Balancing Food Safety and Risk:

Do Drug Residue 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 the health implications of consuming 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 the 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 trade affect of setting harmonized international standards. We find that if international standards set by Codex were followed in antibiotics, global trade in beef would rise by over $3.2 billion. Among other developing countries, South African exports would rise by $160 million, Brazil by $200 million, and Argentina's by over $300 million.

JEL Classification: F18, O13, O19*

1. Introduction

Food safety regulations are motivated by a number of considerations. These include the protection of public health, decisions on acceptable risk, and in some cases protection of domestic firms from competition. When regulations are set to protect public health, they are also driven by the 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 international debate and concern over the past decade.

The total elimination of risks associated with all animal diseases and drug residues is not economically or 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 (stimulate growth). Tighter food safety standards consequently require producers to adopt alternative means to control animal diseases, if they must reduce the use of veterinary drugs in cattle and other animals.

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 euros, respectively. The use of veterinary drugs in developing countries, however, is likely to rise as a result of increased production and availability of drugs

through imports from developed countries (FAO/IAEA Training and Reference Centre, 2002). In addition, the use of drugs in these markets is likely to increase as their application can significantly raise animal-borne food production levels (Botsoglou and Fletouris, 2001).

International standards applied to the use of veterinary drugs are developed, in part, to mitigate against problems associated with discordances between importing and exporting countries with differing food safety standards, as well as attitudes toward food-borne risks. The objective of the Codex Alimentarius Commission (Codex) is to develop international food safety standards that guarantee consumer health while not impeding trade. International standards also support 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 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" (World Trade Organization, 1997). National governments do not, however, generally accept Codex MRLs. Moreover, 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 (IATRC, 2001).

In order to explore the impact of differing national standards and possible benefits of adopting Codex international standards for trade, this paper examines the effect of food safety standards on beef trade between sixteen exporting countries and five importing countries and the EU. We focus on the use of tetracycline in beef production. Among veterinary drugs, tetracycline is one of the most widely used around the world to

promote animal health. For example, approximately 58 percent of the antibiotics manufactured in the United States are tetracycline and penicillin G. (Botsoglou and Fletouris, 2001). There is a minute difference in the purpose of usage of tetracycline and penicillin for animal health protection. Tetracycline is used in animal feed to stimulate growth, whereas penicillin is only used for medication of individual animals. (http://jordbruk.regeringen.se/antibiotika/pdf/swedish_model.pdf-p.10-11).

In the sections that follow, we first provide an overview of the use of veterinary drugs for growing livestock and their effect on food safety. The second section reviews regulatory measures of several countries on veterinary drug residues in beef. The third section reviews patterns of world trade in beef. The next section develops an empirical model to estimate the elasticity of trade flows with respect to tetracycline standards and outlines results of the analysis. The final section summarizes our findings.

2. Beef Trade and Use of Veterinary Drugs

Concern over the use of veterinary drugs in animals is driven, in part, by the inappropriate use of antibiotics in animals. This can promote the spread of drug-resistant bacteria which may affect the treatment of life-threatening diseases in humans. The Institute of Medicine at the National Academy of Sciences, for example, has estimated the annual cost of treating antibiotic-resistant infections in the United States at $30 billion. Of the fifty million pounds of antibiotics produced in the United States each year, twenty million pounds are given to animals. Approximately 80 percent of antibiotics (16 million pounds) is used on livestock to promote more rapid growth. (Earth Times, 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 leave the animal's system prior to slaughter. In addition, cattle fed with antibiotics can lead to the development of antibiotic resistant pathogens. There are several channels through which antibiotics and anti-microbial drug residues can cause adverse effects on human. For example, resistant pathogens might be directly transmitted from animals to humans. This can result in infections that are more difficult to treat (World Health Organization, 1997). Although resistant pathogens may not directly cause disease, they can transfer this resistance to pathogenic bacteria in the human body (World Health Organization, 1997; 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 has caused human illness in the U.S. (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 (Franco et al, 1990).

[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).

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). Besides a few isolated cases as noted in endnote 1, it is very hard to link human illness with consumption of veterinary drugs used in animal feed or used for animal health protection. Even though outbreak of diseases have been suspected to be the consequence of antibiotic use in animal feed, lack of scientific evidence cannot always prove that the use of antibiotic is the actual cause for the disease or illness. A report of the Institute of Medicine in the United States (1989) cites 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."

