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JULY 2015

Working Paper 117

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## A Proposal Based on Cost-Benefit Analysis

Mahdi Ghodsi

The Vienna Institute for International Economic Studies
Wiener Institut für Internationale Wirtschaftsvergleiche

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## A Proposal Based on Cost-Benefit Analysis

MAHDI GHODSI

Mahdi Ghodsi is Research Economist at the Vienna Institute for International Economic Studies (wiiw).

This paper was revised and finalised as part of the project 'Productivity, Non-Tariff Measures and Openness' (PRONTO) funded by the European Commission under the 7th Framework Programme, Theme SSH.2013.4.3 3, 'Untapped Potential for Growth and Employment Reducing the Cost of Non-Tariff Measures in Goods, Services and Investment', Grant agreement No. 613504.

The author is obliged to his colleagues who supported him during the preparation of this paper as the third chapter of his PhD dissertation at Università Cattolica del sacro cuore di Milano. Specifically, the author is truly indebted and grateful to his supervisor Carsten Krabbe Nielsen and his adviser at the University of Warsaw, Jan Jakub Michalek, for imparting the intuition that gave the paper development direction. Thanks are also due to Leo Sleuwaegen, Italo Colantone and Rosario Crinò in the PhD assessment committee, and to Robert Stehrer (wiiw) for his reviews and constructive comments on the work.

# Abstract

This contribution provides a cost-benefit analysis in a partial equilibrium framework to investigate the welfare consequences of a prohibitive non-tariff measure (NTM) aimed at a foreign product with perceived negative characteristics. Two groups of consumers are distinguished: one that is indifferent to the negative attributes of the foreign product and another that is concerned about them. Different scenarios concerning the welfare gains from the introduction of an NTM are explored. The results depend on consumer awareness and information policies pursued by the government. The theoretical model is illustrated with data on the consumption of cattle in eight northern states of the United States of America; this is related to Dispute Settlement 384 on Certain Country of Origin Labelling (COOL). The findings suggest that when the government informs consumers after an NTM that a harmful product is no longer available on the market, that favours domestic producers rather than consumers. Such a framework could assist the Dispute Settlement Body of the World Trade Organisation in determining the true motivations behind the imposition of an NTM.



Keywords: welfare, trade policy, non-tariff measures, technical barriers to trade, dispute settlement

JEL classification: D61, F13

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# 1. Introduction

Ever since the General Agreement on Tariffs and Trade (GATT) took effect in 1948, the tariffs on trade between World Trade Organisation (WTO) members have fallen. However, non-tariff measures (NTMs) have received worldwide attention. The Multi-Agency Support Team (MAST)[1] defined NTMs as follows:

> 'Non-tariff measures (NTMs) are policy measures, other than ordinary customs tariffs, that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both.' (MAST, 2008)

According to the MAST classification of February 2012 (UNCTAD/DITC/TAB/2012/2), NTMs include 16 categories, of which the first and second are those most frequently notified by WTO members. These measures described in MAST are sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT). SPSs are measures that are applied with the aim of: protecting human or animal life from risks arising from additives, contaminants, toxins or disease-causing organisms in their food; protecting human life from plant- or animal-carried diseases; protecting animal or plant life from pests, diseases or disease-causing organisms; preventing or limiting other damage to a country from the entry, establishment or spread of pests; or protecting bio-diversity. SPSs include measures taken to protect the health of fish and wild fauna, as well as forests and wild flora. TBTs are 'measures referring to technical regulations, and procedures for assessment of conformity with technical regulations and standards, excluding measures covered by the SPS Agreement'.

These measures have attracted worldwide attention: the World Trade Report (WTO, 2012) specifically discusses them and analyses their impact on international trade flows. They have been very effective instruments for governments in pursuing different motivations. According to this report, there may be three reasons for imposing these regulatory measures. First, an NTM may address a public welfare policy issue, rather than an economic issue: it may concern the protection of human health or safety, animal or plant life or health, or the environment. For instance, as part of a TBT or SPS measure, a foreign product that could potentially have a harmful effect on consumers may be banned from importation because consumers are not well informed about the damaging attributes of the product. In other words, the NTM policy is imposed with the aim of protecting consumer welfare in the domestic society.

Secondly, from an economic perspective, the NTM might focus on increasing social welfare by correcting market failures without engaging in trade discrimination. Increased market efficiency and an improvement in the information available to market agents through the employment of certain technical

[1] As of July 2008, MAST comprises the following institutional members: Food and Agriculture Organisation of the United Nations (FAO), International Monetary Fund (IMF), Organisation for Economic Cooperation and Development (OECD) Trade and Agriculture Directorate, United Nations Conference on Trade and Development (UNCTAD), United Nations Industrial Development Organisation (UNIDO), World Bank (WB), World Trade Organisation (WTO), International Trade Centre UNCTAD/WTO (ITC). Observers: European Commission (EC), United States International Trade Commission (USITC), United States Department of Agriculture (USDA). UNCTAD and World Bank jointly coordinate MAST. MAST reports to the Group of Eminent Persons, which is convened by the director general of UNCTAD.

regulations, such as the labelling of products, offer a good example of the economic motivations of governments to use NTMs. It may be the case that both producer and consumer welfare are improved by the imposition of new regulations. Since the government has not introduced import tariffs, there is no revenue accruing to it.

Thirdly, NTMs can be purely politically motivated: they may seek to hamper free trade in order to support special interest groups, without even increasing consumer welfare. This leads to protectionism in the interests of domestic industry. Such motivation is described as ‘protection for sale’ in the literature (Grossman and Helpman, 1992; Goldbe and Maggi, 1997). The change in social welfare is determined by adding together the change in the surplus of domestic producers and government gains induced by the support of lobbying industry, and taking account of consumer welfare losses. In such a framework, the government would assign a lower weight to the final element, resulting in positive social welfare change.

The first two reasons demonstrate good faith on the part of a government and receive support in the WTO agreements; but the third may unnecessarily hamper trade and violate the articles related to NTMs. In other words, special interest groups that lobby governments might persuade them to break international rules and take some protectionist measures, which could lead to a corrupt environment. However, in empirical research covering all the countries of the world, Ghodsi (2013) found no statistical evidence of linkages between overall corruption in the country and the aggregate level of protectionism or the level of trade. TBT, SPS and other WTO agreements cover logical frameworks for the imposition of NTMs. They provide WTO members with justifiable authority to implement their own standards, provided they are not discriminatory. For example, a government might claim to be using an NTM to provide protection for the health of its citizens, though in fact it may actually be protecting its own economy or industry at the expense of domestic consumers or other countries.

In general, new standards and new regulations that are imposed in the context of NTMs are followed by various determining factors that can have quite a substantial impact on international trade. Economic considerations, protectionism, technological progress, health and environmental issues are powerful motivations for imposing NTMs. Moreover, due to their complexity, these measures have different consequences across countries and products (Ghodsi, 2015a,b). When the government of a country imposes a new standard, foreign industries need to adapt to that standard in order to gain permission to export to that country. The new standards are generally in line with production in the domestic industry. If the products of a foreign industry are not in line with the new standards, their export to the country in question will be halted until those products comply with the new regulations. If it does not make economic sense for a foreign industry to modify its production procedure, it will simply lose one of its markets. In that case, it will often ask its own government to take legitimate action under international regulations and WTO agreements. However, it can take quite a long time to convince the government that has introduced the new standards to reverse its policy – or even to comply with current agreements, if those have been violated.

During this period, the market structure becomes less competitive, and those consumers who are indifferent to, or unaware of, the negative characteristics of a product that is manufactured in line with outdated standards objectively will feel an effect. On the one hand, if the NTM is imposed ‘correctly’ (i.e. the standard will benefit their health or wellbeing), consumers will gain (they will be protected from bad products or will enjoy higher safety standards), though they will have to pay a higher price, as the

markets become less competitive. In this situation the net gains or losses need to be quantified. On the other hand, if the NTM is not justified, consumers will bear a net loss, as they must pay a higher price without enjoying better quality. Moreover, as was shown in the analysis of Ghodsi (2015b) (dealing with the impact of specific trade concerns raised about Chinese TBTs), when consumers are not willing to pay the higher prices for the better quality that follows the new standards, they divert their demand to other, cheaper products. Therefore, it is crucial to take into consideration the preferences of consumers when imposing a trade policy instrument such as a qualitative NTM. In other words, a trade policy might be ineffective (or even counterproductive) if consumer preferences are ignored.

Governments that act in good faith generally provide scientific and justifiable reasons for the introduction of TBTs and SPSs. Paternalistic governments try to protect their population against outdated standards that would allow the import of harmful products. And thus the new standards and regulations on which the NTM focuses seek to increase the quality of life for consumers. However, regardless of median voter theorem, governments might not heed the true wishes of their domestic consumers. And in fact, this paternalistic attitude does not allow consumers to choose the characteristics of a product for themselves: the decision is made for them. Some consumers do not care about the damaging properties of products; and some are unaware of them. Nevertheless, governments take the decision to impose new quality standards whether or not the policy is in line with international agreements.

If, as a government might claim, consumers are unaware of the harmful nature of a foreign product, then they cannot take account of the damaging effects when deciding on their preferences. For instance, if a consumer does not know (or care) about the potential damage from shrimps treated with antibiotics, then his/her utility increases with the consumption of any type of shrimps – simply because his/her utility is an increasing function of consuming any type of shrimp – and this satisfaction is higher than any anticipated objective future harm from the bad product. Given the consumer's overestimation of utility, the government is concerned about the damage to health and considers the following issues: first, and most importantly, a harmful product might cause death; a price cannot be put on that loss, and it cannot even be evaluated (i.e. it is a cost to society that approaches infinity). Secondly, if the product causes illness that requires treatment, the costs of that treatment can be measured by the government and be accounted for as another negative effect of the bad product. Thirdly, a person in society is one of the main factors of production, and his/her absence due to illness (or death) decreases the total welfare of society. A figure can be put on this loss: average labour productivity relative to the GDP of that society during the period of absence caused by the negative attributes of the product. In this paper, a specific scenario is constructed which assumes that the government can rationally evaluate the damaging consequences of the bad foreign product on which a prohibitive NTM is imposed. Then, it can show that the damage is economically greater than the welfare losses of consumers after a prohibitive NTM. The paper will expand on this.

This paper provides a theoretical framework within which to analyse and quantify the welfare changes in a country that imposes a prohibitive NTM; consumers are assigned either to one group that is indifferent to the properties of a product or to another group that is concerned about them. The analysis is separated into two scenarios, depending on whether or not consumers are aware of the harmful effects of the foreign product. First of all, this enables us to judge the paternalistic behaviour of the government better. Second, if the majority of domestic consumers are concerned about the harmful properties of the foreign product, then government NTMs can act with more justification in the context of international regulations and WTO agreements.

This paper can contribute to the existing literature by establishing a framework to help in judging the motivations of a government in imposing qualitative NTMs. An ongoing Dispute Settlement (DS) case on Certain Country of Origin Labelling (COOL) is examined to show the applications of the framework. In addition to the results of Ghodsi (2015b), the findings of this study also suggest that the implications of a trade policy are closely related to consumer preferences and the market structure. Disclosure of information by the government can play a vital role in the consequences of the trade policy instrument. Moreover, the framework presented here provides a measurement of the damage that may be caused by the product that is the target of the qualitative NTM. In the next section, a brief literature review on this issue is provided, together with anecdotal facts. In the third section, the basic analysis of the theoretical model is presented. The effective welfare changes in the country that imposes an NTM will be illustrated in the fourth section, using data related to the DS384 investigation under COOL. Finally, a summary of findings, conclusions and possible extensions of the model will be discussed.

# 2. Anecdotal fact and literature review

In September 1998, Canada requested consultations (DS144) with the United States within the Dispute Settlement Mechanism (DSM) with respect to certain measures imposed by the US state of South Dakota and other states that prohibited the entry or transit of Canadian trucks carrying cattle, swine and grain. Since then, this DS case has been pending, according to the WTO website.[2] In December 2008, Canada and Mexico requested consultations with the USA over the mandatory Country of Origin Labelling under cases DS384 and DS386, respectively. These two cases appear to be similar to Canada's complaint under DS144. The 27 EU Member States and 12 other countries reserved their third party rights in these disputes. COOL was believed to be discriminatory within the framework of WTO agreements. After several years of analysis and investigation within the DSM, the appellate body issued its findings in June 2012. The USA was proved to have violated Article 2.1[3] of the TBT agreement, and it promised to implement the rulings and recommendations of the Dispute Settlement Body (DSB) by May 2013. Figure 1 shows the changes in swine exports from Canada to the USA.

