ECONOMIC APPLICATIONS OF PRODUCT QUALITY REGULATION IN WTO TRADE AGREEMENTS

by

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ABSTRACT

This thesis comprises three theoretical essays on the economic applications of product quality regulation in WTO Agreements:

Economic Applications of the WTO Consistency Requirement Article 5.5 (consistency) of the SPS Agreement requires countries to avoid arbitrary distinctions in health protection on goods that are associated with the same disease, if such distinctions result in discrimination or a disguised restriction on trade. For a bound tariff, a marginally binding consistency constraint improves welfare but welfare is reduced if the constraint is interpreted too strictly. When tariffs are negotiated subject to consistency, the welfare effects of consistency depend on whether trade negotiators are myopic or forward-looking.

Public Opinion, Product Quality Regulation and Trade attempts to answer the following questions. Should governments be forced to admit products that science deems healthy, but consumers do not? Are consumer fears sufficient to justify a ban on a healthy import or should the fears reflect scientifically proven risk? To what extent can regulatory authorities exploit these fears for protectionist purposes? In an adverse selection model, consumers have imperfect information with regard to government type and import product quality. The government of the country exporting the product of uncertain quality has an incentive to commit to a strategy where it recognises the importing country's right to ban the unhealthy import but tariff retaliates if the importing country bans a healthy import. Under such a strategy *first best* is achieved; consumers learn product quality and consumption distortions associated with consumer fear are eliminated. Allowing the importing country the option of country-of-origin labelling prevents *first-best* because consumers do not learn product quality and a healthy import can be excluded from the import market.

Asymmetric Information and Country-of-Origin Labelling concerns information asymmetries as a rationale for trade policy when adverse selection is an international problem. Firms in countries North and South choose between producing high or low quality. Those choosing low quality take advantage of adverse selection problems, while those choosing high quality do so to establish reputations and earn positive profits in subsequent periods when information is perfect. Cross-country differences

in the relative costs of producing high quality result in different average qualities and prices in autarky. Trade is welfare deteriorating (improving) for the North (South). Allowing the Northern government the option of origin-labelling eliminates the international externalities associated with trade when adverse selection is a transnational problem, and is unambiguously welfare improving for the North.

for Frans, 7374

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I would like to thank staff and fellow students at The Stockholm School of Economics for making the first two years of my PhD interesting and challenging. My thanks also go to the staff and graduate students at the Institute for International Economic Studies. I miss the lunches and tea breaks! I am grateful to Annika Andreasson and Christina Lönnblad for keeping the IIES running smoothly and to Christina for editorial assistance. Financial support from Jan Wallander's and Tom Hedelius' Research Foundation is gratefully acknowledged.

I am eternally grateful to my parents, who, throughout my life, have been constant pillars of strength. They have taught me to question, to learn and always to strive to achieve my full potential. But more importantly, they have instilled in me a sense of family, community and social justice, without which, this PhD would be meaningless.

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Chapter 1

Introduction

The original international trading system began as the General Agreement on Trade and Tariffs (GATT) in 1947. It was premised on the understanding that if governments could commit to not relenting to protectionist demands from domestic producer interest groups, that welfare gains from trade would accrue to consumers. Members of the GATT agreed to bind their tariffs below levels determined during negotiations with other member countries. Moreover, members committed themselves to the multilateral framework of rules, set up by the GATT Agreement, which regulated the manner in which tariffs and trade-impacting non-tariff measures (such as minimum standards, bans), could be applied.

Amongst the most important of rules included in the GATT, is the principle of non-discrimination espoused in Articles I and III. Article I (Most Favoured Nation) requires that imports be accorded treatment no less favourable than that accorded to "like" imports sourced from another country. Article III (National Treatment) requires that all imported goods be accorded treatment no less favourable than that accorded to domestic "like" goods.

With respect to regulation, "like" in Article III(4) has since been interpreted as referring to "directly competitive or substitutable" (DCS) goods. Case law has often understood DCS to mean products grouped according to their end-uses or physical characteristics, or products corresponding to the same consumer preferences.

Despite the importance of non-discrimination, it has since become evident that grouping products according to their end-use is problematic. Different production methods can alter the quality of the good, where *quality* refers to more than just a product's performance at the time of consumption, but may also reflect a product's health or environmental attributes. If the lower quality of an imported product is

not observable at the time of purchase, the domestic and imported goods might be DCS, even though they would not be if consumers were fully informed. Import purchases may be higher than is socially desirable. Traditional gains from trade are no longer guaranteed and governments may be justified in intervening with health or environmental measures that violate National Treatment.

Additionally, regulation that satisfies National Treatment may still be protectionist in the sense of shifting the costs of regulation onto foreign producers. Imported and domestic goods may not be DCS but may be associated with a risk of the same disease. If regulation that reduces the risk imposes costs on producers, governments have an incentive to target sectors where the proportion of imports is relatively high.

Imported and domestic goods may be DCS and of identical quality, but they might not be perceived to be of equal quality by consumers. Perceptions might lead to welfare-deteriorating consumption distortions, thereby justifying intervention that violates non-discrimination.

During the Uruguay Round of GATT negotiations (1987-1994), member states agreed to the establishment of the World Trade Organisation (WTO) which would administer the WTO Agreements which included the original GATT along with various other agreements, such as the Sanitary and Phytosanitary (SPS) Agreement. The principle of non-discrimination continues to remain an important pillar of the international trading system, yet the WTO Agreements include additional rules that attempt to deal with some of the problems just highlighted.