3. Regulations on Veterinary Drug Residues

In the Organization for Economic Cooperation (OECD) countries, registration is typically required for veterinary drugs by different government authorities listed in table 1. As shown in table 1, registration authorities are also in charge of setting drug residue standards in the United States and Japan. Although very general objectives in food safety are common in the OECD countries, regulatory structures, administrative procedures, and setting of national limits for drug residue differ across these countries. In Australia, New Zealand and Canada the registration authority and the government bureau responsible for setting veterinary drug standards are different. In the EU, a coordinating body exists to set common standards among member countries, but registration authorities differ across

countries. Government officials that monitor compliance with domestic or import standards are generally affiliated with agricultural ministries, such as the United States Department of Agriculture (USDA). In contrast, registration and standard-setting bureaus are affiliated with health ministries such as the United States Food and Drug Administration (FDA). Testing facilities are used to determine maximum daily intake of the residues scientifically. These facilities conduct compliance monitoring in most cases.

In the United States, the Center for Veterinary Medicine (CVM) of the FDA is responsible for drug registration. A tolerance level of antibiotic residues is 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. Preventative steps include on-site inspections to determine who is responsible for causing violative residues and also examine the factors contributing to residue violation. Based on the assessment recommendations are made for corrective action. Failure to comply with that may result in banning the product.

In the European Union (EU) maximum residue limits (MRLs) for veterinary drugs are established within the Committee for Veterinary Medical Products (CVMP). This is done 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 Aditives

(JECFA))or reports from internationally renowned research organizations) concerning the safety of residues in the drug.

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 the European regulatory framework. The European Agency for the Evaluation of Medicinal Products is responsible for this task. Since January 1992 a new regulation was passed which prohibits new pharmacologically active substances 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 no veterinary medicines are approved for use as growth-promoting agents in the EU.

In Japan, the principal law related to veterinary drugs is the Pharmaceutical Affairs Law established in 1960. Based on regulations related to the law, foodstuffs are analyzed for residues of antibiotics. Samples are sent for analysis to government laboratories, including meat inspection offices and the 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) and Food and Agriculture Organization (FAO) sponsor the secretariat for the Codex Alimentarius Commission. 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) coordinates the development of standards, guidelines, and recommendation for veterinary drug residues in food. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) provides risk assessments to inform the decisions of CCRVDF.

The World Trade Organization (WTO) Agreement on Sanitary and Phytosanitary Standards encourages their member countries to harmonize national standards with international standards, and recommendations developed by other WTO member governments in international organizations, such as the joint FAO/WHO Codex Alimentarius Commission (Codex) for food safety. The Agreement does permit importing countries to impose more stringent measures than the international standards. The text of the Agreement requires scientific justification, if differing standards create an unnecessary obstacle to trade. In this respect, international standards may be considered a baseline for WTO members to follow. However, Codex guidelines are only recommendations and cannot be enforced on countries regulatory bodies.

4. World Beef Trade

Figures 1 and 2 present the volumes of bovine meat traded between major exporters and importers from 1996 to 2001. 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 missing values. The bilateral trade flow data is available from United Nations Comtrade records.[1]

Figure 2 depicts that 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.

It is evident from figure 1 that the United States was the world's largest beef importer between 1996-2001. 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 Brazil's beef exports are substantially higher than imports. Brazil became the world's third largest beef exporter in 2001, surpassing the EU and Canada.

5. The Econometric Model and Results

5.1 The Econometric Model

We examine 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 is a widely

[1] United Nations Comtrade record is the most exhaustive database for bilateral trade that is currently available. Bilateral trade data, i.e. exports or imports between country pairs are hard to obtain at a very high disaggregated product level (in our case a 4 digit level i.e. SITC 0111 code for bovine meat). Hence, we observe a high number of missing values.

used method to explain trade patterns between countries using each country's measures of 'mass' and geographical distance between countries to assess changes in trade flows. 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) provide a comprehensive overview of the analytical framework for analysis of the impact of technical regulations on trade.

We examine in this analysis 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 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 is the lowest in the sample at US$ 468.