To be more precise, Figure 1 shows the export trends of 'live swine, purebred and breeding' with the Harmonised System (HS) code (revision 1996) 010310 on the right vertical axis (broken line); and 'meat of swine, fresh or chilled' with HS code 020311 on the left vertical axis (solid line) from Canada to the USA. As the example shows, the export of meat of swine dropped dramatically in 1999 (after DS144). Then in 2001, the export of live swine soared; this seems to be a substitute for meat of swine. However, the export of live swine dropped after one year and decreased gradually until 2014. After 2001, export of meat of swine gradually increased, but in 2007 (before DS384) it dropped dramatically. The main reason for the decrease in swine exports from Canada may be the prohibitive NTM imposed by the US. This is an example of a restrictive NTM which completely halts imports of a specific product; it will be the topic of this paper.

The first significant effect of US policy was a prohibition on the import of some products from Canada. Even if the industries of Canada had tried to implement the regulations of the USA, it would have taken a long time to comply with them. More generally, during 1995–2011, different WTO members raised 317 specific trade concerns (STCs) about TBTs imposed by other members; of these, only 251 TBTs were notified directly to the WTO by the imposing countries. In other words, 20% of TBTs were not notified directly to the WTO by the members who imposed them. Thus, it is quite possible that officials who impose NTMs do not inform anybody – not even the authorised international organisations responsible for approving their policies. Governments that try to conceal their actions are reluctant to disseminate information on their policies to the public.

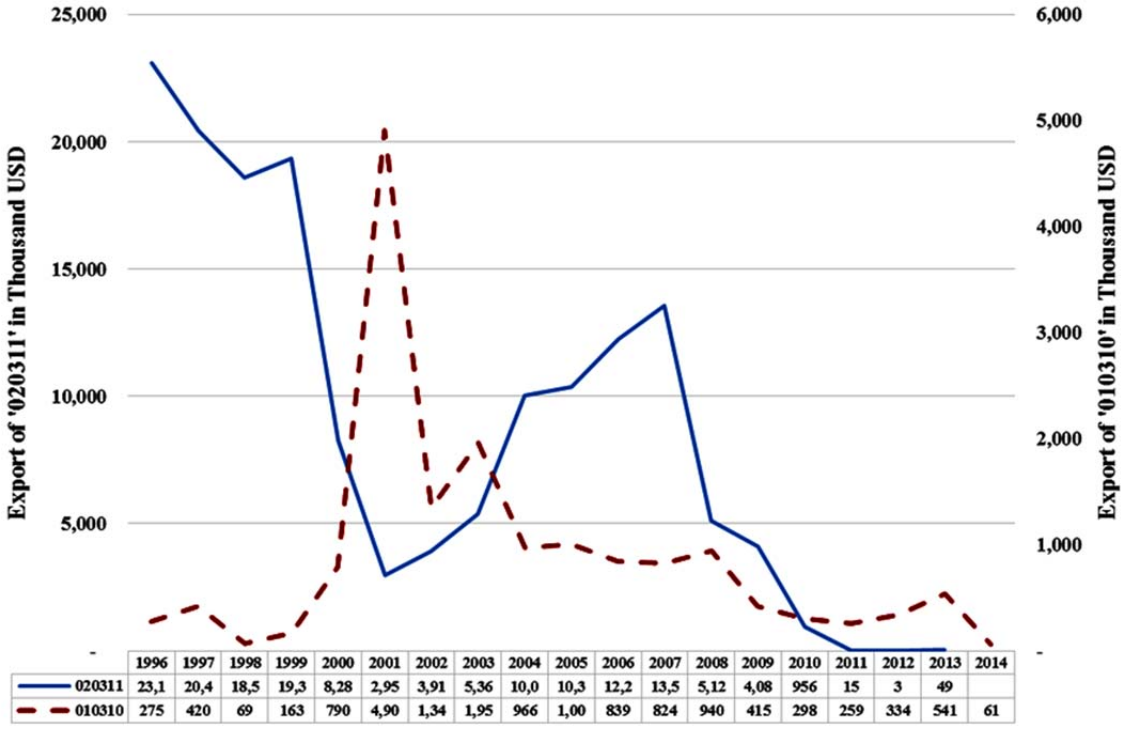
In order to quantify the welfare implications of NTM policies, a cost-benefit analysis can be conducted in a partial equilibrium framework. Paarlberg and Lee (1998) used a numerical partial equilibrium approach

[2] Can be found at: http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds144_e.htm

[3] Article 2.1 of the TBT Agreement indicates that 'Members shall ensure that in respect of technical regulations, products imported from the territory of any Member shall be accorded treatment no less favourable than that accorded to like products of national origin and to like products originating in any other country.'

to investigate the linkages between products at risk of transmitting Foot and Mouth Disease (FMD) that were imported to the US and the level of protectionism. They simply modelled consumer and producer surplus changes, and a government that maximised welfare by assigning the optimal tariff. Then they calculated the output losses after the outbreak of the disease by assigning a probability to its risk.

**Figure 1 / Export of swine from Canada to the USA during 1996–2014**




| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 020311 | 23,1 | 20,4 | 18,5 | 19,3 | 8,28 | 2,95 | 3,91 | 5,36 | 10,0 | 10,3 | 12,2 | 13,5 | 5,12 | 4,08 | 956 | 15 | 3 | 49 | |
| 010310 | 275 | 420 | 69 | 163 | 790 | 4,90 | 1,34 | 1,95 | 966 | 1,00 | 839 | 824 | 940 | 415 | 298 | 259 | 334 | 541 | 61 |

Source: UN COMTRADE
010310: Pure-bred breeding live swine; 020311: Fresh or chilled, carcasses and half-carcasses swine

The consequences of liberalised trade are twofold for the people of any given society. First, the inflow of products from the international market to a country can potentially threaten domestic industry. As a result, the job market in the domestic industry would shrink (or at least require labour market adjustments). Secondly, the import of a variety of products with lower prices and higher quality would increase the satisfaction and welfare of consumers. Baker (2003) constructed a theoretical framework to relate earning power to consumption attitude, in order to explain the popularity of free trade among developing Latin American countries. He provided survey results to show why consumers are interested in the benefits of consumption rather than being concerned about earning power or the job market.[4] In a common microeconomic model, he argues that people work and make an effort to earn, which can be translated as a cost to their leisure. On the other hand, as citizens they try to enjoy and get the most satisfaction out of their leisure time, and they prefer to have a variety of inexpensive bundles of products of high quality. Baker (2003) claimed that this was a reasonable explanation for the pursuit of free trade even in developing countries with high job-market volatility.

[4] However, it is worth mentioning that the model presented here is more on trade between countries with similar levels of developments.

Kono (2006) analysed the role of democracy and autocracy in trade policies. His main argument was that democratic governments try to respond to mass public preference for liberal trade policies. Consumers benefit from the variety of products and the low prices that are a result of liberal trade. Nevertheless, in all governments there are pressures from interest groups seeking protection. The authorities prefer to address liberalisation with transparent policies, such as tariff reduction. However, there are less transparent policy options available to satisfy special interest groups, one of which is the NTM.

According to Kono (2006) the impacts of tariffs can be determined by the degree of pass-through effects. Core NTMs consist of price control measures (such as antidumping) and quantity measures (such as quotas and voluntary export restrictions (VERs)), which are rather more complex in nature than direct tariffs. Although the impacts of core NTMs are related to prices and quantities, consumers who lack either the expertise or the time for analysis cannot easily evaluate the impact of such policy instruments. Qualitative NTMs are generally regulations on technical issues and standards, which have an impact not only on the quantities and prices of imports, but also on the quality of products that feature in consumer preferences. Thus, the effects of these kinds of measures are even more difficult for consumers to evaluate than the previous two instruments (i.e. core NTMs and quantity measures).

When the political opposition wants to criticise the trade policies of those in power, they can inform people about the negative impacts of high tariffs on consumer welfare in the form of simple price changes. However, a reduction in tariffs can also be seen to threaten jobs. It becomes more difficult for them to explain why, for instance, a VER on 250,000 car units increases the price. Informing people about the costs and benefits of qualitative NTMs would be even harder. Besides, political groups in charge know how their competitors try to challenge their actions and policies by providing information to the population in various ways. In autocracies there is no powerful opponent to try and keep people informed; in democracies, people tend to be better informed, but there is great variation in the information about different types of policy instruments. That may explain why governments, even in the most democratic countries, try to implement opaque and complex trade policies instead of simple tariffs (Kono, 2006). Hence, the public's general knowledge, the awareness of consumers, related government policies and the provision of information by NGOs might all matter.

According to Baba (1997), it is costly to inform voters and consumers in general. For instance, in election campaigns for the presidency or parliament, candidates try to give voters information in order to gain their support. But these campaigns are quite costly, and are often supported by special interest groups. Other methods of informing consumers, such as media advertising, are also costly. Thus, in order to have informed consumers who seek liberal trade, there needs to be support from lobbying groups or else taxation of consumers themselves. Governments can easily and relatively cheaply inform society about simple, transparent policy instruments, such as tariffs; but they may conceal the role of opaque and complex ones, such as NTMs, because of the high cost of providing information.

Van Tongeren et al. (2009) constructed a modular partial equilibrium model that focused on demand and supply relationships. Changes in social welfare were analysed for three different scenarios: prohibitive standards that completely bring the market into autarky (NTM), free trade, and mandatory labelling that provides consumers with comprehensive information about the goods. Using these three scenarios, the effects on consumers and producers were investigated, as were the effects of global common externalities.

Beghin et al. (2012) provided a framework similar to that of van Tongeren et al. (2009). They considered two scenarios featuring consumers who were informed and uninformed about the negative characteristics of foreign products. They found that, in certain circumstances, the prohibitive standards can increase international welfare. When consumers are unaware of the negative attributes of a product, only the foreign producer's welfare decreases slightly; meanwhile domestic producers and consumers gain from the regulations. When consumers are thoroughly informed, all these agents gain from the new standards. There are, however, some important issues. First, the authors assume that informed consumers are also concerned consumers. Secondly, the potential negative externalities of consumption are not clearly identified: only negative direct characteristics of the foreign product are introduced in their model. Negative externalities can be discussed when the consumption or production of a product by an agent indirectly decreases utility or profit for another agent. Thirdly, they assumed that consumers could not distinguish between foreign and domestic products, yet those consumers are assumed to include a proportion of foreign products on the market in their preferences. Fourthly, as consumers are assumed to be unable to distinguish between the two products, they can rationally assign a probability to the share of the foreign products in the market and then make a decision.

This research is similar to the contributions of Beghin et al. (2012) and van Tongeren et al. (2009), but there are some modifications. Here, in one scenario it is assumed that consumers are aware of the negative characteristics of the product, but they may then either be indifferent or concerned. In the second scenario, it is assumed that consumers are not aware of the damaging effects, and the government imposes NTM to increase their welfare objectively. NTM policies are strictly prohibitive: they halt the import of those foreign products with the perceived negative attributes until the foreign production procedures improve. The market structure in this model differs from the previous bits of research: here, under free trade, the home country has a duopolistic market (similar to the framework of Brander and Spencer, 1985). Oligopolistic competition instead of perfect competition can provide a clearer situation, in which the government uses consumer safety as an excuse to impose NTM, even though the real reason is to improve the position of domestic industry. The findings of this paper can clarify a government's motivation for imposing NTMs and its implementation of an information policy. In fact, whenever the data is available, the analytical framework discussed in the following shows whether the government is actually increasing consumer welfare by the restrictive measure that targets public issues.

# 3. Presentation of the model

It is assumed that there are two countries, Home country (H) and Foreign country (F), and that the foreign product contains some characteristics that might cause harm to human health. Here it is simply assumed that the foreign government has a different evaluation of potential risk. The foreign industry or government does not know (or care) about these negative characteristics. And the foreign industry manufactures a product of lower quality[5] than the domestic industry does. Some domestic consumers might be concerned about these negative attributes and reflect their concerns in their preferences. A domestic government that tries to protect its population against the potential damage from the foreign product imposes a prohibitive NTM that raises the standard of the product. Let us assume that the domestic industry has already been producing in line with the new standards. Foreign producers now need to comply with the new regulations if they are to export to the home market. This takes time. In this model we attempt to analyse domestic welfare changes after the imposition of an NTM, during the time that the foreign product is not imported into the home market because of its lower quality and before the foreign industry complies with the new standards.

The supply side of the market is an oligopolistic Cournot competition between the industries of the two countries[6] before the prohibitive NTM. It is also assumed that the cost of transportation is included in the cost of the final good imported from the foreign supplier. Industries maximise their output with respect to a quadratic cost function in output. Considering N individuals in each society and $Q(p) = \sum_{i=1}^{N} q_i\,(p)$, where $q_i(p)$ and $Q(p)$ are, respectively, the demand of individual *i*, and the total demand at Home; the profit for this industry in each country is:

$$\pi_j = p(Q)q_j - c_{1j}q_j - \frac{1}{2}c_{2j}q_j^2 - K_j \text{ , for } j = \{H, F\} \quad (1)$$

where $c_{1j}$ and $c_{2j}$ are the variable cost parameters, and $K_j$ is the sunk cost related to the market entry for each industry.