In Chapter 2, I consider the economic rationale behind Article 5.5 (Consistency) of the SPS Agreement. Consistency requires countries to avoid arbitrary distinctions in health protection on goods that are associated with the same disease, if such distinctions result in discrimination or a disguised restriction on trade. Consistency groups products according to disease rather than end-use. If it is not interpreted too strictly, consistency, by limiting the ability that governments may have to target sectors where the proportion of "health like" imports is high, can lead to welfare improvements.

In Chapter 3, I consider the economic rationale for Article 5.1 of the SPS Agreement. Article 5.1 imposes a "scientific assessment of risk" criterion on regulating authorities. That is, in order for a government to legally impose health measures on imports, their must be scientific evidence that the imports are associated with a health risk, or there must be a rational relationship between the measure and the risk assessment.

Yet this criterion can be also be interpreted as imposing a discipline on the use of

tariff retaliation by the exporting country. That is, the exporting country can only retaliate against a trade-distorting health measure, if it is applied to the exporting country's healthy exports. I show that the exporting country may have an incentive to commit itself to the retaliation strategy specified by the "scientific assessment criterion" because it may correct information problems leading to erroneous consumer perceptions and consumption distortions.

In Chapter 4 I consider the case where adverse selection is an international problem. Trade is welfare deteriorating if the quality of imports is not observable at the time of purchase. The average quality of imports may lower the average quality available on the domestic market compared with autarky. If consumers have some idea about the average qualities across countries, country-of-origin labelling can eliminate the welfare losses associated with trade.

The success of the framework of rules in protecting the gains from trade depend on their interpretation and implementation in the case law. Each case brought before the WTO adjudicators will have its own complexities: background, political history, consumer heterogeneity etc. These idiosyncrasies will have to be dealt with on a case by case basis, thereby making sure that WTO laws are not implemented too rigidly, but also in a way that discretion does not prevent the rules from doing what they were designed to do.

Chapter 2

Economic Applications of the WTO Consistency Requirement*

1 Introduction

The Agreement on Agriculture, negotiated under the GATT in the 1986-1994 Uruguay Round, was considered a significant first-step towards serious trade liberalisation in agriculture. Yet the subsequent proliferation of food safety regulations means that agriculture remains one of the most protected sectors globally. While such regulation is a legitimate weapon against verifiable health risks, there is some concern that its pervasiveness reflects its usefulness as a non-tariff barrier. Consequently, trade disputes between WTO Members regarding the legitimacy of such measures have arisen.[1]

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) came into force with the establishment of the World Trade Organization, on 1 January 1995, as a further attempt at stemming disruptions in agricultural trade. The Agreement's framework of rules recognises a country's right to protect the health of its plant, animal and human populations but also aims at limiting the illegitimate use of health measures as non-tariff barriers.[2]

* I am indebted to Henrik Horn and Harry Flam for many insightful discussions and to Petros Mavroidis for helpful comments on Section 2. I also thank Mathias Herzing and Ulrika Stavlöt and seminar participants at the IUI (Stockholm) and the ETSG Conference (Madrid, 2003). Thanks also to Christina Lönnblad for editorial assistance. Any remaining errors are my own. Financial support from Jan Wallander's and Tom Hedelius' Research Foundation is gratefully acknowledged.

[1] For a discussion of the trade impacts of such measures refer to Henson and Loader (2001), Otsuki and Wilson (2001 and 2002) and Otsuki, Sewadeh and Wilson (2001).

[2] In the Agreement, SPS measures refer to any law, decree, regulation, requirement or procedure that aims to protect plant, animal or human life from the risks arising from entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms, additives,

Members can implement an SPS measure to achieve the level of health protection they deem appropriate, as long as the measure is based *inter alia* on scientific evidence of the risks and is the least trade-restrictive measure available. Furthermore, Article 5.5 (Consistency) of the SPS Agreement, which is the focus of this paper, requires that:

> *...each Member shall avoid arbitrary or unjustifiable distinctions in the levels it considers to be appropriate in different situations, if such distinctions result in discrimination or a disguised restriction on international trade.*

Article III of GATT 1947 (National Treatment) requires that all imported goods be accorded treatment no less favourable than that accorded to domestic "like" goods, where "like" has since been interpreted as referring to "directly competitive or substitutable" (DCS) goods, or as a strict subset of DCS goods. In contrast, Article 5.5 has been interpreted as referring to foreign and domestic goods associated with the same disease, irrespective of whether they are DCS.

Consistency can be justified on the grounds that it prevents countries from shifting the burden of their health polices onto foreign producers. But there is a concern that requiring countries to treat goods as diverse as champagne, meat and eggs as "health-like" is too onerous for the regulating country and may reduce the overall levels of health protection.

This paper evaluates the economic rationale of consistency in terms of a two good, two-country, partial equilibrium model, where consumption of both goods is associated with a risk of getting a non-fatal disease.[3] A welfare maximizing government in each country chooses a tariff on the import good and production standards on both the import and domestically produced goods. Compliance with regard to standards is mandatory and fully-enforceable. I interpret consistency as limiting the size of the gap between the levels of the standards, with strict consistency requiring that standards be equal. Consistency may improve welfare for certain bound tariff levels, but will reduce welfare if interpreted too strictly. *First-best* is not attainable under consistency.

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contaminants, toxins or disease-causing organisms in foods, beverages or feedstuffs or which aims to protect human life or health from risks arising from diseases carried by animals, plants or products thereof.

[3] The importance of non-fatal diseases must not be overlooked. While foodborne diseases are estimated to cause as many as 9,000 deaths per year in the United States, they are also estimated to cause 6.5 to 33 million cases of diarrheal disease with economic losses of between $5 and $6 billion annually. (Brynjolfsson, Giddings, Josephson, and Thayer, 1996).