Tinbergen (1962) and Pöyhönen (1963) independently developed a model that explained bilateral trade between two countries in terms of their GNPs and distance between them. This model became popular as gravity model. Bilateral trade flow in

their gravity model is proportional to the GNPs of the countries and inversely proportional to the distance between them. This simple model was further extended by Linnemann (1966) when he added a population variable to the model. The gravity model has been developed further to include additional variables to examine the effect of trade promoting and trade limiting factors. In a functional form this generalized gravity equation can be written as:

$$Y_{ij} = K_i^{\mu} K_j^{\eta} \frac{(X_i)^{\alpha} (X_j)^{\beta} (P_i)^{\sigma} (P_j)^{\rho}}{D_{ij}^{\gamma}} \qquad (1)$$

where Y_{ij} is the value of trade, X_j and X_j are the GNPs of country i and j, P_j and P_j are the populations of country i and j and D_{ij} is the distance between the two countries. K_i and K_j are country specific other factors that play role in the gravity model. Tetracycline standard of the importer fits in this 'other factor'. In Moenius's (2000) model the trade creation effect of bilaterally shared standards and trade limiting effect of country specific standards were examined by including counts of these standards as explanatory variable. Otsuki et al. (2001) study the impact of the stringency of food safety standards on bilateral trade.

In our gravity model, the key economic variables are Gross National Product (GNP) and the geographical distance between the corresponding pair of importing and exporting countries. 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 variables that can account for the rest of the variation (Maskus and Wilson, 2001) in the equation. In our study, such variables include 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 a cross section panel is formed (Wooldridge, 2002). We assume that tetracycline residue standards are constant across time as the information is available only for a single year in our sample. These standards may change over time reflecting the evolution of scientific evidence and change in consumer preference toward risks. We assume that the scientific information and consumer's preference vary together in all the importing countries, and hence, the change in standards, if any, are considered to be controlled by time dummies. While we do not have time-wise variation in standards variable, we can still take advantage of having multiple years since it allows to control for policy changes in particular set of countries such as hormone beef, which might mask the effect of food safety standards. Also the use of panel data allows for unobserved characteristics of exporting country to be controlled for by fixed effects.

The specification of the gravity model in double logs is as follows:

$$ln(V_{ij}^{t}) = b_0 + b_1 ln(GNP_i^{t}) + b_2 ln(GNP_j^{t}) + b_3 ln(POP_i^{t}) + b_4 ln(POP_j^{t}) + b_5 ln(DIST_{ij}) + b_6 ln(VST_i^{t}) + b_7 D_{hormone} + b_8 D_{FMD} + b_9 D_{APEC} + b_{10} D_{NAFTA} + b_{11} D_{1995} + b_{12} D_{1996} + b_{13} D_{1997} + b_{14} D_{1998} + b_{15} D_{1999} + b_{16} D_{COL} + \varepsilon_{ij}^{t} \quad (2)$$

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. Annual data is used 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. The international standard proposed by Codex is 0.6 ppm. Table 3 lists the tetracycline standard of the importers.

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 imports of U.S. beef

treated with growth hormones in 1989.[2] The ban has also been extended to imports of Canadian beef. The BSE outbreak in Europe may have affected beef trade within Europe and with the rest of the world.[3] Even though BSE outbreak had taken place in several countries in Europe, in the list of the exporting countries we have in our analysis (as shown in table 2), Switzerland is the only country that had a BSE outbreak. The fixed effects model used here examines specific effects by each exporting country. In sum, 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 1999 and 2000. There was an epidemic of Foot and Mouth disease in year 2001, which is beyond our sample period. A total of 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 with the EU on trade flows. This colonial tie dummy variable assumes the value unity if an exporter had colonial tie with any of the EU countries. The NAFTA and APEC dummies (D_{APEC} and D_{NAFTA}, respectively where both exporter and importer are

[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 FMD in both 1999 and 2000, whereas Uruguay, Argentina and South Africa had cases reported in year 2000 only.

members) are included to capture the trade promoting effects due to free trade agreement (Aitken, 1973). NAFTA and APEC dummies assume the value one when both exporters and importers are either NAFTA or APEC members.[2] 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.

5.2 Results of the Gravity Model

We estimate the gravity model in Equation (2) using a fixed-effects model can allow the constant term to vary across exporting countries. We also examine an alternative specification by allowing the case in which tetracycline standards affect beef imports differently when an exporter's standard is more stringent than an importer's standard.

