the rest of the world.[3] In our sample, Switzerland is the only country that had BSE case. The fixed effect model used here examines specific effect by each exporting country. In other words the BSE case in Switzerland is taken into account by the fixed effect model.

Another dummy variable D_{FMD} is included to capture the outbreak of Foot and Mouth Disease (FMD) in several countries in fiscal year 1999 and 2000. There was an epidemic of Foot and Mouth disease in year 2001 which is beyond our sample period. However prior to that , 64 and 59 countries reported the outbreak of FMD in 1999 and 2000 respectively.[4]

Colonial tie dummy (D_{COL}) is included to control for the effect of having colonial ties on trade flows. The NAFTA and APEC dummies (D_{APEC} and D_{NAFTA}, respectively where both exporter and importer are members), are included to capture the trade promoting effects due to free trade agreement (Aitken, 1973). Year dummies, D_{1995}, D_{1996}, D_{1997}, D_{1998}, D_{1999}, are included in the model to control for systematic differences across time.

In the analysis, fifteen importing countries in EU, which are former EEC members, are aggregated and treated as one since they adopted a common tetracycline standard. We ruled out trade between EU member countries in our dataset since cross-border regulation is exempted in many cases among the member countries.

Results of the Gravity Model

A fixed-effects model can allow the constant term to vary across exporting countries, but it is not sufficient to account for the heterogeneity in how the tetracycline residue standards affect the trade flow.

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[2] The EU and the United States have disputed the safety of growth hormones and antibiotics used in cattle since mid 1980's. The disagreement peaked with the EU ban in 1989 on the export of U.S. beef treated with growth hormones. The case was brought to the attention of WTO in 1996. EU was consequently asked to bring its measure into compliance by May 13, 1999. EU was required either to drop the ban or compensate the United States if it chooses to leave the ban. However, EU chose not to comply with the WTO ruling to lift its hormone ban

[3] Between 1989 and 2000, BSE cases have been identified among cattle in United Kingdom, Belgium, Denmark, France, Germany, Ireland, Italy, Liechtenstein, the Netherlands, Portugal, Spain and Switzerland. In June 2000, the EU Commission on Food Safety and Animal Welfare adopted a decision requiring all member states to remove specified risk materials (SRMs) from the animal feed as of October 1, 2000; and such bans have already been instituted in most member states (see HHS (2001)). Henson and Mazzocchi (2002) study how agribusiness in the United Kingdom gets affected due to the possible effect of BSE on human health.

[4] In our sample China, India, Thailand and Brazil reported the outbreak of some type of FMD in both 1999 and 2000, whereas Uruguay, Argentina and South Africa had cases reported in year 2000 only.

We first examine whether the major country heterogeneity will affect the estimated coefficient for the tetracycline residue standard variable. Distinction is made for difference in development stage of the exporters in our sample.

A product term of the OECD dummy for the exporters, D_{OECD}, and standard is added in order to test if the effects are different between OECD and non-OECD exporting countries. The dummy variable assumes a value of one for OECD countries and for non-OECD countries it is zero.

Two different fixed-effects models are estimated and results are reported in Table 4. The first column of the table reports results without the interaction term between OECD dummy and the standard variable. The second column includes the interaction term between OECD dummy and the standard variable.

The tetracycline standard is positive and significant for both OECD and non-OECD countries in both the models indicating that beef imports are greater for a country that has less stringent standards on tetracycline. The second model suggests that the effect of tetracycline standard on trade flow is not significantly different between developing (non-OECD) and developed (OECD) countries.

The estimated coefficient is positive and less than unity in both the models. This implies that, in terms of level, a change in trade flow associated with a change in the standard is smaller for a higher level of standard. This seems realistic since a tightening of standard by the same level will require a greater cost, i.e., a greater loss of trade flow at a lower level of standard.

The models suggest that the EU hormone beef ban against the United States and Canada could have had a significant negative impact. The FMD dummy does not have any significant effect on trade flow. The insignificance of APEC and NAFTA dummy suggest a limited effect of their trade creation effect in beef trade. Colonial tie dummies are positive and significant and so is the GNP of the importing country. The hormone ban dummy is negative and significant implying that trade decreases due to the imposition of EU's ban on U.S. beef, but the insignificance of FMD dummy indicates that this is not the case with foot and mouth disease. Distance is as usual significantly negative.

Simulation Analysis: Harmonization of Tetracycline Standards

The elasticity of trade flows with respect to tetracycline standards that are estimated in the previous regression can be used to predict changes in trade flows under different standard setting. This is particularly useful to quantitatively examine the implications of harmonization at the international standard relative to pre-harmonization standards (standards at the original levels) in the importing countries.

The double-log model implies that a percentage change in trade flow associated with a percentage change in standard is constant. Given that this underlying assumption holds, the estimated elasticity is constant over the levels of the standards in our sample. It is also assumed that predicted increase or decrease in trade flow will not exceed 100 percent of the pre-harmonization level of trade flow.

We have missing values for bilateral bovine meat trade for a large number of importing and exporting country pairs. We use the average of the predicted change in the value of trade for each country pair over the years for which data on the value of trade flow are available. Even with this, 34 out of the full 92 country pairs are missing.