Next I discuss related literature. Horn (2004) considers National Treatment as it applies to internal taxation. The methodology and analytical results of my paper are based on Horn (2004) but given the difference in focus, the interpretation of the results and the policy implications differ.

Battigalli and Maggi (2003) provide an *ex-ante,* efficiency-enhancing role for National Treatment in a general equilibrium model where international agreements on standards are incomplete contracts and *ex-post* bargaining over standards is inefficient from an *ex-ante* perspective. The emphasis of my paper is different in that I include a tariff-setting stage and discuss the implications of consistency for tariff and standard setting.

Bagwell and Staiger (2001) show that if tariffs are bound and a domestic standard is subsequently set subject to the constraint that market access levels do not change, the efficiency locus can be achieved under certain conditions. Copeland (1990) shows that trade negotiations, where tariffs are bound in the first stage, are nonetheless welfare enhancing even though protectionist governments exploit less efficient instruments in the second stage. The two previous papers consider the case where governments have access to a single domestic standard. Consistency is a rule for at least two domestic standards.

Fischer and Serra (2000) present a model of oligopolistic competition where a minimum standard is imposed on a good produced both by a domestic and foreign firm. The standard chosen by the Home local social planner is higher than it would be if all firms were domestic. Fischer and Serra (2000) ignore tariffs and do not explicitly discuss international agreements.

Section 2 discusses the interpretation of consistency in the WTO case law. Section 3 sets up the basic model and examines the competitive equilibrium with exogenous instruments. In section 4 I treat instruments as endogenous and compare the Nash equilibrium in tariffs and standards to the globally efficient Nash bargaining solution. I provide a definition and a possible welfare-enhancing role for consistency. Section 5 evaluates tariff and standard setting both with and without consistency. I show that *first-best* is not attainable if tariffs, but not standards, are negotiated. If it is not interpreted too strictly, consistency can have a welfare-enhancing role. Section 6 concludes.

2 The Three-Prong Test of Consistency

In this section I highlight some aspects of the manner in which consistency has been interpreted in two WTO cases. *Hormones*[4] deals with a European Communities (EC) sales ban on meat and meat products treated with three natural and three synthetic growth hormones. The hormones had been weakly linked with carcinogenicity in humans. *Salmon*[5] deals with a risk to Australian fish life from the introduction of exotic diseases due to imports of fresh, chilled and frozen salmon for human consumption.

The Appellate Body (AB) in *Hormones* identified three conditions, which if simultaneously met, deem a country's health measures inconsistent.[6] These three conditions have been adopted as a three-prong test for inconsistency by subsequent Panels. The three conditions are:

1. different levels of protection in "comparable situations",
2. the difference in levels of protection is arbitrary or unjustifiable, and
3. the measure employed to achieve the level of protection leads to discrimination or a disguised restriction on trade.

2.1 Different Levels of Protection in "comparable situations"

In *Hormones*, "comparable situations" is interpreted as situations where the "same substance" (for example hormones) or an "adverse health effect" (cancer) is involved. The ban on hormones in beef production was compared to the few controls on the level of natural hormones endogenously occurring in food products (such as broccoli, milk and eggs), on those administered for veterinarian purposes and on those used in swine production. The ban was found to violate the first prong of the test.

In *Salmon* "comparable situations" are such situations where either a risk of "entry, establishment or spread of the same or a similar disease" exists or where the same or similar "associated biological and economic consequences" occur. The ban on salmon imports was compared to the few controls on the admission of herring

[4] *Hormones:* European Communities - Measures Affecting Meat and Meat Products WT/DS26/AB/R.

[5] *Australia Salmon:* Measures Affecting the Importation of Salmon WT/DS18/AB/R.

[6] The three conditions were first identified by the Panel. Once a Panel decision has been rendered, both parties to a dispute have the right to appeal to the Appellate Body.

as bait and the allowed importation of live, ornamental finfish, and was deemed to violate the first condition.

The *Hormones* ban was applied to all imported and domestic beef production and therefore complied with Articles I (Most-Favoured Nation) and III (National Treatment) of GATT 1947. But the "comparable situations" test recognizes that health regulation can go against the spirit of the GATT even if it is non-discriminatory. If domestic and foreign goods are associated with the same disease, governments can transfer a larger proportion of the costs of their non-discriminatory health regulation onto foreigners, by targeting sectors where a large proportion of production is non-domestic. On the flip-side, 5.5 suggests that even if goods are "like", they might not be "health-like" and may therefore require different, or discriminatory, treatment.

The "comparable situations" test does open itself to problems. If interpreted too widely, it may pose an overly onerous burden on governments by requiring them to target all products with similar adverse impacts on health. Moreover, two goods might be associated with the same disease but the way in which one good is consumed might significantly reduce the risk of falling ill relative to the other good. In this case, it is not clear whether the goods should be treated as "comparable". If they are deemed "comparable", differences in levels of protection might be justified under the second prong of the test, which I discuss in the next sub-section.

2.2 Arbitrary or Unjustifiable?

This part of the test recognizes that even if goods are "health-like", treating them differently might still be justifiable. A higher level of protection on import sectors does not necessarily mean that regulators are deliberately protectionist. The costs of protection in domestic industries might be infinitely high or the demand for imports might be much higher, thereby making the import good the logical target for protection. Furthermore, the different ways in which the "comparable" goods are used or consumed might result in significantly lower risk levels for some goods (whether the goods should still be deemed "comparable" is debatable).