This alternative specification hinges upon an assumption that a stringent standard by the importer restricts trade only if the exporter applies a higher standard domestically. However, if the exporter applies a standard i.e. at the same level or more stringent than the importer's standard then extra restrictions are unlikely to its exports. We consequently create a dummy variable known as the exporting country dummy that takes the value of one where the importer's standard is more stringent than the exporter's and zero where the importer's standard is equal or less stringent than the exporter's. This dummy variable is interacted with the standard variable to capture the exporting country

[2] NAFTA member countries in our sample are U.S., Mexico and Canada. Member countries belonging to APEC are Australia, Canada, Chile, China, Japan, Mexico, New Zealand, Thailand and U.S.

effect. Since the information on exporters' standards are not available for developing countries, we assume that all the developing exporters in our sample have less stringent standard than the importers. This assumption seems to be reasonable since the importers in our sample are all developed countries**.** With this assumption and the available standards for the importing countries, we can include all the countries in our sample except for Switzerland. Switzerland being a developed country, we fail to apply this assumption for this particular case.

The results for the two different fixed effects models are presented in Table 4. The first column of the table reports results without the exporting country interaction term. The second column includes the interaction term between the standard variable and the exporting country dummy.[3]

The coefficient for tetracycline standard is positive and significant for both the models. This indicates that beef imports are greater for a country that has less stringent standards on tetracycline. The coefficient of 0.59 implies that a 1% decrease in the stringency of the standard increases trade flow by 0.59%. The second model suggests that the product term of the standards to be insignificant, indicating that there is no statistically significant difference in the effect of standards between the case where the importer's standard is equal to or less stringent than the exporter's and the case otherwise. This implies that some of the beef exports of an exporting country whose standards is more stringent than those in importing countries do not satisfy its domestic standard, thus some of its exports are still subject to importing country's regulations. The coefficient

for the non-product term of standards is 0.58 and is sufficiently close to the first speciation.

The estimated standard coefficient is positive and less than unity in both the models. This implies that a change in trade flows associated with a change in the standard is smaller for a higher level of standard. This appears logical, as a tightening of the standard by the same level will involve greater costs, 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 has a significant negative impact implying a decline in trade flow due to the imposition of EU's ban on U.S. beef. The FMD dummy does not have any significant effect on trade flows. The insignificance NAFTA dummy suggests a limited effect of its trade creation effect in beef. Colonial tie dummies are positive and significant along with the GNP of the importing country in both the models. Distance is as usual significantly negative.

5.3 Simulation Analysis: Harmonization of Tetracycline Standards

Simulation exercise is carried out based on the results presented in the first column of Table 4. Although the alternative specification has a greater flexibility by incorporating the exporter's standards, it is not suitable for simulation for these two reasons: We do not observe the actual standards of some of the exporters, which makes simulation incomplete. The two specifications offer coefficients that are sufficiently close; hence the choice of the model will not affect the simulated trade.

[3] As an experiment, a product term of the OECD dummy for the exporters, D_{OECD}, and standard has been included to test if the effects are different between OECD and non-OECD exporting countries. The dummy

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 scenarios. This is particularly useful in examining the implications of harmonization at the international standard, relative to pre-harmonization standards (standards at the original levels) in the importing countries. The following formula is used to simulate changes in trade flow associated with changes in standards:

$$d\,V_{ij}^{k} = \phi^{k} \frac{V_{ij}^{k}}{VST_{i}^{k\bullet}} \left(VST_{i}^{k*} - VST_{i}^{k\bullet}\right)$$

where $d\,V_{ij}^{k}$ is the change in the value of trade for commodity k which is beef in our analysis from 16 exporting countries j to 6 importing countries $\underline{i}$. ϕ^{k} is the estimated elasticity of trade flow of commodity k with respect to standards (i.e. 0.59 in our estimation), V_{ij}^{k} is the value of trade, VST_{i}^{k*} is the Codex standard i.e. 0.6 ppm or the harmonized level and $VST_{i}^{k\bullet}$ is the pre-harmonized level standards for the importers.