If we treat a missing value as zero, then the total trade flow of bovine meat is US$ 5.6 billion. If the standard recommended by the Codex guideline were followed by all the importing countries, the total

trade value would be US$ 8.8 billion. This is US$ 3.2 billion or 57 percent higher than the value of total trade flow under the pre-harmonization level. If the most stringent standard on tetracycline among the importing countries examined (the EU and New Zealand) were adopted, then the value of trade flow would be US$ 1.9 billion (or 34 percent) lower than that under the pre-harmonization level. This is US$ 5.1 billion lower than that under the Codex guideline.

Instead of treating missing values as zero, we compute the average predicted trade flows of bovine meat over country pairs for which data are available. The average of the total trade flow for a single country pair is US$ 97 million under the pre-harmonization standards, the average of the trade flow under the most stringent standard would be US$ 64 million, and that under the Codex standard is US$ 152 million.

Table 5 shows the result of simulation for each pair of the importing and exporting countries, and total changes for importing or exporting countries. When all the importing countries adopt the Codex standard on tetracycline residue in beef, all exports to the EU, Japan and New Zealand will increase by more than 100 percent because the Codex standard (0.6 ppm) is less stringent than those of the three countries. This implies that Latin American and African countries will increase their exports to EU by a significant amount, and that the United States and Australia will increase their exports to Japan. In contrast, the largest exporters to the United States will decrease exports because the Codex standard is tighter than the U.S. standard.

Table 4 Estimated Coefficients

Fixed-effects Model, Dependent variable = log of value of trade

Column heading	*Column heading*	*Column heading*
Constant	4.60**	4.71**
	(2.05)	(2.08)
Standard	0.59***	0.69**
	(0.16)	(0.31)
Standard*OECD dummy		-0.13
		(0.37)
GNP of importing country	1.40**	1.50**
	(0.67)	(0.72)
Population of importing country	-0.32	-0.44
	(0.79)	(0.86)
GNP of exporting country	-3.92	-4.18
	(4.50)	(4.57)
Population of exporting country	-21.78	-22.08
	(13.61)	(13.68)
Distance	-1.36***	-1.31***
	(0.25)	(0.28)
Hormone Ban Dummy	-3.73***	-3.73***
	(1.28)	(1.28)
Foot and Mouth disease dummy	0.73	0.72
	(0.70)	(0.70)
Year 1995 dummy	-1.66*	-1.72*
	(0.90)	(0.92)
Year 1996 dummy	-1.38*	-1.42*
	(0.78)	(0.79)
Year 1997 dummy	-0.64	-0.67
	(0.64)	(0.65)
Year 1998 dummy	-0.33	-0.34
	(0.55)	(0.55)
Year 1999 dummy	0.06	0.06
	(0.47)	(0.47)
Colonial ties dummy	3.41***	3.63***
	(0.66)	(0.91)
NAFTA member dummy	-0.79	-0.57
	(0.92)	(1.11)
APEC member dummy	-1.06	-1.16
	(1.10)	(1.13)
Adjusted R-squared	0.736	0.735
Number of observations	207	207

1. *, ** and *** imply significance at the 10 percent, 5 percent and 1 percent levels under a two-tailed test respectively.
2. Inside parentheses are standard errors.

In addition to the simulation on trade flow, the amount of tetracycline residues in the traded beef is predicted. The amount of tetracycline is computed by multiplying the trade flow with tetracycline standard at differing levels. These amounts are normalized by the amount associated with the pre-harmonization levels of standard. It is assumed that the pre-harmonization residue levels per unit are exactly the same as the importing country's MRLs. Likewise, the residue levels per unit at the hypothetical harmonized standard are assumed to be the same as the hypothetical standard.

The latter residue levels are normalized by the pre-harmonization total residue level over the importing and exporting countries.

Table 5 Change in Trade Flow from Pre-harmonization Standards to Codex Standard

percentage

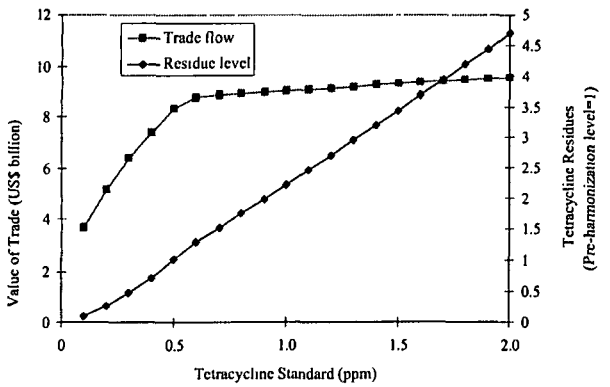
Exporting countries	*Importing countries*						
	Australia	*Canada*	*EU15*	*Japan*	*New Zealand*	*U.S.*	*Total*
Argentina		+84	+100	+100		-42	+86
Australia		+84	+100	+100	+100	-42	+55
Brazil			+100	+100			+100
Canada	+84		+100	+100	+100	-42	-33
Switzerland		+85	+100			-43	+97
Chile			+100			-40	+47
China			+100	+100			+100
Hungary			+100				+100
Mexico				+100		-42	-35
Nicaragua			+100	+100		-42	-41
New Zealand	+84	+84	+100	+100		-42	0
Thailand			+100	+100			+100
Ukraine		+84	+100	+100		-43	+69
Uruguay		+84	+100	+100		-42	+68
U.S.	+84	+84	+100	+100	+100		+98
South Africa			+100	+100		-41	+100
Total	+84	+84	+100	+100	+100	-42	