In *Hormones* the Panel found the differences in levels of protection on the "comparable" goods to be arbitrary because all hormones are associated with a similar cancer risk. The AB overturned the Panel decision arguing arbitrariness with respect to swine production only. Growth hormones are continuously administered whilst veterinarian hormones are used less frequently and the costs of regulating naturally

occurring hormones would be infinitely high. The different conclusions reached by the Panel and the AB in *Hormones* reflect the complexities of the second prong.

The Panel in *Salmon* concluded that the second prong had been violated with respect to herring bait and ornamental finfish. Since bait is introduced directly into the aquatic system and ornamental finfish are often released into the wild, while salmon imports are consumed, Australia could not show that the risks were significantly higher for salmon imports.

2.3 Disguised Restriction on Trade

The *Salmon* Panel concluded that the ban was a disguised restriction on trade because of the lack of sanitary measures to control the spread of disease within the internal market. In *Hormones,* the third prong of the test proved much more contentious.

The Panel concluded that compared with the few controls on hormones in swine production, the import ban was a disguised restriction on trade. The AB disagreed, concluding that the EC *intent* was not to restrict trade but to protect consumer health. The Panel concluded that because a larger proportion of US than of EC meat supply used growth hormones, the sales ban *de facto* discriminated against US imports. They also concluded that the differences in treatment between beef and pork production could have been explained by the lack of pork surpluses in the EC market as compared to the beef surpluses, which had occurred as a result of the reduction in intra-community barriers to trade.

The AB instead took into consideration the depth and extent of the anxieties experienced within the EC concerning the results of the general scientific studies, the dangers of abuse of hormones and other substances used for growth promotion (highlighted by scandals relating to black-marketing and smuggling of prohibited veterinary drugs in the EC), the intense concern of consumers within the EC over the quality and drug-free character of the meat available on their internal market and the economic effects of the import ban on EC farmers, both hormone and non-hormone using. Since some EC beef producers were also affected by the ban, the AB concluded that it did not *de facto* discriminate against US producers.

The AB finding suggests that measures *must* be discriminatory before they can be deemed inconsistent. But 5.5 clearly states that measures must be "discriminatory" or a "disguised restriction on trade" capturing the idea that non-discriminatory legislation can be distortionary.

Whether consumer anxieties should be taken into consideration in determining intent is a hotly debated topic. The issues surrounding consumer fears are addressed in Chapter 3 and I abstract away from such issues in this Chapter.

The main points to be garnered from the case law can be summarized as follows:

1. There must be a difference in the levels of protection across "comparable" goods.

2. "Comparable" goods must share the same regulated substance or be associated with a similar adverse health effect or economic/biological consequences.

3. Different treatment of "comparable" goods can be justified on the basis of demand, cost and risk differences.

4. Non-discriminatory regulation, or regulation that meets the requirements of National Treatment, can still violate consistency (*Salmon* decision).

5. Whether the measure is a "disguised restriction on trade" goes to the intent of the policymaker (*Hormones* decision) making a decision under 5.5 somewhat less objective.

This section has highlighted some of the difficulties associated with consistency. These complexities will have an impact on whether 5.5 can successfully protect the health of domestic populations and thus protect the gains implied by trade liberalisation. I believe that a good starting point for evaluating the welfare implications of consistency must abstract away from many of these complexities and evaluate whether welfare improvements are possible in the simplest case. Therefore, in the next section I set up a model where, absent tariffs, *first-best* requires that standards (levels of protection) be equal on both "comparable" goods. The model is not general in the sense that I ignore health synergies between sectors and the risk and costs are linear in standards. However, the results are sufficient at illustrating some interesting facets of the consistency problem.

3 The Model

In a two-period, partial equilibrium model two symmetric countries, Home and Foreign, trade two goods x and y. The numeraire good, m in Home and m^* in Foreign, is non-tradeable. Markets are segmented.

A monopoly in Home produces a quantity x of quality Q for the Home market and exports a quantity x^* of quality Q^* to Foreign. Likewise a monopoly in Foreign produces a quantity y of quality q and a quantity y^* of quality q^* for Home and Foreign respectively.

Both tradeable goods come in a continuum of versions, where each version is characterised by the amount of a harmful ingredient, pathogen or toxin per unit of the good consumed. Quality, in the context of this model, refers to a product's health safety attributes and a higher quality implies a lower level of the toxin and lower negative health side effects for consumers (discussed below).[7]

A monopolist can choose the quality of the product it sells to each market subject to $0 \leq q, q^*$ and $0 \leq Q, Q^*$, where zero quality is the quality (or level of toxin) that occurs naturally. Where the inequalities are strict, a monopolist improves quality above that which occurs naturally but subject to increasing production costs. Let $c(Q)$ and $c(Q^*)$ be the constant marginal costs for x and x^* respectively. Cost functions are smooth and satisfy $c_i > 0, c_{ii} = 0$ for $i = Q, Q^*$.

Marginal costs for y and y^* can be likewise defined as $c(q)$ and $c(q^*)$ with $c_i > 0, c_{ii} = 0$ for $i = q, q^*$.

If quality is unobservable, monopolists have no incentive to improve it but they do have an incentive to pretend to be of higher quality if consumers are willing to pay a higher price.

If $Q = q$ ($q^* = Q^*$) and $x = y$ ($x^* = y^*$), the per-good levels of the toxin ingested by Home (Foreign) consumers are equal. A monopolist bears no fixed set-up costs for choosing $Q \neq Q^*$ or $q \neq q^*$.