Concerning the demand side, it is assumed that consumers are unable to distinguish between the good and the bad products. Even if, according to the rules of origin, consumers know where the product comes from, because of the uncertainty related to the intermediate goods employed in the production they cannot distinguish between the good and bad products. Thus, products are not differentiable. However, it is assumed that the good product is produced domestically, without any negative characteristics, while the bad product is produced abroad and has some negative attributes.

In the following subsections, two scenarios are analysed. In the first, it is assumed that consumers are aware of the harm that could be caused by a product on the market (let us assume that the media and

[5] In this model, the low quality of products is assumed to directly affect an individual consumer after consumption. These are not negative externalities associated with the consumption or production of others affecting another individual.

[6] It is simply assumed that there exists one industry in each country; each industry acts as a monopoly in autarky even if it comprises various firms (think of a cartel). The rationale for the selection of such a market structure is simply to show the possibility of government support for the home industry, which can be easier to observe here than a perfect competition.

scientists have informed consumers that there is a specific product with certain harmful effects). Now, consumers are divided into two groups: a proportion of society ($\eta$) is indifferent to those characteristics; the rest of the population is concerned about the perceived damage from the foreign product and take this into account when making a decision. Consumers can rationally allocate their budget in line with the demand for a product. Given undifferentiated products, they can assign a probability to their ending up with the foreign (bad) or domestic (good) product.

In the second scenario, it is assumed that society is not aware of the harm from the foreign product, and that only the government knows about its attributes. Thus, it can be considered that all consumers are indifferent to the characteristics of the foreign product. The government is well aware of the danger of the imported goods and considers them in the utility of all consumers objectively.

## 3.1. SCENARIO A

Since consumers do not know whether or not the product they consume is the one with negative or positive characteristics, they cannot include the two types of product in their preferences exclusively. In other words, they cannot distinguish between the good and bad products, even though they know their origins. Hence, foreign and home goods are mixed in one single market. What they include in their preferences is simply one type of good ($q_i$) with mixed characteristics. Assume that by probability $\tau$ the consumer gets the foreign product, and by probability $(1-\tau)$ he gets the domestic product. Considering quadratic preferences of the good and an additive numeraire, the utility function of each domestic consumer $i = \{1, \dots, N\}$ is as follows:

$$U_i(q_i, w_i) = \tau\left(aq_i - \overline{b}\, q_i^2/2 - I_i r q_i + w_i\right) + (1-\tau)\left(aq_i - \overline{b}\, q_i^2/2 + w_i\right) \quad (2)$$

Here $w_i$ is the numeraire good, the term $aq_i - \overline{b}\, q_i^2/2$ is the satisfaction of consumer *i* from consuming quantity $q_i$. $rq_i$ is the perceived damage from the product for every concerned consumer, which might be at the focus of the technical policy or new regulations. In order to have positive demand, it is simply assumed that $r < a$. Term $I_i$ represents the concerned knowledge of the consumer regarding the harmfulness of the product. Therefore, if the good is not perceived by the consumer to be harmful, this term will be equal to zero. Conversely, if $I_i = 1$, it means that the consumer will be concerned about the negative properties of the good. Hence, term $I_i r q_i$ captures the impact of harm and the concern about consuming this good felt by the representative consumer.

$\eta = N_1/N$ is the proportion of the population who are indifferent to the negative characteristics of the good. It means that $I_i r q_i = 0$ for $i \in [1, N_1]$. The rest of society is concerned about the damaging effect of the product, which comprises the proportion $1 - \eta = 1 - (N_1/N)$. Thus, for $i \in [N_1 + 1, N]$, $I_i r q_i > 0$.

The demand function for each consumer can be derived by utility maximisation, subject to a budget constraint. Total demand in society is simply the sum of the demand functions of the two groups. The total demand schedule is truncated where price is equal to $a - \tau r$. In fact, above this price, only indifferent consumers demand good $q_i$, while concerned consumers demand nothing because of the perception of high negative effects. Therefore, the total inverse demand by society is given by:[7]

[7] Calculations can be found in Appendix 1.

$$p_A^D(Q,r) = \begin{cases} a - \frac{b}{\eta}\, Q, 0 \le Q \le \frac{\tau r \eta}{b} \\ a - \tau r(1-\eta) - bQ, Q \ge \frac{\tau r \eta}{b} \end{cases} \quad (3)$$

The concerned consumers assign a value $\tau$ to the probability of getting the foreign variety of the product. Although they cannot distinguish between the two products, they have access to statistical data and consider the ratio of the imported products (with bad characteristics) relative to the total consumption of the product (with two types of characteristics) in the market to be $\tau$. This allows us to simply assume that $\tau = q_F/(q_F + q_H)$. Firms in both countries maximise their profits in a duopolistic market subject to the inverse demand function (3), and they consider the value of $\tau$ to be determined from pre-NTM patterns. It is further assumed that both industries are symmetric and their cost parameters are identical ($c_{1H} = c_{1F} = c_1;\ c_{2H} = c_{2F} = c_2;\ K_H = K_F = K$). Therefore, it is clearly observed that both industries supply the same amount of product in the market, and thus $\tau = 1/2$. Considering these assumptions and deriving the Cournot (Nash) Equilibrium for the Best Response (BR) functions of the two industries, before imposition of restrictive NTM, total quantity supplied in the oligopolistic market ($Q_{AO}$) will be:[8]

$$Q_{AO} = \begin{cases} \frac{2\eta(a-c_1)}{3b + c_2\eta}, a - \frac{r}{2} \le p \le a \\ \frac{2\left(a - \frac{r}{2}(1-\eta) - c_1\right)}{3b + c_2}, 0 \le p \le a - \frac{r}{2} \end{cases} \quad (4)$$

The equilibrium price in this duopoly ($P_{AO}$) will be:

$$P_{AO} = \begin{cases} a - \frac{2b(a-c_1)}{3b + c_2\eta}, 0 \le Q \le \frac{r\eta}{2b} \\ a - \frac{r}{2}(1-\eta) - \frac{2b\left(a - \frac{r}{2}(1-\eta) - c_1\right)}{3b + c_2}, Q \ge \frac{r\eta}{2b} \end{cases} \quad (5)$$

Consumer welfare in this oligopoly before new regulations ($CA_{AO}$) will be as follows:[9]

$$CS_{AO} = \int_0^{Q_{AO}} (p_A^D(Q,r) - P_{AO})dQ$$

$$= \begin{cases} 2b\eta\left[\frac{(a-c_1)}{3b + c_2\eta}\right]^2, a - \frac{r}{2} \le p \le a \\ \frac{b}{2}\left[\frac{2\left(a - \frac{r}{2}(1-\eta) - c_1\right)}{3b + c_2}\right]^2 + \frac{r^2\eta(1-\eta)}{8b}, 0 \le p \le a - \frac{r}{2} \end{cases} \quad (6)$$

Now consider an NTM policy that prohibits the import of goods from abroad completely. Simply assume that it is a high sunk cost imposed on the foreign firm that induces exit from the home market for a long

[8] These are not closed solutions but analytical solutions. A pure strategy Nash Equilibrium may not exist. For the proof of existence refer to Appendix 2. However, the simulation in the next section is based on the existence of pure strategy Nash Equilibrium.

[9] Since the demand is truncated where $p = a - \frac{r}{2}$, the calculation of CS below this price is:

$$CS_{AO} = \int_{a-\tau r}^{a} \left(\frac{\eta(a-p)}{b}\right) dp + \int_{P_{AO}}^{a-\tau r} \left(\frac{a - \tau r(1-\eta) - p}{b}\right) dp$$

period of time. The market goes to autarky and a single monopoly supplies the product domestically. There may be two cases regarding the information provided by the new NTM; these will be presented next.

There are numerous standards and regulations that are publicly available on government-affiliated websites, but many are not advertised. For instance, supply of genetically modified organisms (GMOs) is restricted in the EU market by regulations and standards. These have long been debated domestically and internationally, and they still play an important role in the negotiations over the Transatlantic Trade and Investment Partnership (TTIP). Such broad policies – affecting production and international trade significantly – attract the attention of the media, and consequently of consumers. However, there are many other qualitative standards and regulations that are not highlighted by the media, and so consumers miss out on the information. One such example is the EU Commission Regulation No. 2257/94, which lays down restrictions on the import of bent bananas and curved cucumbers. The regulation was issued on 16 September 1994 and came into force on 1 January 1995. Even though some major EU members, such as France, Italy and Spain, benefited economically from this protectionist measure, others, including Britain and Ireland, voted to reform the rules. The interesting point is that such a regulation had been in place in Austria since 1967, yet Austrians were not aware of it until the EU regulation was ridiculed in the media.[10,11] The regulation was finally dropped in 2009, as it was creating an unnecessary barrier to trade. Whether or not a government is willing to inform its consumers by providing extensive advertising in the media, is the focus of the post-NTM case scenarios presented next.

## Case I: Complete information on the existence of a foreign product after NTM

When a government informs the producer and all consumers that there is no product with harmful characteristics on the market, concerned consumers have certainty and assign a probability $(1-\tau)=1$ to the chances of receiving the home product. In other words, their expected utility (2) will be reduced to only the second term on the right-hand side. There will be no more disutility *rq* in the preferences of consumers. The domestic industry becomes a monopolist and maximises its profit subject to an inverse total demand on the part of society $p_{AI}^{D}(Q,r)=a-bQ$. The equilibrium price ($P_{AMI}$) and quantity ($Q_{AMI}$) supplied by the home monopolist will be:

$$P_{AMI}=a-\frac{ab-bc_{1H}}{2b+c_{2H}}\;;\;Q_{AMI}=\frac{a-c_{1H}}{2b+c_{2H}} \tag{7}$$

Total consumer surplus in this case ($CS_{AMI}$) will be as follows:

$$CS_{AMI}=\int_{0}^{Q_{AMI}}(p_{AI}^{D}(Q,r)-P_{AMI})dQ=\frac{b}{2}\left(\frac{a-c_{1H}}{2b+c_{2H}}\right)^{2} \tag{8}$$

[10] http://www.telegraph.co.uk/news/worldnews/europe/2453204/Bent-banana-and-curved-cucumber-rules-dropped-by-EU.html

[11] http://ec.europa.eu/austria/documents/_1341_gurken.pdf

## Case II: No information on the existence of the foreign product after NTM

Assume that a government informs the domestic producer, but not consumers, about the new regulations, so that consumers believe that the supply of foreign products is still mixed with the home product on the domestic market. As explained before, there have been some examples where the government has not informed other countries or the WTO about the new measure. The government does not inform *anybody* (except a special interest group) – not even its own citizens – about the new measures and policies. Even though this rarely happens in reality, it raises specific trade concerns (STCs) that are likely to lead to trade disputes in the WTO (Ghodsi and Michalek, 2014). According to Baba (1997), informing voters and consumers generally is costly. Not only may the government be reluctant to inform the WTO about its new policy instrument, but it may also be concerned about consumers learning of the less liberal trade.

Consumers do not have information regarding the characteristics of products after the imposition of NTM. Moreover, in the short run, the data on the importation and consumption of a product is not published, and consumers cannot gain access to statistics in order to assign a correct value to $\tau$. Therefore, the inverse aggregate demand function remains equivalent to that in equation (3). Profit maximisation of the home industry, acting as a monopolist, yields the analytical solution for total supply ($Q_{AMII}$) as follows:

$$Q_{AMII} = \begin{cases} \frac{a\eta - c_{1H}\eta}{2b + c_{2H}\eta}, a - \frac{r}{2} \leq p \leq a \\ \frac{a - \frac{r}{2}(1-\eta) - c_{1H}}{2b + c_{2H}}, 0 \leq p \leq a - \frac{r}{2} \end{cases} \quad (9)$$

Equilibrium price in this case ($P_{AMII}$) will be as follows:

$$P_{AMII} = \begin{cases} a - \frac{ab - bc_{1H}}{2b + c_{2H}\eta}, 0 \leq Q \leq \frac{r\eta}{2b} \\ a - \frac{r}{2}(1-\eta) - b\frac{a - \frac{r}{2}(1-\eta) - c_{1H}}{2b + c_{2H}}, Q \geq \frac{r\eta}{2b} \end{cases} \quad (10)$$

Total subjective consumer surplus in this case ($CS_{AMI}$) will be as follows:[12]

$$CS_{AMII} = \int_0^{Q_{AMII}} (p_A^D(Q, r) - P_{AMII})dQ$$

$$= \begin{cases} \frac{b\eta}{2}\left[\frac{a - c_{1H}}{2b + c_{2H}\eta}\right]^2, a - \frac{r}{2} \leq p \leq a \\ \frac{b}{2}\left[\frac{a - \frac{r}{2}(1-\eta) - c_{1H}}{2b + c_{2H}}\right]^2 + \frac{r^2\eta(1-\eta)}{8b}, 0 \leq p \leq a - \frac{r}{2} \end{cases} \quad (11)$$

[12] Since the demand is truncated where $p \leq a - \frac{r}{2}$, the calculation of CA below this price is:

$$CS_{AMII} = \int_{a-\tau r}^{a} \left(\frac{\eta(a-p)}{b}\right)dp + \int_{P_{AMII}}^{a-\tau r} \left(\frac{a - \tau r(1-\eta) - p}{b}\right)dp$$

However, the reality is different, and consumers are no longer subject to any harmful effects from the bad product ($r = 0$). In the calculation of subjective welfare of consumers (11), the negative effect of the foreign product is included mainly in the second line where both groups of consumers show demand. Hence, to calculate the objective surplus, this damaging effect must be excluded. In other words, $\tau r Q(1-\eta)$ should be added to the second line of equation (11), while the first line will remain unchanged, as it is the demand of unconcerned consumers (in the illustration of the model, this will be referred to as Case IIb).