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. The upper bound is required since when the standard has a wide range of variation between 0.1 ppm and 2.0 ppm i.e. the highest residue level is 20 times greater than the least residue level, the effect of standard on trade becomes 20 times larger. It is beyond the production capacity of a country to

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variable assumes a value of one for OECD countries and for non-OECD countries it is zero. The effect for OECD dummy has been found insignificant.

increase trade by 100% as a consequence of relaxing standard. The lower bound is necessary to prevent a negative change in value of trade beyond the base traded value as a consequence of tighter standard.

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. In other words, if bilateral trade value is missing for certain country pair then the average of the trade flow per country pair for the entire sample period (1995-2000) is used. For example if the trade flow between Argentina and U.S. is missing for 1996 then we use the average for 1995 and 1997-2000 i.e. the average for 5 years. However, if the bilateral trade flow between Argentina and U.S. is missing for the entire period then we have missing values for each year for that country pair. Even employing this approach, 34 of the 92 country pairs are missing.

If we treat a missing value as zero, then the total trade flow of bovine meat under pre-harmonization standards is US$ 5.6 billion. If all importing countries followed the standard recommended in Codex guidelines (i.e. 0.6 ppm), 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 (i.e. the standard followed by the EU and New Zealand) among the importing countries examined 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, while 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, along with total changes for importing or exporting countries. When all the importing countries adopt the Codex standard on tetracycline residue in beef, value of exports to the EU, Japan and New Zealand will increase by more than 100 percent. This is due to the fact that 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, while 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.

In addition to the simulation on trade flows 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 the 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 pre-harmonization total residue level normalizes the latter residue levels over the importing and exporting countries.

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. The curvature is almost linear at a higher level of the 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 imposed the effect of relaxed standard dominates

Table 6 shows the predicted average gains and losses of the exporting countries (grouped into three income categories - OECD, middle income, and low-income) when all importing countries harmonize tetracycline standards at the Codex international standard. An exporting country in the OECD group is estimated to increase exports in this scenario more than middle-income countries. Low-income countries exports fall. This is because our three low-income countries exported more beef to the United States relative to the EU and also due to the fact that the Unites States has a standard that is less stringent than the Codex standard. It is assumed that low-income countries are technologically less well equipped and export to countries with less stringent food safety

standards. In total, 46 percent of bovine meat exports from all the low-income countries in the world entered into the U.S. market. Only 11 and 17 percent of bovine meat exports from all the medium- and high-income countries, respectively, entered the U.S. market.

6. Conclusions

The analysis in this paper aims to help inform policy decisions where policy makers encounter two objectives- food safety and risks, given that health risk is correlated with trade flows. The analysis suggests there exists a trade-off between these two objectives, and that food safety standards have a critical role in balancing these objectives.

This paper analyzed the quantitative effect of veterinary drug standards on trade flows of bovine meat between sixteen exporting and five importing countries and the EU. 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 Codex guideline (0.6 ppm) was followed by all importing countries the total trade value of bovine meat reaches 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 adoption by all importers of the Codex standard is estimated to significantly increase bovine meat exports from the OECD countries in our sample. The low-income

countries in our sample are estimated to decrease beef exports. If less developed countries tend to export to a country that has a less stringent food safety standard due to limited capacities to keep veterinary drug residues low in 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 is accepted as a general guideline to protect public safety, the more restrictive national standards currently in place may pose an excessive restriction on beef trade. In addition, the trade-off between export expansion, and risk with results presented here indicate that not following international harmonized standards does have a significant impact on beef exports, including those from developing countries. If the relationship between the amount of tetracycline residue and standard (MRLs) is correctly captured by the curve in Figure 3, then policy makers can have additional quantitative information to inform decision making. There are other issues associated with import regulation with respect to veterinary drug residues.