The Home (Foreign) government imposes a specific tax τ (τ^*) on imports of y (x^*). Monopolies maximise profits across both (segmented) markets and for both periods, which simplifies to a per-period maximization problem. In Home:

$$\Pi_t(P_t, x_t, P_t^*, x_t^*, Q, Q^*, \tau^*) = P_t x_t + P_t^* x_t^* - c(Q)x_t - [c(Q^*) + \tau^*]\, x_t^*$$

where $t = \{1, 2\}$ denotes period. P_t and P_t^* are the producer and consumer prices of good x in Home and Foreign respectively. Letting p_t^* and p_t denote the producer and consumer prices of good y in Foreign and Home respectively, profits for the

[7] For example, shell fish and some cheeses contain histamine-producing bacteria associated with Scombroid poisoning. Quality prescribes the minimum level of histamine units in parts per million (ppm) consumed.

Foreign monopoly can be similarly defined as:

$$\Pi_t^*(p_t^*, y_t^*, p_t, y_t, q^*, q, \tau) = p_t^* y_t^* + p_t y_t - c(q^*) y_t^* - [c(q) + \tau]\, y_t$$

Cost functions are equal across countries. Define $p_t^w = p_t - \tau$ and $P_t^w = P_t^* - \tau^*$.

Each country is populated by a representative consumer with identical preferences across countries. I describe the Home consumer problem only. The consumer has a per-period utility function $u_t = v(y_t) + v(x_t) + m_t$. The sub-utility functions are smooth and satisfy $v_i > 0$, $v_{ii} < 0$ for $i = x_t, y_t$.

Consumers do not value quality *per se* but first-period consumption of both products is associated with a risk $\theta(x_1, y_1, Q, q) \in [0, 1]$, of getting a non-fatal disease in period 2. θ is increasing in first period consumption of both products and is decreasing in quality.

I assume that the risk is identical for all consumers and that consumers have full information regarding the determination of θ as a function of consumption and quality. θ is additively separable that is, $\theta(x_1, y_1, Q, q) \equiv f(x_1, Q) + g(y_1, q)$ and

$$\begin{aligned} \theta_{xQ} &< 0,\ \theta_{yq} < 0 \\ \theta_{yy} &= \theta_{xx} = \theta_{qq} = \theta_{QQ} = 0 \end{aligned}$$

I assume that the consumer suffers no direct disutility from illness, but second period income when the consumer is well (Z^w) exceeds that when they are ill (Z^u). If $x_1 = y_1 = 0$, $\theta = 0$ and $Z = Z^w$.

Subject to a budget constraint, the consumer chooses consumption levels for both periods to maximise utility, $U = u_1 + E[u_2]$, where u_1 is

$$u_1 = v(x_1) + v(y_1) + Z_1 - P_1 x_1 - p_1 y_1 \tag{2.1}$$

and $E[u_2]$ is expected second period utility given by:

$$E[u_2] = v(x_2) + v(y_2) + Z^w - \theta \hat{Z} - P_2 x_2 - p_2 y_2 \tag{2.2}$$

where $\theta \hat{Z} = \theta(Z^w - Z^u)$. Optimal consumption choices are independent of tariff revenue, which is redistributed lump-sum. For tractability I have suppressed tariff revenue in (2.1) and (2.2) above. The problem simplifies to a static optimization

problem.[8] Inverse demand functions in period 2 are given by:

$$\begin{aligned} v_x &= P_2 \\ v_y &= p_2 \end{aligned}$$

Since quality is unobservable at the time of purchase, consumers rationally expect firms to "cheat", or produce at the minimum quality. A consumer's optimal first-period consumption bundle is a function of prices, θ and income:

$$\begin{aligned} v_x &= P_1 + \theta_x \hat{Z} \\ v_y &= p_1 + \theta_y \hat{Z} \end{aligned}$$

where θ_x and θ_y are evaluated at the naturally occurring toxin levels. By the law of large numbers θ represents the proportion of the population that falls ill. The government in each country cares about the distribution of income between the healthy and the sick. In period 2, the government taxes the healthy $\theta\hat{Z}$ and redistributes $(1-\theta)\hat{Z}$ to the sick such that expected income is equalized across states. The budget is balanced:

$$Z^u + (1-\theta)\hat{Z} = Z^w - \theta\hat{Z}$$

Insurance results in consumer moral hazard because consumers perceive their first-period consumption choices to be too small to affect second period income.[9] Inverse demand functions in Home in period 1 simplify to:

$$\begin{aligned} v_x &= P_1 \\ v_y &= p_1 \end{aligned}$$

Firms continue to choose zero quality.[10]

Allow the government three instruments in period one to maximise welfare given firm and consumer moral hazard. There is no reason for instruments in period 2 since no damage occurs as a result of period 2 consumption. The thee instruments

[8] Consumers are risk neutral and I ignore savings.

[9] As long as consumption is positive and sickness is associated with income loss, moral hazard would still result even if direct disutility from illness was introduced.

[10] An argument for government intervention in response to firm moral hazard could have been made without introducing insurance but having consumption choices independent of quality levels is convenient for tractability.

Private insurance would not solve firm moral hazard nor necessarily consumer moral hazard and government intervention would continue to be justified.

are a domestic quality standard Q, an import quality standard q, and a specific tariff on imports τ. The quality standards are fully enforceable.

Consider the competitive equilibrium in Home for insurance and exogenous instruments. Each monopolist maximizes per-period profits by taking inverse demand and governments' instrument levels as given. First-period equilibrium prices can be defined as a function of instruments: $\bar{P}_1 = \bar{P}(Q)$ and $\bar{p}_1 = \bar{p}(q,\tau)$ are increasing in their arguments.[11] Equilibrium output levels are given by $\bar{x}_1 = \bar{x}(Q)$ and $\bar{y}_1 = \bar{y}(q,\tau)$ which are decreasing in their arguments.