In the above case scenarios, the impact of the NTM on the welfare of consumers ($\Delta CS_A$) can be evaluated by simply deducting consumer welfare after NTM ($CS_{AM}$) from consumer welfare before ($CS_{AO}$). Domestic producer surplus changes are simply the difference between the home industry's profit in the monopoly and its profit under oligopoly in each case. Since the foreign market is not the focus of the modelling here, it is simply assumed that the foreign producer is out of the home market after NTM, and its welfare losses will be its profit in duopoly before NTM, excluding the sunk fixed costs ($K_F$).

## 3.2. SCENARIO B

This scenario focuses on the paternalistic behaviour of a government when consumers are not aware of the harm of the bad (foreign) products. Consumers therefore cannot take account of the negative effects in their preferences. On the other hand, a government can provide scientific evidence for measuring the harm of a foreign product on society. In this scenario, it is assumed that government can rationally measure these negative effects of the bad product produced abroad (*r*).

EU aflatoxin safety standards governing the importation of food products decrease the health risk by 1.4 deaths per billion a year (Otsuki et al., 2001). Even if the infinite cost of 1.4 deaths per billion is not considered, *r* can still be measured as the healthcare costs and/or less productive labour in society. To analyse the impact of an NTM on the welfare of society in this scenario, it is simply assumed that all consumers are indifferent to, or unaware of, the negative characteristics of the product, as already mentioned above. Before imposition of the NTM, the two industries are competing in a duopoly and it does not matter whether the origins of the products are identifiable or not. However, asymmetry of industries is assumed in this scenario. After maximising the profits of the industries and finding the Nash Equilibrium in the Cournot competition, total quantity supplied in the oligopoly in Scenario B ($Q_{BO}$) will be:

$$Q_{BO} = \frac{(a-c_{1H})(b+c_{2F}) + (a-c_{1F})(b+c_{2H})}{(2b+c_{2H})(2b+c_{2F}) - b^2} \tag{12}$$

The equilibrium price in this duopoly ($P_{BO}$) will be:

$$P_{BO} = a - b\frac{(a-c_{1H})(b+c_{2F}) + (a-c_{1F})(b+c_{2H})}{(2b+c_{2H})(2b+c_{2F}) - b^2} \tag{13}$$

Considering utility of consumers objectively in the eyes of government, consumer surplus before NTM ($CS_{BO}$) will be the area below inverse demand function $p_B^D(Q,r) = a - r - bQ$, and above equilibrium price in duopoly:

$$CS_{CO} = \int_0^{Q_{CO}} (p_B^D(Q,r) - P_{BO})dQ$$

$$= \frac{b}{2}\left(\frac{(a-c_{1H})(b+c_{2F})+(a-c_{1F})(b+c_{2H})}{(2b+c_{2H})(2b+c_{2F})-b^2}\right)^2 - \frac{r}{2}\left(\frac{(a-c_{1H})(b+c_{2F})+(a-c_{1F})(b+c_{2H})}{(2b+c_{2H})(2b+c_{2F})-b^2}\right) \quad (14)$$

where the second term on the right-hand side of equation (14) is the total negative effect caused by consumption of the foreign product. After imposition of NTM, quantities and prices in the monopoly of domestic producer ($Q_{BM}, P_{BM}$) will be the same as equation (7), and consumer welfare changes ($CS_{BM}$) will be equal to equation (8). Hence, the consumer welfare changes measured by government ($\Delta CS_B$) is as follows:

$$\Delta CS_B = \frac{b}{2}\left(\frac{a-c_{1H}}{2b+c_{2H}}\right)^2 - \frac{b}{2}\left(\frac{(a-c_{1H})(b+c_{2F})+(a-c_{1F})(b+c_{2H})}{(2b+c_{2H})(2b+c_{2F})-b^2}\right)^2$$

$$+\frac{r}{2}\left(\frac{(a-c_{1H})(b+c_{2F})+(a-c_{1F})(b+c_{2H})}{(2b+c_{2H})(2b+c_{2F})-b^2}\right) \quad (15)$$

A government imposing a prohibitive NTM in this scenario is trying in good faith to improve consumer welfare in society, as well as pursuing a public policy aimed at health and safety. In order to justify its motivations within international regulatory frameworks, it should be proved that consumer welfare would increase after new measures ($CS_{BM} > CS_{BO}$). In other words, a government should provide scientific reasons showing that the negative effects related to the consumption of foreign product *r* are such that the NTM prohibiting the product will not decrease the consumer welfare of society, even after the structure of the market is changed to become monopolist. In fact, the harmful attributes of a foreign product should have a greater impact on consumers than the inefficiencies associated with monopoly.[13] A damaging effect of foreign product *r* that renders objective consumer welfare before and after the imposition of NTM equal can be a good benchmark for acknowledging that the government was justified in imposing the NTM. Thus, an *r* that yields non-negative changes in consumer surplus after NTM ($\Delta CS_B \geq 0$) can be calculated as follows:

$$\Delta CS_B \geq 0 \Rightarrow r \geq b\left(Q_{BO} - \frac{Q_{BM}^2}{Q_{BO}}\right) = b\left(\frac{Q_{BO}^2 - Q_{BM}^2}{Q_{BO}}\right) \quad (16)$$

If the government declares and proves that the foreign product has a negative effect *r* that satisfies condition (16), it is actually acting in good faith to improve consumer welfare and the health of its citizens. Thus, *r* has to cross a certain threshold for the NTM to be justified.

[13] As discussed earlier in the introduction, an extreme case of such harm is death of a consumer, which cannot be explicitly measured in economic terms.

# 4. Illustration and application of model

According to the United States Department of Agriculture, in 2007 the US was the largest importer of beef in the world (Susanto et al., 2008). Imports of meat have been interrupted by the US government on several occasions in recent years. As stated earlier, there have also been DS cases before the WTO over this issue. In this section, the theoretical model will be calibrated using data on consumption and the import by the USA of cattle from Canada.[14]

The US is one of the biggest producers of red meat in the world. The bulk of red meat import to US is from Canada and Mexico. Canadian products generally are imported across the northern borders of the USA, and are usually consumed and distributed in neighbouring states; but this does not necessarily mean that these are the major consumption areas. However, let us assume that the border states are the final consumers of the imported products from Canada – an assumption that may be more justifiable in the case of meat products. According to the Canadian Ministry of Agriculture and Agri-Food, the following states were the only US points of import of cattle from Canada in 2007: Idaho, Maine, Michigan, Montana, New York, North Dakota, Vermont and Washington. In the illustration of the model, the data on import and production is analysed for these states. Table 1 presents the data gathered from different sources.

Let us assume that, for some reason, the American authorities find a negative attribute in the cattle imported from Canada. For instance, let us assume that there is a major outbreak in the USA of bovine spongiform encephalopathy (BSE), and the media warns consumers about the consumption of meat. Some consumers might become concerned about the foreign products imported into the USA, and would prefer domestic meat rather than imported. Thus, they perceive a negative impact from the consumption of meat imported from Canada. On the other hand, some consumers remain indifferent: they do not regard Canadian meat in a worse light than US meat. In other words, they trust the quality of the meat produced in Canada. The government authorities also try to ensure the health of the domestic market by monitoring domestic production. Even though there is no evidence that the foreign meat is of bad quality, they halt the import of meat products to the USA by imposing an NTM. For the negative characteristics of the foreign product, the survey results of Beghin et al. (2012) will be used in the analysis.[15] In their experiment, consumers were asked to indicate their willingness to pay (WTP) for shrimps before and after receiving information regarding the shrimps' potential to cause harm. The average difference between the two prices determines the perceived negative effect of the harm of the product. The authors found the effect to be 47% of the price of the harmless product. Based on this experiment, and considering the average price per head of cattle to be US$781.63, the perceived negative characteristics of the bad product would equate to US$367.43.

[14] The simulation is undertaken only to show the application of the theoretical framework. Therefore, it is assumed that the real world data provided for the analysis is only a proxy for parameterisation, and not an accurate replicate of the model in the reality.

[15] Although their survey was for the consumption and import of shrimps to the EU, here it is assumed that consumers behave similarly in the US for the consumption of another category of food, like red meat.

**Table 1 / Data on consumption of cattle (measured in head) in 2007**

| Variable | Description | Data for eight states[a] |
|---|---|---|
| $q_H$ | Domestic cattle sold on the domestic market (in head)[b] | 7,015,001 |
| $q_F$ | Import of cattle sold on the domestic market (in head)[c] | 1,425,998 |
| P | Average price per head (US$)[d] | 781.63 |
| $\varepsilon_D$ | Own-price elasticity of demand[e] | -1.225 |
| $\varepsilon_S$ | Own-price elasticity of supply for both industries[f] | 1.81 |
| $r$ | Per-unit damage of product (in USD)[g] | 367.43 |

Sources of data are in the following notes:
a: Selection of eight US states is based on their imports from Canada. According to the Canadian Ministry of Agriculture and Agri-Food, the following states were the only US points of imports of cattle from Canada in 2007: Idaho, Maine, Michigan, Montana, New York, North Dakota, Vermont, and Washington.[16]
b: Sale of cattle in those states is gathered from the National Agricultural Statistical Service, US Department of Agriculture.[17]
c: Import of Cattle is gathered from the FAO Statistics Division.[18]
d: Average price per head is derived simply by dividing total cash receipts of sale by total sale in head, obtained from the sources mentioned in notes b and c.
e: Own price elasticity of demand is calculated by Susanto et al. (2008) for live cattle.
f: Own price elasticity of supply is calculated by Zhang et al. (2006) for live cattle.
g: Perception of per unit damage of product is from the experiment by Beghin et al. (2012).

**Table 2 / Calculated parameters of the model on consumption of cattle in 2007**

| Variable | Calculation | Description | Value |
|---|---|---|---|
| b | $b = -P/(\varepsilon_D Q)$ | Slope of demand | 0.000224 |
| a | $a = (bQ) + P$ | Demand intercept | 1419.94 |
| $c_2$ | $c_2 = P/\left(\varepsilon_S \frac{Q}{2}\right)$ | Cost parameter 2 of two symmetrical industries in Scenario A | 0.000303 |
| $c_1$ | $c_1 = \left(c_2 \frac{Q}{2}\right) - P$ | Cost parameter 1 of two symmetrical industries in Scenario A | -349.85 |
| $c_{2H}$ | $c_{2H} = P/(\varepsilon_S q_H)$ | Cost parameter 2 of home industry in Scenario B | 0.0000616 |
| $c_{1H}$ | $c_{1H} = (c_{2H} q_H) - P$ | Cost parameter 1 of home industry in Scenario B | -349.85 |
| $c_{2F}$ | $c_{2F} = P/(\varepsilon_S q_F)$ | Cost parameter 2 of foreign industry in Scenario B | 0.000303 |
| $c_{1F}$ | $c_{1F} = (c_{2F} q_F) - P$ | Cost parameter 1 of foreign industry in Scenario B | -349.85 |

Source: own calculations

To calibrate the parameters, it is assumed that the data illustrates a situation in which consumers have not yet received any information regarding the harmfulness of a foreign product from the media. It is also assumed that the market in the US, as represented by the data, is a perfect competition between many domestic and many Canadian producers. Hence, for the simple calculation of cost parameters, reality is considered to be perfect competition. Then, the parameters will be plugged into the Cournot model specified earlier. Thus, the marginal cost function of each industry represents total supply. The supply of each industry is $(p(q_j) = c_{1j} + c_{2j} q_j, j \in \{H, F\})$. According to the price elasticity of supply presented in Table 1, cost parameters can be calculated and then used in each case for the model presented in the

[16] More information can be found at: http://www.agr.gc.ca/redmeat-vianderouge/tra-com_eng.htm
[17] More information can be found at: http://quickstats.nass.usda.gov/
[18] More information can be found at: http://faostat3.fao.org/faostat-gateway/go/to/home/E

previous section. Moreover, for Scenario A, in which symmetrical industries are assumed, it is hypothesised that the cattle imported from Canada are mainly demanded and consumed in some northern counties of the US. Hence for the illustration of Scenario A, the production of the domestic country is assumed to be equal to the total import from Canada. This is mainly due to the similarities between the costs of production and transportation for the two countries. However, since asymmetries have been assumed in Scenario B, the real amounts of imports from Canada and of production of cattle in those portal states are considered according to the real data. Table 2 represents the calculation of parameters of the model, using the data in Table 1.