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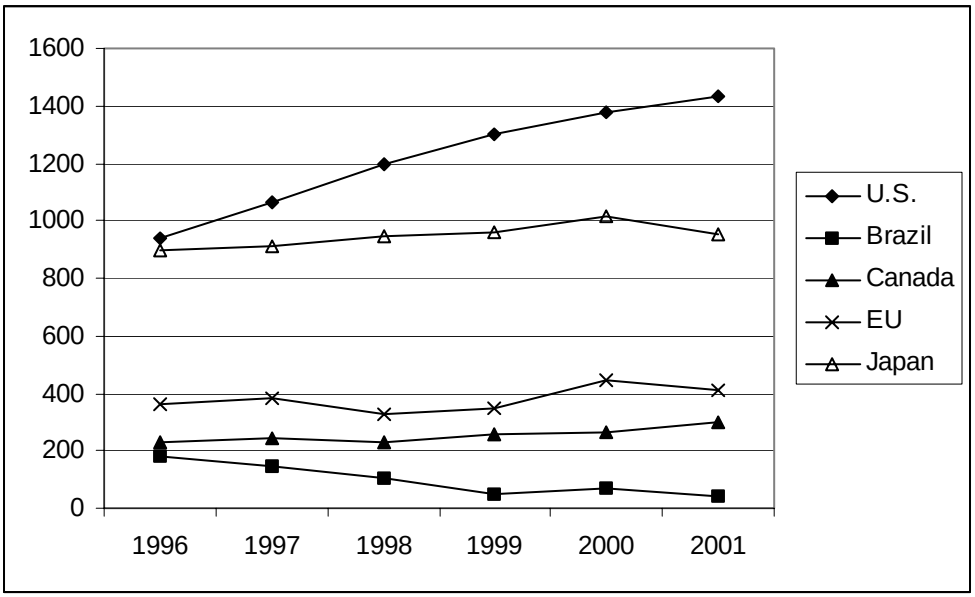
Table 1. Regulating Authorities of Veterinary Drugs in Selected Countries

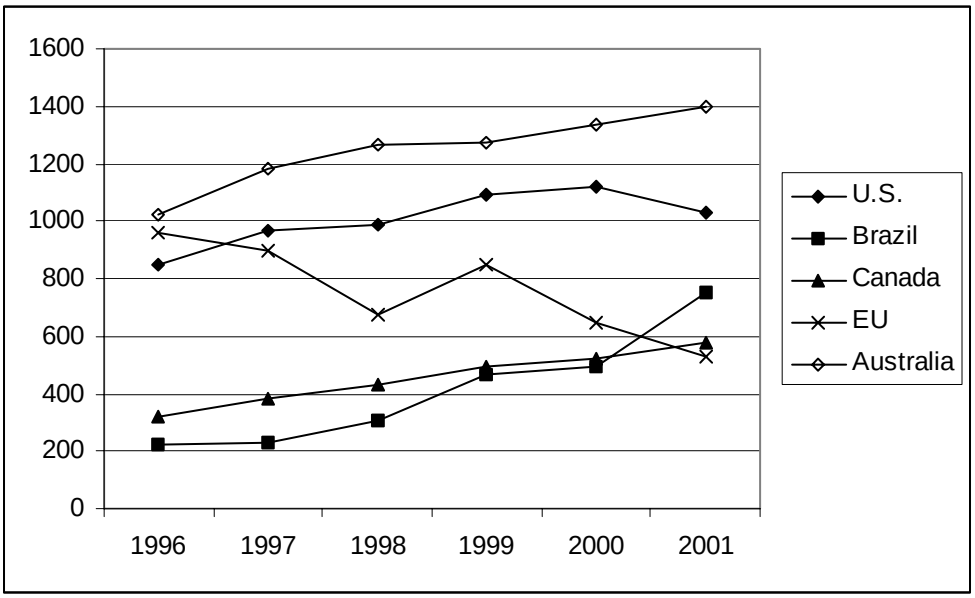
	Drug registration	Setting veterinary drug standard	Monitoring compliance with drug standard (Domestic)	Monitoring compliance with drug standard (Imports)
EU		Committee for Veterinary Medicinal Products (CVMP)	Each country has its own surveillance scheme. To oversee this surveillance, there exists a Community 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
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

Figure 1. Bovine Meat Imports by Major Importers (in 1,000 tons)



Source: USDA, FAS (2002)

Figure 2. Bovine Meat Exports by Major Exporters (in 1,000 tons)



Source: USDA, FAS (2002)

Table 2. Value of Bilateral Beef Exports, 1995-2000 Average (US$1,000)

	Importing countries					
	Australia	Canada	EU15	Japan	New Zealand	U.S.
Exporting countries						
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: UN Comtrade records.