I assume that $\bar{p}_{1\tau} \in (0,1)$ and it must follow that $\bar{p}^w_{1\tau} < 0$, reflecting the terms of trade gain:

$$\bar{\Pi}^*_\tau = -\bar{y}_1 < 0$$

Likewise, prices do not increase by the full amount of an increase in marginal costs and,

$$\bar{\Pi}^*_q = -c_q \bar{y}_1 < 0$$

$$\bar{\Pi}_Q - c_Q \bar{x}_1 < 0$$

Identical demand and cost functions imply that if $c(Q) = c(q) + \tau$, then $\bar{x}_1 = \bar{y}_1$ but for $\tau > 0$, per-unit consumption of the domestic good is healthier or $Q > q$. In equilibrium:

$$\begin{aligned}
\bar{\theta}_\tau &= \theta_y \bar{y}_\tau < 0 \\
\bar{\theta}_Q &= \theta_x \bar{x}_Q + \theta_Q < 0 \\
\bar{\theta}_q &= \theta_y \bar{y}_q + \theta_q < 0
\end{aligned}$$

I assume that in equilibrium the import instruments are strategic health substitutes:

$$\bar{\theta}_{\tau q} = \theta_{yq} \bar{y}_\tau + \theta_y \bar{y}_{\tau q} > 0 \tag{2.3}$$

Period 2 equilibrium prices and outputs are independent of instruments. Utility can be redefined in terms of instruments as:

$$\bar{U}(q,\tau,Q,p_2,P_2) = \bar{u}_1(q,\tau,Q) + E[\bar{u}_2(q,\tau,Q,p_2,P_2)] + \tau \bar{y}(q,\tau)$$

[11] If the Home monopolist faced a non-separable cost function $C(x,x^*,Q,Q^*)$ then $\bar{p}_1 = \bar{p}(Q,Q^*,\tau^*)$. I ignore these cross-border effects which are likely to be secondary.

where $\tau\bar{y}(q,\tau)$ is redistributed tariff revenue.

$$\begin{aligned}\bar{u}_1(q,\tau,Q) &= \bar{v}(q,\tau)+\bar{v}(Q)+Z_1 \qquad (2.4)\\ &\quad -\bar{p}(q,\tau)\bar{y}(q,\tau)-\bar{P}(Q)\bar{x}(Q) \qquad (2.5)\end{aligned}$$

$$\begin{aligned}E[\bar{u}_2(q,\tau,Q,p_2,P_2)] &= v(y_2)+v(x_2)+Z^w\\ &\quad -\bar{\theta}(q,\tau,Q)\hat{Z}-p_2y_2-P_2x_2\end{aligned}$$

$\bar{U}(q,\tau,Q,p_2,P_2)$ is separable across import instruments and domestic instruments. First period Home and Foreign profits can be written as:

$$\begin{aligned}\bar{\Pi}_1(Q,Q^*,\tau^*) &= \bar{P}(Q)\bar{x}(Q)+\bar{P}^*(Q^*,\tau^*)\bar{x}^*(Q^*,\tau^*)\\ &\quad -c(Q)\bar{x}(Q)-\left[c(Q^*)+\tau^*\right]\bar{x}^*(Q^*,\tau^*)\end{aligned}$$

$$\begin{aligned}\bar{\Pi}_1^*(q^*,q,\tau) &= \bar{p}^*(q^*)\bar{y}^*(q^*)+\bar{p}(q,\tau)\bar{y}(q,\tau)-c(q^*)\bar{y}^*(q^*)\\ &\quad -\left[c(q)+\tau\right]\bar{y}(q,\tau)\end{aligned}$$

$\bar{\Pi}_1(Q,Q^*,\tau^*)$ and $\bar{\Pi}_1^*(q^*,q,\tau)$ are both separable across import instruments and domestic instruments. In the next section I treat instruments as endogenous and compare efficient instrument setting to unilateral setting of standards and tariffs.

4 Instrument Setting Under Different Regimes

Assume that each government provides insurance as discussed above and chooses instrument levels to maximise welfare (the sum of consumer and producer surplus over both periods). The Home government's objective function is given by :

$$W(q,\tau,Q,Q^*,\tau^*)=\bar{u}_1(q,\tau,Q)-\bar{\theta}(q,\tau,Q)\hat{Z}+\bar{\Pi}_1(Q,Q^*,\tau^*)+\tau\bar{y}_1 \qquad (2.6)$$

where I have suppressed expressions independent of instruments and $\tau\bar{y}_1$ is redistributed tariff revenue. The Foreign government's objective function can be analogously defined as $W^*(Q^*,\tau^*,q^*,q,\tau)$. The following is assumed to hold:

1. $W_{\tau\tau}+W^*_{\tau\tau}<0$, $W_{qq}+W^*_{qq}<0$, $W_{QQ}+W^*_{QQ}<0$
2. $W_{\tau\tau}<0$, $W_{qq}<0$, $W_{QQ}<0$

3. $W_{\tau q} < 0$ and $W_{\tau q} + W^*_{\tau q} < 0$

By the third assumption, import instruments are strategic substitutes. In Appendix A I show that only one of the import instruments is sufficient. Since this paper is concerned with standard setting in the context of tariff liberalisation, I assume the tariff to be sufficient; that is, if the tariff is not constrained by a trade agreement, the import standard is not used. The condition for this to be true is

$$\frac{-\bar{\theta}_q \hat{Z}}{c_q} < \bar{y}_1 \tag{2.7}$$

The left-hand side reflects the *direct* increases in welfare from increasing the import standard, that is the effect that does not travel through equilibrium outputs or prices. The right-hand side reflects the *direct* increase in revenue from a tariff increase. The import standard and tariff impact on equilibrium price and output in much the same way, except that the standard's effect on marginal costs is scaled down if $c_q < 1$ and scaled up if $c_q > 1$. That is, the standard's *indirect* effect is scaled up or down by c_q. Therefore, (2.7) captures the difference in effects of the standard and tariff on income.