## 4.1. SCENARIO A

Table 3 shows the calibration of the models in Scenario A. There are three main columns in the table. The first main column from the left shows the case when the total population is indifferent to the negative characteristics of the foreign product. As is observed, different cases elaborated in Scenario A have similar welfare implications when all members of the population are indifferent to the potential harm of cattle imported from Canada.

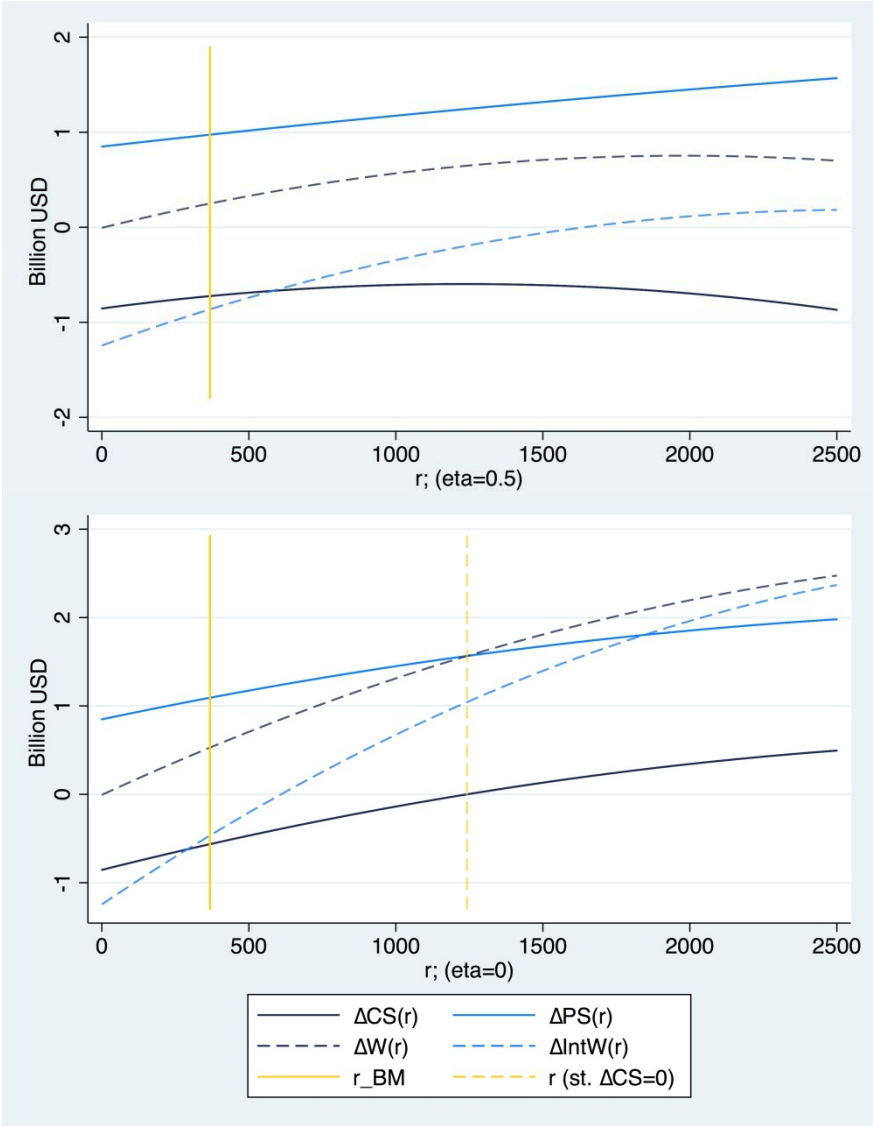
**Table 3 / Calibration results for Scenario A**

| Variables | $(\eta = 1)$ | | | $(\eta = 0.5)$ | | | $(\eta = 0)$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Case I | Case II | Case IIb | Case I | Case II | Case IIb | Case I | Case II | Case IIb |
| $CS_O$ | 1.48 | 1.48 | 1.48 | 1.35 | 1.35 | 1.35 | 1.19 | 1.19 | 1.19 |
| $PS_{OH}$ | 1.24 | 1.24 | 1.24 | 1.11 | 1.11 | 1.11 | 1.00 | 1.00 | 1.00 |
| $CS_M$ | 0.62 | 0.62 | 0.62 | 0.62 | 0.58 | 0.78 | 0.62 | 0.50 | 0.89 |
| $PS_M$ | 2.09 | 2.09 | 2.09 | 2.09 | 1.88 | 1.88 | 2.09 | 1.68 | 1.68 |
| $\Delta CS$ | -0.86 | -0.86 | -0.86 | -0.72 | -0.77 | -0.56 | -0.56 | -0.69 | -0.30 |
| $\frac{\Delta CS}{CS_O}$ | -0.06 | -0.06 | -0.06 | -0.05 | -0.06 | -0.04 | -0.05 | -0.06 | -0.03 |
| $\Delta PS$ | 0.85 | 0.85 | 0.85 | 0.97 | 0.76 | 0.76 | 1.09 | 0.68 | 0.68 |
| $\frac{\Delta PS}{PS_O}$ | 0.069 | 0.069 | 0.069 | 0.087 | 0.069 | 0.069 | 0.110 | 0.069 | 0.069 |
| $\Delta W$ | -0.006 | -0.006 | -0.006 | 0.25 | -0.005 | 0.20 | 0.53 | -0.005 | 0.38 |
| $\frac{\Delta W}{W_O}$ | -0.0002 | -0.0002 | -0.0002 | 0.0100 | -0.0002 | 0.008 | 0.024 | -0.0002 | 0.018 |
| $\Delta IntW$ | -1.24 | -1.24 | -1.24 | -0.86 | -1.12 | -0.91 | -0.47 | -1.00 | -0.61 |
| $\frac{\Delta IntW}{IntW_O}$ | -0.03 | -0.03 | -0.03 | -0.02 | -0.03 | -0.03 | -0.02 | -0.03 | -0.02 |

Source: own calculation.
Welfare amounts are in billions of USD.
CS: Consumer Surplus; PS: Producer Surplus; W: Home Total Welfare; IntW: International Welfare.
Case IIb is the Case II of Scenario A, with objective calculation of welfare after NTM, while Case II was mainly calculating the subjective welfare after NTM.

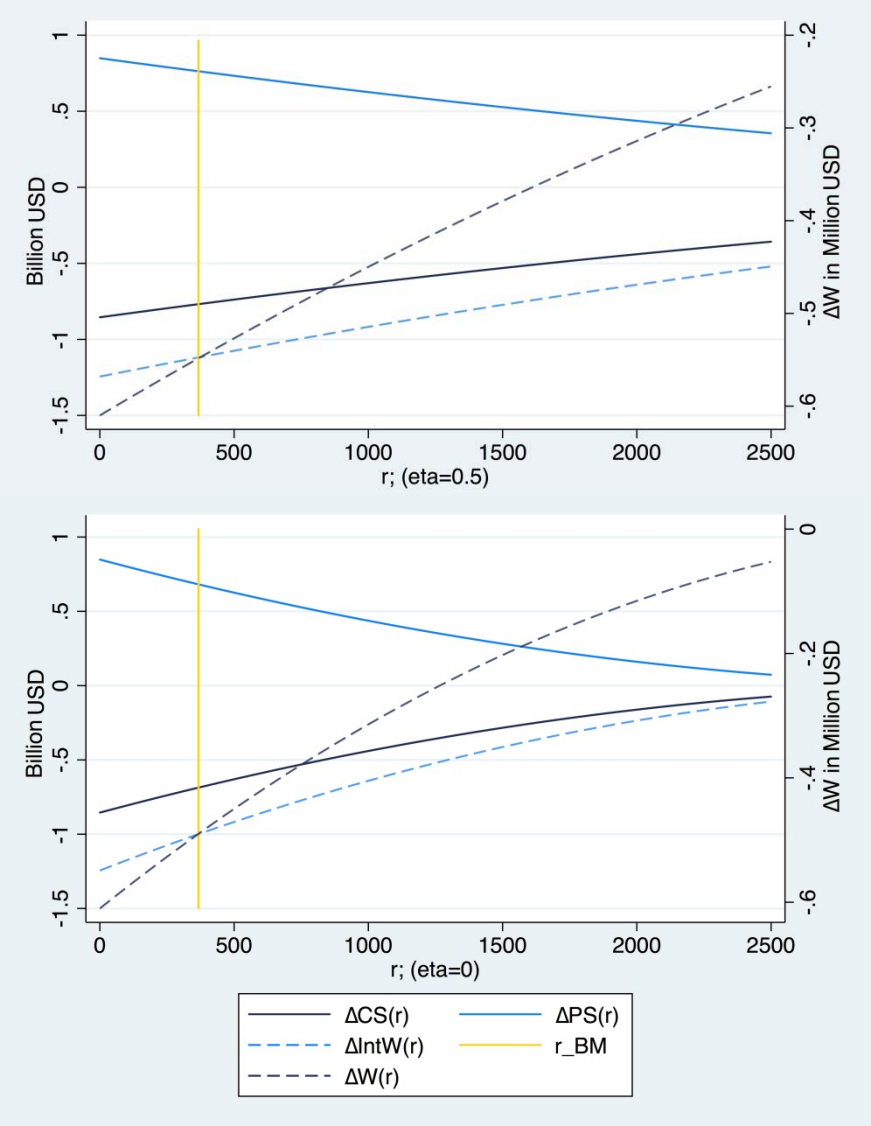
The first main column from the right shows the situation when the whole population is concerned about the negative attributes of the imported cattle. As is observed here, the initial welfare of consumers and domestic producers is lower than when the whole population is indifferent or when half of the population is concerned (second main column from the right). This is mainly because of a decrease in demand due to the perceived harm of the Canadian product by concerned consumers. When consumers are not informed about the exclusion of the harmful product from the market after NTM (Case II), their subjective welfare drops even more than when they are informed (Case I). However, their objective welfare when they are not informed (Case IIb) is higher than when they are informed. Although they perceive that they still receive products with bad characteristics, they do not actually suffer after NTM. This is because after NTM the market structure changes to a monopoly. If they are informed that there is no bad product on the market, the total demand curve will shift upwards. This will lead to a price burden on them, as the market is working as a monopoly and also because there are increasing costs due to scale effects.

**Figure 2 / Sensitivity test of welfare changes with respect to r, Scenario A, Case I**




Note: r_BM is the line showing the benchmark value of *r* used in illustration of real data. The broken vertical yellow line shows the amount of *r* for which the Consumer Surplus increases after NTM (r=1242).