Table 3: Tetracycline Standard in Beef by Importing Country

Importers	Standard
EU, New Zealand	0.1 ppm
Japan	0.2 ppm
Australia, Canada	0.25 ppm
Codex	0.6 ppm
U.S.	2.0 ppm

Note: The term ppm implies parts per million

Table 4: Estimated (Fixed-Effects) Coefficients of Bilateral Beef Trade Model (Dependent variable = log of value of trade)

	Coefficients without the interaction term	Coefficients with the inclusion of the interaction term
Constant	4.60** (2.05)	-4.12*** (0.77)
Standard	0.59*** (0.16)	0.58** (0.27)
Standard*Exporting country dummy		0.14 (0.29)
GNP of importing country	1.40** (0.67)	2.88*** (0.79)
Population of importing country	-0.32 (0.79)	-2.35*** (0.90)
GNP of exporting country	-3.92 (4.50)	2.24*** (0.16)
Population of exporting country	-21.78 (13.61)	-2.14*** (0.20)
Distance	-1.36*** (0.25)	-1.08*** (0.26)
Hormone Ban Dummy	-3.73*** (1.28)	-3.26*** (0.82)
Foot and Mouth disease dummy	0.73 (0.70)	0.51 (0.76)
Year 1995 dummy	-1.66* (0.90)	0.57 (0.59)
Year 1996 dummy	-1.38* (0.78)	0.33 (0.58)
Year 1997 dummy	-0.64 (0.64)	0.61 (0.57)
Year 1998 dummy	-0.33 (0.55)	0.40 (0.59)
Year 1999 dummy	0.06 (0.47)	0.44 (0.56)
Colonial ties dummy	3.41*** (0.66)	3.12*** (0.62)
NAFTA member dummy	-0.79 (0.92)	0.83 (0.95)
APEC member dummy	-1.06 (1.10)	-2.77*** (0.60)
Adjusted R-squared	0.736	0.563
Number of observations	207	198

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.

Table 5: Change in Bilateral Trade Flows from Pre-harmonization Standards to Codex Standard (in Percentage)

	Importing countries						
	Australia	Canada	EU15	Japan	New Zealand	U.S.	Total
Exporting countries							
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	

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

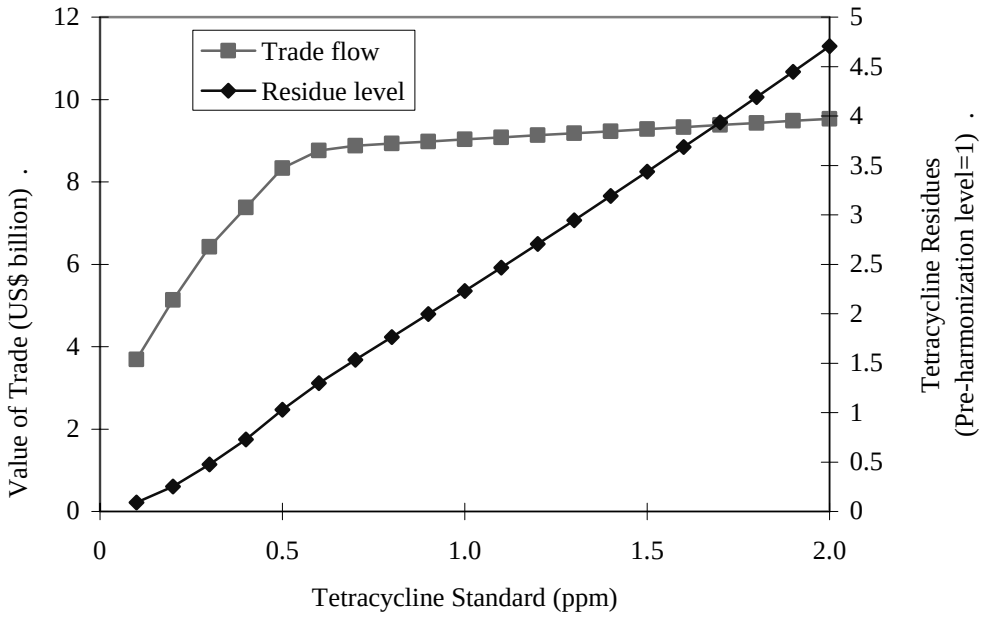


Table 6: Change in Value of Trade under the Codex Standard by Income Groups (Average for one exporting country)

	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