In the next section, I consider the globally efficient Nash bargaining solution in the symmetric case. Using the bargaining solution as the benchmark, I discuss the inefficiencies associated with unilateral instrument setting and provide a definition of consistency. All time subscripts are dropped for simplicity. All proofs not explicitly included in the text can be found in Appendices A and B. A linear example of the model and results are provided in Appendix C.

4.1 Efficient and Unilateral Instrument Setting

Assume that governments bargain over all instruments. The Nash bargaining solution maximizes global welfare and provides efficient instrument levels denoted by

$$q^B, \tau^B, Q^B, Q^{*B}, \tau^{*B}, q^{*B}$$

With respect to any instrument i the Nash bargaining solution is given by:

$$\max_i \ (W + W^*)$$

and given symmetry, the solution must have $W = W^*$ and $Q^B = q^{*B}, q^B = Q^{*B}$ and $\tau^B = \tau^{*B}$.[12] The first-order conditions with respect to Home import instruments define the decreasing functions $q^b(\tau)$ and $\tau^b(q)$. The Nash bargaining solution is:

$$\tau^B = \tau^{*B} > 0 \tag{2.8}$$

$$q^B = Q^{*B} = 0 \tag{2.9}$$

$$Q^B = q^{*B} \geq 0 \tag{2.10}$$

By (2.7), the tariff is sufficient (see Appendix A). At $\tau = 0$, $q^b(0) = Q^B$.

Assume that governments set instruments unilaterally. The Home government chooses the level of its instruments to solve:

$$\max_{q,Q,\tau} W$$

The first-order conditions with respect to import instruments define the decreasing functions $q^n(\tau)$ and $\tau^n(q)$. Using symmetry and $W^*_\tau = \bar{\Pi}^*_\tau$, $W^*_q = \bar{\Pi}^*_q$ and $W^*_Q = 0$, the Nash Equilibrium is:

$$\tau^N = \tau^{*N} > 0 \tag{2.11}$$

$$q^N = Q^{*N} = 0 \tag{2.12}$$

$$Q^N = q^{*N} = Q^B = q^{*B} \geq 0 \tag{2.13}$$

While standards remain at their efficient levels, the Nash tariffs are inefficiently high as governments manipulate their terms of trade at the expense of their trading partner's profits. Evaluated at (τ^N, q^N):

$$W_\tau + W^*_\tau = -\bar{y} < 0$$

and both countries can gain if tariffs are reduced.

[12] Let $\bar{W}^N$ ($\bar{W}^{*N}$) be Home's (Foreign's) welfare in the equilibrium where governments do not co-operate. By symmetry $\bar{W}^N = \bar{W}^{*N}$. The Nash bargaining solution with respect to any instrument i is given by:

$$\max_i (W - \bar{W}^N)(W^* - \bar{W}^N)$$

or

$$\frac{\partial W}{\partial i}(W^* - \bar{W}^N) + \frac{\partial W^*}{\partial i}(W - \bar{W}^N) = 0$$

but with symmetric welfare functions, the solution requires $W = W^*$ (the gains from bargaining are distributed equally across countries).

At this point it is useful to provide a formal definition of consistency. Consistency is specified on the assumption that tariffs are bound during trade negotiations, that is, consistency relates specifically to regulation and is not a requirement, or rule, on tariff setting.

Definition 1 (Consistency): *The consistency constraint requires that for a given tariff level* τ, $q^n(\tau) - Q \leq s$, *where* $s \geq 0$.

The consistency constraint is most strict at $s = 0$. If the import standard for a given tariff level exceeds the domestic standard by more than s, the level of health protection on imports is, in the context of this paper, illegal. At $\tau = 0$, $q^n(0) > q^b(0) = Q^B$. Evaluated at $\tau = 0$ and $q^n(0)$, $W_q + W_q^* < 0$.

Lemma 1: *In both the efficient solution and the Nash Equilibrium, consistency is not violated because* $q^N \leq Q^N$ and $q^B \leq Q^B$.

The level of protection on the import good in the Nash Equilibrium is inefficient but does not violate consistency. Consistency assumes that countries bargain over tariffs and is a restriction on non-tariff barriers and thus, inefficiently high tariffs are not part of the consistency definition.

5 Tariff Bargaining

Assume a two-stage game where governments bargain over tariffs in the first stage and they are free to unilaterally set standards in the second stage. I consider Home only. I solve backwards, starting in period 2 for a bound tariffs τ^T and τ^{*T}.

Stage 2: Given τ^T, the Home government chooses standards to maximise welfare, or

$$\max_{q,Q} \; W^T(q, \tau^T, Q, Q^*, \tau^{*T})$$

Let q^T and Q^T denote optimal standards in the second stage, which are respectively the solutions to:

$$\begin{aligned} W_q^T &= W_q = 0 \\ W_Q^T &= W_Q = 0 \end{aligned}$$

or $q^T = q^n(\tau^T)$ and $Q^T = Q^N = Q^B$.

Define the tariff levels $\bar{\tau}$ and $\tilde{\tau}$ where $q^n(\bar{\tau}) = Q^T$ and $q^n(\tilde{\tau}) = 0$. If the domestic standard is strictly positive, it must be that $\bar{\tau} < \tilde{\tau}$ because $q^n_\tau < 0$. Furthermore, $\bar{\tau} > 0$ because $q^n(0) > Q^T$. The Nash import standard exceeds the domestic standard for $\tau^T < \bar{\tau}$.