**Figure 3 / Sensitivity test of welfare changes with respect to r, Scenario A, Case II**



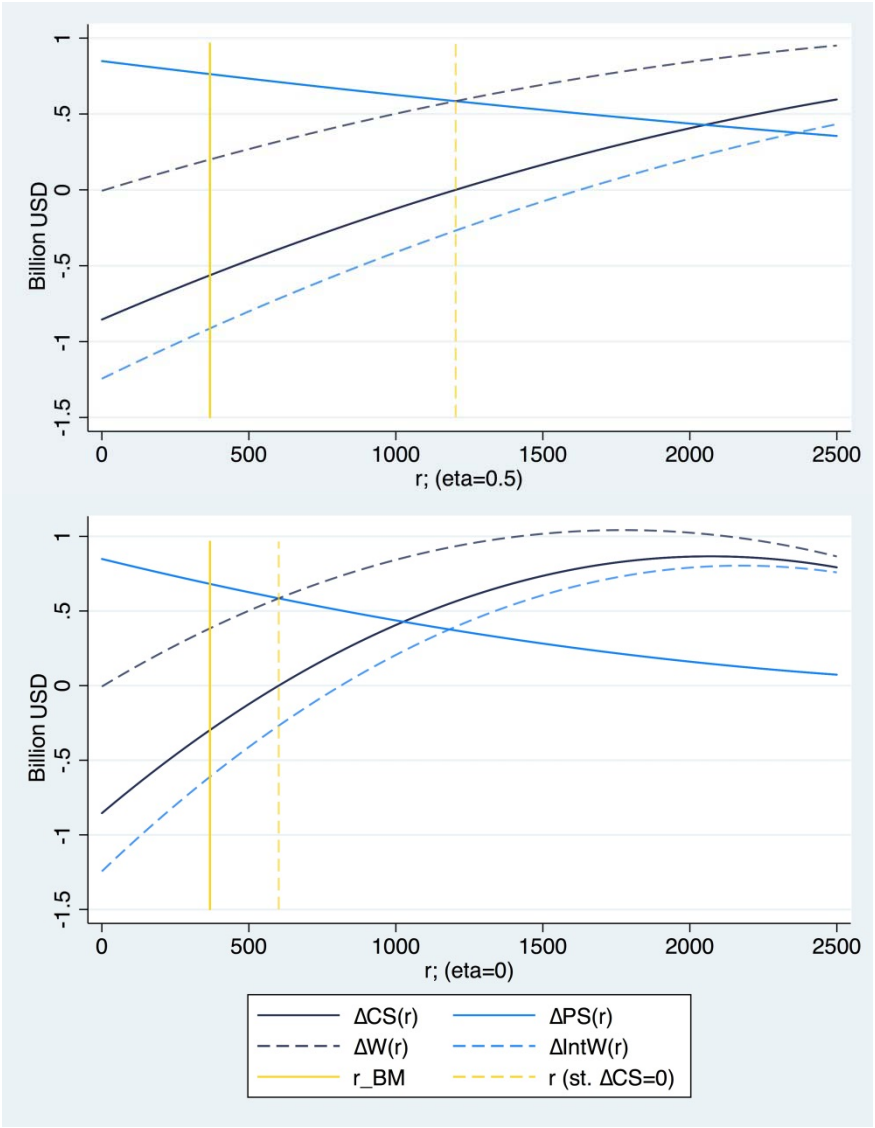

Note: r_BM is the line showing the benchmark value of *r* used in illustration of real data.
Right vertical axis presents the changes in domestic social welfare ($\Delta W$) in millions of USD. Left vertical axis presents the changes in CS, PS and International Welfare in billions of USD.

When the government informs consumers that there are no more foreign products on the market, the domestic producers' profit will increase more than if the government does not inform consumers. However, as mentioned above, consumers' welfare is better when they receive no such information. Therefore, these results might suggest that the government is rather pursuing a support strategy for domestic industry. As has been observed, consumer welfare declines after the introduction of the NTM and the prohibition of imports.

Considering consumers as the owners of the domestic industry, it can be shown that, in the case of concerned consumers in society, there are social welfare gains resulting from the introduction of a prohibitive NTM. In other words, the increase in the domestic producers' profit is higher than the consumers' welfare losses when there is a larger share of concerned consumers in society. However,

when everybody is indifferent to the potential harm caused by the foreign product, the NTM will cause losses to the whole of society, as the increase in profit for the home industry does not compensate for the losses suffered by consumers. This happens also because the government does not earn any revenue by imposing an NTM, whereas it does through the introduction of tariffs. Since the market becomes monopolistic, and the marginal cost is an increasing function of production, such a loss is evident.

**Figure 4 / Sensitivity test of welfare changes with respect to r, Scenario A, Case IIb**




Note: r_BM is the line showing the benchmark value of *r* used in illustration of real data. The broken vertical yellow line shows the amount of *r* for which the Consumer Surplus increases after NTM
(r=1203 when $\eta = 0.5$; and r=601.6 when $\eta = 0$).

Figures 2, 3 and 4 present sensitivity analyses of welfare changes with respect to changes in the perceived negative impact of Canadian cattle (*r*) in Cases I, II and IIb, respectively, all other things being equal. When the whole of society is unconcerned about the negative characteristics of a foreign product ($\eta = 1$), welfare is not affected by the changes in *r*. On the other hand, when the proportion of concerned

consumers increases in society, welfare becomes more sensitive to the changes in *r*. As **Fehler! Verweisquelle konnte nicht gefunden werden.** shows, when all consumers are concerned, their welfare can increase through the imposition of an NTM, when *r* is greater than US$1,242. Hence, if the perception of the harm from the Canadian product is higher than this amount, initial demand is very low, so that an unpublicised ban on imports can increase consumers' welfare. A similar issue arises for consumers' objective function after an unpublicised NTM (Case IIb). However, even when half of the population is concerned in this case, the NTM can improve consumers' welfare if the perception of the negative effect of the foreign product is higher than US$1,203. Considering the whole population concerned about the negative attributes of the foreign product, the NTM can improve consumer surplus when *r* is greater than US$601.60.

To consider the situation from a protectionism perspective, the following can be argued. First, because consumers' perceived harm from consumption of the foreign product is not very high, the prohibitive NTM decreases their welfare. Secondly, domestic industry always gains from change in the market structure to monopoly. Therefore, according to these findings, it can be observed that the government is not pursuing an improvement in consumer welfare when *r* is very small. However, when domestic industry lobbies government, it seeks to attract consumers by gaining government support for its products. Through the introduction of a prohibitive NTM, the domestic producer will become first a monopolist. Then, after the removal of the competitor from the market, some information regarding the availability of a harmless product on the market after NTM will boost demand from consumers. The information provided by government will vividly support the domestic industry, and profits will increase even more than when such information is not provided to consumers. Overall, according to the assumptions of the model whereby consumers are completely aware of the harm of the product and can rationally adjust their budget in line with their preferences for the product, such a policy instrument favours the domestic producer, rather than consumers. This assumption is lifted in Scenario B which will be illustrated next.

## 4.2. SCENARIO B

Table 4 presents the results from the calibration of Scenario B. There are two main columns in this table, showing symmetrical industries and asymmetrical industries. If we consider the lack of awareness of consumers about the possible damaging effects of Canadian cattle, two values of *r* are calculated for each main column, in addition to the benchmark value (367.43): US$3.41 and US$91.88 are the amounts of the negative effects at which the prohibitive NTM becomes neutral in terms of social welfare in symmetrical and asymmetrical cases, respectively. The left-most columns of the two main columns show that, for these values, the total welfare of society is unchanged after imposition of NTM, whereas consumers face billions of losses. By increasing the amount of *r*, consumers' welfare losses decrease, and from a certain point onward even increase after the prohibitive regulation. **Fehler! Verweisquelle konnte nicht gefunden werden.** and **Fehler! Verweisquelle konnte nicht gefunden werden.** also show that consumer welfare changes after NTM with respect to the negative effect of the foreign product, while changes to producer profits are neutral with respect to *r*. If *r* becomes higher than US$470.48 and US$392.08 in the symmetrical and asymmetrical cases, respectively, the NTM will increase consumer welfare substantially.

If the government tries legitimately to impose NTMs in line with international agreements for the sake of consumers, it should provide evidence that the potential harm of the imported product is at least *r*, to neutralise the consumer welfare changes. If the evidence shows less damage than this amount, it is clear that the government is not acting in pursuit of consumer welfare. In such a case, we can conclude that protection of domestic industry is being prioritised over protection of consumers' health.

**Table 4 / Calibration results for Scenario B**

| Variables | Symmetrical industries | | | Asymmetrical industries | | |
|---|---|---|---|---|---|---|
| $r$ | Social welfare equaliser | Benchmark | Consumer welfare equaliser | Social welfare equaliser | Benchmark | Consumer welfare equaliser |
| | **3.41** | **367.43** | **470.48** | **91.88** | **367.43** | **392.08** |
| $CS_O$ | 4.353 | 2.396 | 1.842 | 3.349 | 1.966 | 1.842 |
| $PS_{OH}$ | 3.665 | 3.665 | 3.665 | 4.670 | 4.670 | 4.670 |
| $CS_M$ | 1.842 | 1.842 | 1.842 | 1.842 | 1.842 | 1.842 |
| $PS_M$ | 6.177 | 6.177 | 6.177 | 6.177 | 6.177 | 6.177 |
| $\Delta CS$ | -2.511 | -0.554 | 0.000 | -1.507 | -0.124 | 0.000 |
| $\frac{\Delta CS}{CS_O}$ | -0.057 | -0.023 | 0.000 | -0.045 | -0.006 | 0.000 |
| $\Delta PS$ | 2.512 | 2.512 | 2.512 | 1.507 | 1.507 | 1.507 |
| $\frac{\Delta PS}{PS_O}$ | 0.069 | 0.069 | 0.069 | 0.032 | 0.032 | 0.032 |
| $\Delta W$ | 0.000 | 1.958 | 2.512 | 0.000 | 1.383 | 1.507 |
| $\frac{\Delta W}{W_O}$ | 0.000 | 0.032 | 0.046 | 0.000 | 0.021 | 0.023 |
| $\Delta IntW$ | -3.665 | -1.708 | -1.153 | -2.334 | -0.951 | -0.828 |
| $\frac{\Delta IntW}{IntW_O}$ | -0.031 | -0.018 | -0.013 | -0.023 | -0.011 | -0.009 |

Welfare amounts are in billions of USD.
CS: Consumer Surplus; PS: Producer Surplus; W: Home Total Welfare; IntW: International Welfare.

Figure 7 depicts the sensitivity analysis of *r* neutralising consumers' surplus changes after the prohibitive NTM, with respect to the relative costs of foreign industry and domestic industry. When the foreign industry produces at a lower cost than domestic industry, the government needs to justify its actions by citing a higher level of damaging effects from the foreign product. In such a situation, banning the efficient foreign industry from the domestic market will cause a huge loss to consumers. Thus, such an NTM should be based on sound evidence of the highly damaging effects of the foreign product, whose elimination would compensate for the big losses to society. If the efficiency of domestic industry is improved, a smaller *r* can be claimed by the government. Therefore, in an extreme case, if the domestic industry is the main market supplier, the elimination of the foreign product has a negligible impact on the welfare of consumers.