Source: Authors' Calculation

Figure 3 illustrates both the predicted value of total trade flow of bovine meat for the studied countries and the amount of tetracycline residue at differing levels of harmonized standards. The concave (increasing at a decreasing rate) curvature of the path of trade flow reflects both the elasticity with respect to the standards to be less than one and the upper ceiling imposed on the predicted change from the pre-harmonization level of trade flow. The flatter curvature at a higher level is particularly due to the ceilings. The increase in trade flow in most importing countries would have reached 100 percent at the standard greater than 0.5 ppm.

The path of the predicted amount of tetracycline residues has a convex (increasing at an increasing rate) curvature around a lower level of tetracycline standard, and a curvature that is almost linear at a higher level of standard. The convex curvature is due to the combined effect of the increased trade flow and the relaxed standard. Once the trade flow slows down in its increase due to the upper ceiling, the effect of relaxed standard dominates. This may not be the case, however, the exporting countries let the tetracycline residue levels increase without limit responding to a greatly relaxed standard.

Figure 3 The Value of Total Trade Flow under Varying Levels of Tetracycline Standard



Source: Authors' Calculation

Table 6 shows the predicted average gains and losses of the exporting countries that are grouped into three income groups (OECD, middle income, and low-income) when all the importing countries harmonize their tetracycline standards on bovine meat at the Codex standard instead of keeping their standard unchanged at the pre-harmonization levels. An exporting country in the OECD group is estimated to increase exports more than middle-income countries. Low-income countries actually will decrease exports. This is because our three low-income countries have exported beef more to the United States relative to the EU and also because the Unites States has a standard that is less stringent than the Codex standard. Low-income countries are thought to be technologically less equipped and hence they tend to export to countries that have a less stringent food safety standard. In total, 46 percent of bovine meat exports from all the low-income countries in the world entered into the U.S. market, whereas only 11 and 17 percent of bovine meat exports from all the medium- and high-income countries respectively entered into the U.S. market. These can support the result of our case study regarding the implication of the international standard on low-income countries.

Table 6 Change in value of trade under the Codex standard by income groups

Average for one exporting country

Income Grouping	*Change in value of trade (US$ 1,000)*	*% in GNP*	*% in Agricultural GDP*
OECD	+489,652	0.0256	4.4459
Middle income countries	+90,599	0.0396	0.5904
Low-income countries	-3,282	(-)0.0045	(-)0.0060

Source: Authors' Calculation

6. Conclusions

This paper analyzed the quantitative effect of veterinary drug standards on trade flow of bovine meat between sixteen exporting and five importing countries and the EU as a whole. We find that bovine meat imports are lower for an importing country that has a more stringent tetracycline standard. Reducing the maximum residue limit (MRL) on tetracycline antibiotics by one percent is found to result in a 0.59 percent reduction of exports from the exporters in our sample.

It is estimated that, if the standard recommended by the Codex guideline (0.6 ppm) is followed by all the importing countries, the total trade value of bovine meat is US$ 8.8 billion. This is US$ 3.2 billion or 57 percent higher than the value of total trade flow under the pre-harmonization level, or US$ 5.1 billion higher than the trade value when the most stringent (0.1 ppm) tetracycline standard is adopted by the studied importing countries.

The Codex standard is estimated to lead to a significant increase in bovine meat exports from the OECD countries in our sample. While it will lead to a moderate increase in exports from the middle-income countries, the low-income countries in our sample is estimated to decrease their exports. It is mainly because the largest part of their exports had been exported to the United States whose standard was much less stringent than the Codex standard. If least developed countries tend to export to a country that has a less stringent food safety standard due to their limited capacity to keep veterinary drug residues low in their exported products, an international standard may result in a loss of exports from those countries, at least in the short run.

If the Codex standard sufficiently guarantee consumers' dietary safety, the current levels of tetracycline standards in the studied importing countries would on average pose an excessive restriction on beef trade. In general, however, there is not a concrete scientific support for the minimum safety levels of drug residues. If a lower amount of intake of tetracycline residues than the Codex level still achieves a greater food safety, policy makers should consider the trade-off between trade flows and consumer's health. If the relationship between amount of tetracycline residue and standard (MRLs) can be correctly captured by the curve in Figure 3, then policy makers can have a quantitative information on this trade-off.

There are other issues associated with import regulation with respect to veterinary drug residues. Reducing the use of veterinary drugs for the compliance with a more stringent standard may result in a greater exposure of the livestock to the risks of common veterinary diseases. Such estimates would help more integrated and well-balanced international policy coordination of regulation on veterinary drug residue in bovine meat trade.

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