**Figure 5 / Sensitivity test of welfare changes with respect to r, Scenario B, symmetrical industries**

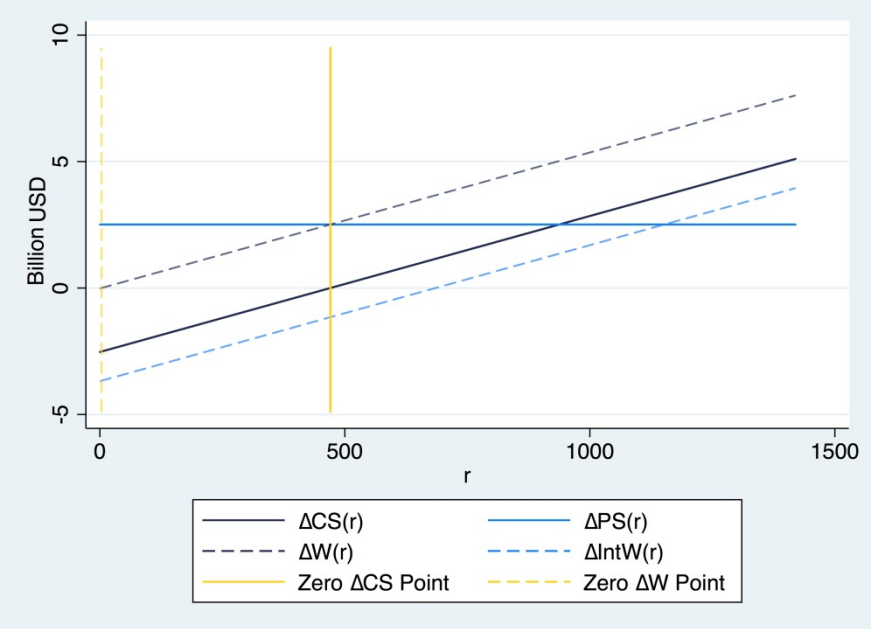



**Figure 6 / Sensitivity test of welfare changes with respect to r, Scenario B, asymmetrical industries**

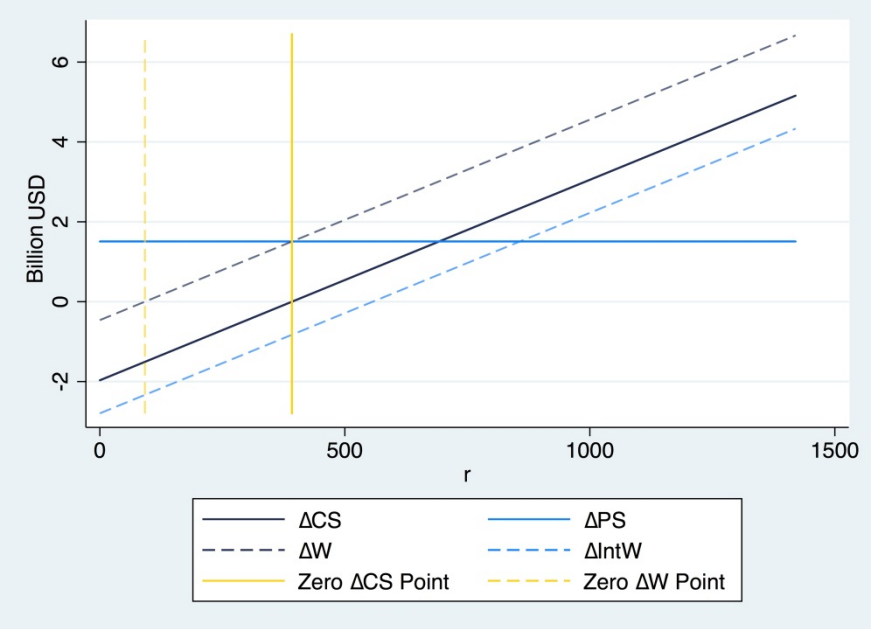
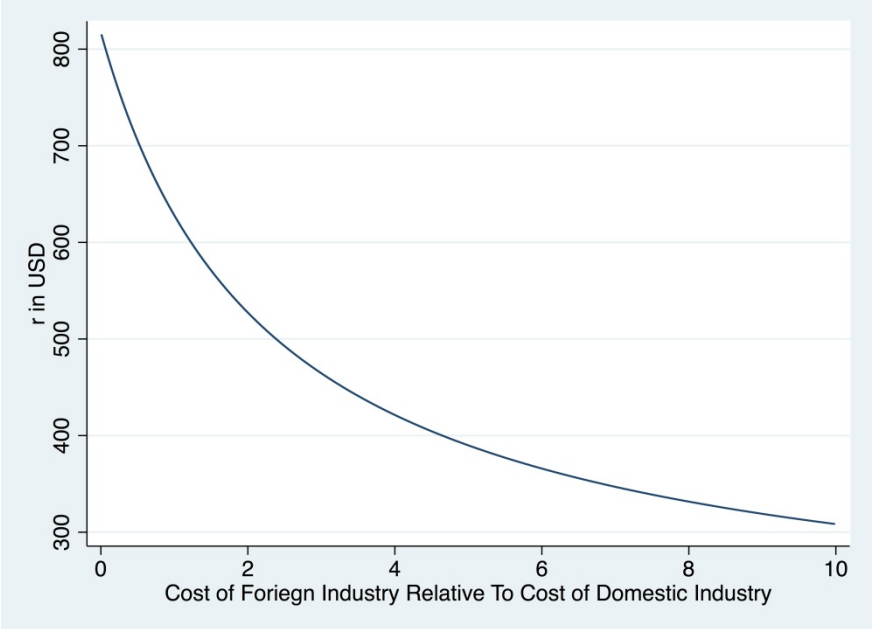


**Figure 7 / Sensitivity analysis of ΔCS neutralising r with respect to the relative industries' costs**




Note: changes in relative secondary cost parameters $(c_{2F}/c_{2H})$ of the two industries are shown on the horizontal axis.

# 5. Summary and conclusions

In December 2008, two Dispute Settlement cases were initiated by Canada and Mexico under the WTO Dispute Settlement Mechanism. The cases involved an NTM imposed by the US regarding the Country of Origin Labelling of agricultural products. Among the findings of the DS panel of the WTO, it was mentioned that the COOL measure was a technical regulation under the TBT Agreement, which is inconsistent with the USA's obligations towards the WTO. One of the main findings of the DS Appellate Body suggests that '… albeit for different reasons, the Panel's finding [is] that the COOL measure violates Article 2.1 of the TBT Agreement by according less favourable treatment to imported Canadian cattle and hogs than to like domestic cattle and hogs'.[19] The measure has not yet been withdrawn, and the consultations and appeals continue.

The theoretical model of this study assists the cost-benefit analysis of such trade policy. The model is illustrated with data on the consumption of cattle in eight northern states of the USA. The welfare losses related to halting the import of Canadian cattle are mostly related to changes in the structure of the market to a less competitive environment. Consumers face higher prices, while there is not enough evidence of damaging characteristics of the Canadian products. The US trade policy instrument imposed favoured domestic producers, which was reflected in the rulings of the WTO's DS bodies.

This paper provides a partial equilibrium framework in which to analyse the welfare implications of a prohibitive NTM imposed on a foreign product with negative characteristics. A model with both a foreign and a domestic supplier of the domestic market was considered to support the idea of the possibility of protection of the domestic industry. The analysis focuses mainly on consumer awareness of the damaging effects of the goods produced abroad. Whether or not the consumers are aware of these characteristics was considered in two different scenarios. However, it was assumed that products cannot be differentiated and that consumers cannot distinguish between the origins of the products. Two types of consumers in society were considered: the first group of consumers might be indifferent to the potential harm of a product, whereas the second group is assumed to be concerned about the potential damage from a foreign product.

In the first scenario of the model, it was assumed that consumers receive valid information from the media that there is a harmful product that may be coming in from abroad. However, since they cannot distinguish between the good and the bad product, they assign a probability to their chances of purchasing the harmful product. The equilibrium quantities and prices in the oligopolistic market were calculated analytically and the initial level of welfare of consumers and producers was established; on the basis of that, the situation after the imposition of a prohibitive NTM and the emergence of a monopolistic market was studied. According to this scenario, two cases were analysed: whether or not consumers are informed that the harmful product is no longer available on the market following the imposition of the NTM.

[19] https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds384_e.htm

An application of this model was illustrated using data on the consumption of cattle in eight northern states of the USA. The calibration of the first scenario showed that a prohibitive NTM decreases consumer welfare. Consumer surplus changes can be influenced by two issues: first, consumer welfare should increase when the foreign product with bad features is removed from the market; there will be gains for concerned consumers after the imposition of the NTM. Second, consumers will lose from the changes in the market structure from oligopoly to monopoly. When the perceived damaging effect of the foreign product is very low, the gains from the former consideration are less than the losses from the latter; therefore, there will be a net loss in consumer welfare. The loss in consumer welfare is larger when all (or most) of the population is indifferent to the negative effects of Canadian cattle. However, the domestic producer always gains from protectionist policy. Moreover, when, in the wake of the NTM, the government informs consumers that the harmful product is no longer available on the market, producer profits increase more than if the government does not tell consumers. By contrast, objective consumer welfare decreases more when the information is forthcoming. It can be concluded that such information benefits the producer rather than the consumer. Thus, based on the assumptions of the model, such a policy tends to be implemented to support and protect domestic industry.

The second scenario of the model analysed a situation in which consumers are not aware of the damaging effect of the foreign product. Only government has such knowledge and it can introduce a prohibitive NTM to eliminate the potential damage of a foreign product on the domestic market. Government seeks to improve the welfare of consumers through the qualitative NTM. Hence, the minimum damaging effect of the foreign product that leaves the consumer surplus unchanged after the policy was calculated. The model shows that when the foreign industry has a major share of the domestic market, a high value for the damaging effect of the foreign product needs to be provided as evidence by the government imposing the NTM. Therefore, it is quite difficult to justify an NTM in terms of support for domestic consumers, when domestic industry is less efficient than the foreign industry. The government might try to overstate the damaging effect of the foreign product in order to provide solid motivation for the policy. In a departure from telling the truth, the authorities might try to conceal their industrial protectionism: by overstating the negative attributes of the product targeted by the NTM, the government tries to appear to be in line with international agreements supporting consumers. The honesty of governments in such a situation can be analysed within a mechanism design framework. Such an analysis can be proposed as an extension to this model for the purposes of justifying policy in international disputes before the Dispute Settlement Mechanisms of the WTO.

Constructing a similar model for NTMs that do not halt trade completely, but impose costs on foreign suppliers to comply with the new regulations may provide another line of future research. After the prohibitive NTMs analysed in this research, foreign industry must bear certain costs to raise the quality of the product and remove its negative characteristics, thus enabling the foreign industry to re-enter the domestic market. It is proposed that this could be modelled as an extension to this paper. Furthermore, conducting an experimental survey to evaluate the perception of consumers regarding the potential harm of a given foreign product may provide another avenue for future research. In this framework, surveys can be conducted to understand the expectations of the people of a country that imposes an NTM on a foreign product. Such an experiment would firstly identify the consumer awareness of the trade policy and the product characteristics. Secondly, it would verify compatibility of the trade instrument with consumer behaviour, which is the major issue for the legitimacy of the NTM imposed. Last but not least, it would facilitate cost-benefit analysis as suggested in this paper.

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# Appendix 1. Calculations of Scenario A and Scenario B

## SCENARIO A

### Consumers' utility maximisation problem:

The utility function for an indifferent consumer will be as follows:

$$U_i(q_i, w_i) = aq_i - \overline{b}\, q_i^2/2 + w_i\,, i \in [1, N_1] \quad (1)$$

The individuals in society maximise their utility subject to a budget constraint:

$$pq_i + w_i = y_i \quad (2)$$

where *p* represents the price of the good, $y_i$ stands for the income of the representative consumer *i*, and price of the numeraire is equal to 1. The Lagrangian utility maximisation problem is:

$$\mathcal{L}_i = aq_i - \overline{b}\, q_i^2/2 + w_i + \lambda(y_i - pq_i - w_i), i \in [1, N_1] \quad (3)$$

First Order Conditions (FOC) for utility maximisation of an indifferent individual will give the demand of each indifferent individual:

$$q_i = \frac{a-p}{\overline{b}}, i \in [1, N_1] \quad (4)$$

The Lagrangian utility maximisation problem for a concerned individual will be:

$$\mathcal{L}_i = aq_i - \overline{b}\, q_i^2/2 - \tau r q_i + w_i + \lambda(y_i - pq_i - w_i), i \in (N_1, N] \quad (5)$$

After setting FOC for utility maximisation, the demand of each concerned consumer will be:

$$q_i = \frac{a-\tau r-p}{\overline{b}}, i \in (N_1, N] \quad (6)$$

Considering aggregate demand of all consumers as $Q_A^D = \sum_{i=1}^{N} q_i\,(p, r)$, the proportion of indifferent consumers as $\eta = N_1/N$, and assuming $b = \overline{b}/N$, the aggregate demand will be derived as follows:

$$Q_A^D(p, r) = \begin{cases} \frac{a-p}{\overline{b}}\eta N, p \geq a - \tau r \\ \frac{a-p}{\overline{b}}\eta N + \frac{a-\tau r-p}{\overline{b}}(1-\eta)N, 0 \leq p \leq a - \tau r \end{cases} = \begin{cases} \frac{\eta(a-p)}{b}, p \geq a - \tau r \\ \frac{a-\tau r(1-\eta)-p}{b}, 0 \leq p \leq a - \tau r \end{cases} \quad (7)$$

Therefore, the aggregate inverse demand will be:

$$p_A^D(Q,r) = \begin{cases} a - \frac{b}{\eta}\, Q, 0 \le Q \le \frac{\tau r \eta}{b} \\ a - \tau r(1-\eta) - bQ, Q \ge \frac{\tau r \eta}{b} \end{cases} \tag{8}$$

## Firms' profit maximisation:

Assuming symmetry, the profit of each firm competing in a Cournot duopoly ($Q = q_H + q_F$) is:

$$\pi_j = \begin{cases} \left(a - \frac{b}{\eta}\, Q\right) q_j - c_1 q_j - \frac{1}{2} c_2 q_j^2 - K, 0 \le Q \le \frac{\tau r \eta}{b}\ , j = \{H, F\} \\ (a - \tau r(1-\eta) - bQ) q_j - c_1 q_j - \frac{1}{2} c_2 q_j^2 - K, Q \ge \frac{\tau r \eta}{b}, j = \{H, F\} \end{cases} \tag{9}$$

The FOC for profit maximisation of each firm is:

$$\frac{\partial \pi_j}{\partial q_j} = 0 \Rightarrow \begin{cases} a - \frac{b}{\eta} q_{j'} - c_1 - \left(\frac{2b + \eta c_2}{\eta}\right) q_j = 0, p \ge a - \tau r\ ; (j, j') \in \{(H,F),(F,H)\} \\ a - \tau r(1-\eta) - b q_{j'} - c_1 - (2b + c_2) q_j = 0, 0 \le p \le a - \tau r;\ (j, j') \in \{(H,F),(F,H)\} \end{cases} \tag{10}$$

Therefore, before imposition of a restrictive NTM, the best response functions of the home industry ($BR_{HA}$) and the foreign industry ($BR_{FA}$) in a Cournot duopoly will be, respectively:

$$BR_{HA}(q_F)\colon q_H = \begin{cases} \frac{\eta(a-c_1)}{2b + c_2 \eta} - \frac{b}{2b + c_2 \eta} q_F\ , a - \tau r \le p \le a \\ \frac{a - \tau r(1-\eta) - c_1}{2b + c_2} - \frac{b}{2b + c_2} q_F, 0 \le p \le a - \tau r \end{cases} \tag{11/1}$$

$$BR_{FA}(q_H)\colon q_F = \begin{cases} \frac{\eta(a-c_1)}{2b + c_2 \eta} - \frac{b}{2b + c_2 \eta} q_H\ , a - \tau r \le p \le a \\ \frac{a - \tau r(1-\eta) - c_1}{2b + c_2} - \frac{b}{2b + c_2} q_H, 0 \le p \le a - \tau r \end{cases} \tag{11/2}$$

After finding the Nash Equilibrium, quantities supplied by the home industry ($q_{AOH}$) and the foreign industry ($q_{AOF}$) in the oligopoly will be as follows:

$$q_{AOH} = q_{AOF} = \begin{cases} \frac{\eta(a-c_1)}{3b + c_2 \eta}\ , a - \tau r \le p \le a \\ \frac{a - \tau r(1-\eta) - c_1}{3b + c_2}, 0 \le p \le a - \tau r \end{cases} \tag{12}$$

## Domestic monopolist's profit maximisation problem, Case I

There is no foreign product with negative characteristics on the market after NTM, and consumers are informed of this. The inverse aggregate demand is $p_{AI}^D(Q,r) = a - bQ$. The profit of the home industry acting as a monopolist after imposition of NTM that is to be maximised is as follows:

$$\pi_H = (a - b q_H) q_H - c_1 q_H - \frac{1}{2} c_2 q_H^2 - K_H \tag{13}$$

The FOC of the profit maximisation with respect to quantity will give the equilibrium supply quantity ($Q_{AMI}$) as:

$$\frac{\partial \pi_H}{\partial q_H} = 0 \Rightarrow Q_{AMI} = q_H = \frac{a - c_1}{2b + c_2} \tag{14}$$

## SCENARIO B

Unaware consumers' aggregate inverse demand is $p_B^D(Q, r) = a - bQ$. The two industries maximise the following profit in the Cournot duopoly:

$$\pi_j = (a - bQ)q_j - c_{1j}q_j - \frac{1}{2}c_{2j}q_j^2 - K_j, j = \{H, F\};\ Q = q_H + q_F \tag{15}$$

The first order conditions for the profit maximisation problem of each firm will be:

$$\frac{\partial \pi_j}{\partial q_j} = 0 \Rightarrow a - bq_{j'} - c_{1j} - \left(2b + c_{2j}\right)q_j = 0, (j, j') \in \{(H, F), (F, H)\} \tag{16}$$

The best response functions of the home industry ($BR_{HB}$) and the foreign industry ($BR_{FB}$) in this duopoly will be, respectively:

$$BR_{HB}(q_F): q_H = \frac{(a - c_{1H})}{2b + c_{2H}} - \frac{b}{2b + c_{2H}}q_F \tag{17/1}$$

$$BR_{FB}(q_H): q_F = \frac{(a - c_{1F})}{2b + c_{2F}} - \frac{b}{2b + c_{2F}}q_H \tag{17/2}$$

After finding the Nash Equilibrium, quantities supplied by the home industry ($q_{BOH}$) and the foreign industry ($q_{BOF}$) in the oligopoly will be, respectively:

$$q_{BOH} = \frac{(a - c_{1H})(2b + c_{2F}) - b(a - c_{1F})}{(2b + c_{2H})(2b + c_{2F}) - b^2} \tag{18/1}$$

$$q_{BOF} = \frac{(a - c_{1F})(2b + c_{2H}) - b(a - c_{1H})}{(2b + c_{2H})(2b + c_{2F}) - b^2} \tag{18/2}$$

Total quantity supplied in the oligopolistic market ($Q_{BO}$) will be:

$$Q_{BO} = \frac{(a - c_{1H})(b + c_{2F}) + (a - c_{1F})(b + c_{2H})}{(2b + c_{2H})(2b + c_{2F}) - b^2} \tag{19}$$

# Appendix 2. Proof of the existence of pure strategy Nash Equilibrium

Given the demand and inverse demand functions in equations (7) and (8) in the main text, and assuming that $q_F$ is given, define

$$\pi_1(q_H|q_F) = \left(a - \frac{b}{\eta}(q_H + q_F)\right)q_H - c_1 q_H - \frac{1}{2}c_2 q_H^2 - K \quad (1/1)$$

$$\pi_2(q_H|q_F) = \left(a - \tau r(1-\eta) - b(q_H + q_F)\right)q_H - c_1 q_H - \frac{1}{2}c_2 q_H^2 - K \quad (1/2)$$

$\pi(q_H|q_F) = \pi_1(q_H|q_F)$ for $q_H + q_F \leq \frac{\tau r \eta}{b}$, $\pi(q_H|q_F) = \pi_2(q_H|q_F)$ for $q_H + q_F \geq \frac{\tau r \eta}{b}$

***Symmetric pure strategy Cournot equilibrium (Nash Equilibrium in quantities):***

Pair $(q^*, q^*)$ s.t.

$$q^* solves \max_{q_H \geq 0} \pi(q_H|q^*)$$

Since for any $q_F \geq 0$, the maximand of $\pi(q|q_F)$ is $\leq \frac{a-\tau r(1-\eta)}{b}$ and, as we shall see, the profit function is continuous, there is a mixed strategy Nash Equilibrium. However, a pure strategy Nash Equilibrium may not exist.

We now consider some properties of the profit functions $\pi_1(.|q_F)$ and $\pi_2(.|q_F)$.

1. They are both strictly concave
2. Suppose $\frac{\tau r \eta}{b} > q_F$ . Then $\pi_1(q_H|q_F) = \pi_2(q_H|q_F)$ if and only if $q_H = \frac{\tau r \eta}{b} - q_F$, in particular, the profit function $\pi(.|q_F)$ is continuous.
3. Suppose $\eta < 1$ and $\frac{\tau r \eta}{b} > q_F$. For $q_H > \frac{\tau r \eta}{b} - q_F$. $\pi_2(q_H|q_F) > \pi_1(q_H|q_F)$ and for $q_H < \frac{\tau r \eta}{b} - q_F$. $\pi_2(q_H|q_F) < \pi_1(q_H|q_F)$. This in particular means that

$$\frac{\partial \pi_2}{\partial q_H}(q_H|q_F) > \frac{\partial \pi_1}{\partial q_H}(q_H|q_F) \; for \; q_H = \frac{\tau r \eta}{b} - q_F$$

***Proposition:***

$(q^*, q^*)$ is a pure strategy Nash Equilibrium if and only if one of the following three conditions holds:

i (a) $q^* \geq \frac{\tau r \eta}{b}$ and (b) $\frac{\partial \pi_2}{\partial q_H}(q^*|q^*) = 0$

ii (a) $q^* \leq \frac{\tau r \eta}{b}$ and (b) $2q^* \geq \frac{\tau r \eta}{b}$ , (c) $\frac{\partial \pi_2}{\partial q_H}(q^*|q^*) = 0$ and (d) with $\hat{q}$ solving $\frac{\partial \pi_1}{\partial q_H}(q^*|q^*) = 0, \pi_1(\hat{q}|q^*) \leq \pi_2(q^*|q^*)$.

iii (a) $q^* \leq \frac{\tau r \eta}{b}$ and (b) $2q^* \leq \frac{\tau r \eta}{b}$ , (c) $\frac{\partial \pi_1}{\partial q_H}(q^*|q^*) = 0$ and (d) with $\hat{q}$ solving $\frac{\partial \pi_2}{\partial q_H}(q^*|q^*) = 0, \pi_1(q^*|q^*) \geq \pi_2(\hat{q}|q^*)$.

***Proof:***

***(I) Sufficiency:***

In case (i), for any choice $q_H \geq 0$ by a domestic firm, $q_H + q^* \geq \frac{\tau r \eta}{b}$, so that the profit of the firm 1 is $\pi_2(q_H|q^*)$, which is by concavity and (i)(b) maximised at $q_H = q^*$. Hence, $(q^*, q^*)$ is a Nash Equilibrium.

In case (ii), if a domestic firm chooses $q_H > \frac{\tau r \eta}{b} - q_F$, its profit is $\pi_2(q_H|q^*)$ which by (ii)(b) is maximised at $q_H = q^*$. If a domestic firm chooses $q_H \leq \frac{\tau r \eta}{b} - q_F$, its profit is $\pi_1(q_H|q^*) \leq \pi_1(\hat{q}|q^*) \leq \pi_2(q^*|q^*)$ by (ii)(d). Thus, $(q^*, q^*)$ is a Nash Equilibrium.

In case (iii), if a domestic firm chooses $q_H < \frac{\tau r \eta}{b} - q_F$, its profit is $\pi_1(q_H|q^*)$ which by (iii)(b) is maximised at $q_H = q^*$. If a domestic firm chooses $q_H \geq \frac{\tau r \eta}{b} - q_F$, its profit is $\pi_2(q_H|q^*) \leq \pi_2(\hat{q}|q^*) \leq \pi_1(q^*|q^*)$ by (iii)(d). Thus, $(q^*, q^*)$ is a Nash Equilibrium.

***(II) Necessity:***

If $(q^*, q^*)$ is a symmetrical pure strategy Nash Equilibrium, then either (i)(a) or (ii)(a) and (b) or (iii)(a) and (b) holds.

If (i)(a) holds, for any $q_H \geq 0$ chosen by a domestic firm, the resulting profit is $\pi_2(q_H|q^*)$. Since the domestic firm is maximising profit, by function concavity (i)(b) must then hold.

If (ii)(a) and (b) hold, let $q_F^*$ solve $\max_q \pi_2(q|q^*)$. If $q_F^* < \frac{\tau r \eta}{b} - q^*$ by property (ii), $\pi_1(q_F^*|q^*) \geq \pi_2(q_F^*|q^*) > \pi_2(q^*, q^*)$, so that $(q^*, q^*)$ is not a Nash Equilibrium, i.e. we have a contradiction. Hence, $q_F^* \geq \frac{\tau r \eta}{b} - q^*$, i.e. $q_F^* = q^*$, then, (ii)(c) must hold. If $\hat{q} \geq \frac{\tau r \eta}{b} - q^*$, by property (ii) $\pi_2(q^*, q^*) \geq \pi_2(\hat{q}|q^*) \geq \pi_1(\hat{q}|q^*)$, so (ii)(d) holds. If $\hat{q} \leq \frac{\tau r \eta}{b} - q^*$, since $(q^*, q^*)$ is a Nash Equilibrium, $\pi_1(\hat{q}|q^*) \leq \pi_2(q^*, q^*)$, so again (ii)(d) holds.

If (iii)(a) and (b) hold, let $q_H^*$ solve $\max_q \pi_1(q|q^*)$. If $q_H^* > \frac{\tau r \eta}{b} - q_F^*$ by property (ii),$\pi_2(q_H^*|q^*) \geq \pi_1(q_H^*|q^*) \geq \pi_1(q^*|q^*)$, contradicting that $(q^*, q^*)$ is a Nash Equilibrium. Hence, $q_H^* \leq \frac{\tau r \eta}{b} - q^*$, i.e. $q_H^* = q^*$, then, (iii)(c) must hold. If $\hat{q} \leq \frac{\tau r \eta}{b} - q^*$, $\pi_1(q^*, q^*) \geq \pi_1(\hat{q}|q^*) \geq \pi_2(\hat{q}|q^*)$, where the first inequality comes from (iii)(b) and the last one follows from property (ii), thus, (iii)(d) holds. If on the other hand $\hat{q} > \frac{\tau r \eta}{b} - q^*$, since $(q^*, q^*)$ is a Nash Equilibrium, $\pi_2(\hat{q}|q^*) \leq \pi_1(q^*, q^*)$, so again (iii)(d) holds.

The simulated model in the illustration section fulfils the first condition in the proposition above to constitute a pure strategy Nash Equilibrium for the model.

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Herausgeber, Verleger, Eigentümer und Hersteller:
Verein „Wiener Institut für Internationale Wirtschaftsvergleiche“ (wiiw),
Wien 6, Rahlgasse 3

ZVR-Zahl: 329995655

Postanschrift: A 1060 Wien, Rahlgasse 3, Tel: [+431] 533 66 10, Telefax: [+431] 533 66 10 50
Internet Homepage: www.wiiw.ac.at


P.b.b. Verlagspostamt 1060 Wien

Offenlegung nach § 25 Mediengesetz: Medieninhaber (Verleger): Verein "Wiener Institut für Internationale Wirtschaftsvergleiche", A 1060 Wien, Rahlgasse 3. Vereinszweck: Analyse der wirtschaftlichen Entwicklung der zentral- und osteuropäischen Länder sowie anderer Transformationswirtschaften sowohl mittels empirischer als auch theoretischer Studien und ihre Veröffentlichung; Erbringung von Beratungsleistungen für Regierungs- und Verwaltungsstellen, Firmen und Institutionen.

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