As tariffs decrease below their Nash levels, substitution towards the import standard occurs. Because prices do not increase by the full amount of costs, part of the costs of domestic health policy are shifted onto the foreign monopoly eventually resulting in import standards that exceed their efficient levels.

It is straightforward to show $\tau^B < \tilde{\tau}$. At $q^n(\tilde{\tau})$, $W_q = 0$ and $W_\tau > 0$ and given by

$$\frac{\bar{\theta}_q \hat{Z}}{c_q} + \bar{y},$$

which in turn gives

$$W_\tau + W^*_\tau = \frac{\bar{\theta}_q \hat{Z}}{c_q} < 0$$

evaluated at $q^n(\tilde{\tau}) = 0$ and $\tilde{\tau}$. Yet whether $\tau^B < \bar{\tau}$, depends on the level of the domestic standard. If the domestic standard is zero, $\tau^B < \tilde{\tau} = \bar{\tau}$.

Proposition 1: *If $\tau^T = \tau^B$, the import standard is positive and inefficiently high but may not violate consistency. Consistency is violated if and only if $\tau^T < \bar{\tau}$ and $s < q^n(\tau^T) - Q$.*

Stage 1: Redefine welfare as $\tilde{W}^T(q^n(\tau), \tau, Q, Q^{*n}(\tau^*), \tau^*)$. Relying on symmetry and the envelope theorem, the first-order condition when governments bargain over tariffs is:

$$\tilde{W}^T_\tau = W_\tau + (1 + c_q q^n_\tau) W^*_\tau > 0$$

The sign follows from $W_\tau > 0$ when $W_q = 0$ and $(1 + c_q q^n_\tau) < 0$ (refer Appendix A).

Proposition 2: *Under a trade agreement, governments bind their tariffs such that $\tau^T = \tilde{\tau}$ and $q^T = q^n(\tilde{\tau}) = 0$. Standards remain at their efficient levels and consistency is not violated.*

Governments reduce tariffs until $\tilde{\tau}$ because there is no substitution towards standards in response to tariff liberalisation ($q^n_\tau = 0$ for $\tau > \tilde{\tau}$). Any further liberalisation of tariffs beyond $\tilde{\tau}$ erodes the profit gains to exports from liberalisation since countries respond by increasing their import standards. What should be noted here is that with forward-looking trade negotiators, a trade agreement results in efficiency

gains but import standards are never used. The question is whether it is ever the case that import standards are positive. As noted by Horn (2004), import standards are positive if trade negotiators are myopic in stage one. Without forward-looking negotiators:

$$\tilde{W}_{\tau}^{T} = W_{\tau} + W_{\tau}^{*} = 0$$

the solution to which is τ^{B}. But $q^{T}(\tau^{B}) > 0$ is inefficiently high and may violate consistency. The rationale behind rigid rules, like consistency, is the incompleteness of contracts; that is, trade negotiators are not forward-looking and non-tariff measures may need to be constrained to prevent the erosion of trade gains. A clear role for consistency has been identified, but whether it is binding depends on s, the level of the domestic standard and the bound tariff level. In the following section, I continue with the two-stage bargaining game, but assume that in the second stage, governments set standards subject to the consistency constraint.

5.1 Tariff Bargaining Subject to Consistency

I first consider standard setting in the second stage for bound tariffs τ^{C}, τ^{*C} and for a given s.

Stage 2: Given τ^{C} and τ^{*C} and assuming that the constraint binds, the Home government chooses standards to maximise welfare, or

$$\max_{q,Q} W^{C}(q, \tau^{C}, q - s, Q^{*}, \tau^{*C})$$

Let $q^{C}(\tau^{C}, s, \tau^{*C})$ denote the optimal import standard which is the solution to:

$$W_{q}^{C} = W_{q} + W_{Q}Q_{q} = 0$$

where $Q_{q} = 1$. The first feature to notice with regard to a binding consistency constraint is that it constrains the strategic relationship between import instruments: $q_{\tau}^{n} < q_{\tau}^{c} < 0$ or

$$\frac{-W_{\tau q}}{W_{qq}} < \frac{-W_{\tau q}}{W_{qq} + W_{QQ}}$$

As noted in the previous section, the negotiated tariff when negotiators are forward-looking is $\tilde{\tau} > \tau^{B}$, because the substitution towards import standards prevents any further liberalisation. The question remains whether foward-looking negotiators have an incentive to lower tariffs when standard setting is constrained by consistency in the second period.

The second feature is that for a given tariff τ^C, consistency distorts the domestic standard away from its efficient level, $Q^C(s, \tau^C) = q^C - s > Q^B$:

$$W_Q = -W_q < 0$$

because $q^C < q^N$. This result fits with the evidence in some WTO cases. In response to losing the *Salmon* dispute, Australia relaxed its ban on salmon imports but new restrictions were instead placed on other products (Atik, 2003).

Substituting $Q^C(s, \tau^C)$, $q^C(s, \tau^C)$ and $Q^{*C}(s, \tau^{*C})$ into the welfare function and redefining it as $\tilde{W}^C(\tau^C, \tau^{*C}, s)$, the welfare effects of a tightening of the constraint are reflected in the following condition:

$$\tilde{W}_s^C = W_q + W_q^* q_s^C \tag{2.14}$$

where I have used the envelope theorem and $Q_s^C = q_s^c - 1$. The first term reflects the costs to Home of having its own standards constrained, which are offset by the gains ($q_s^C > 0$) in its export market, reflected by the second term.

Proposition 3: *For a binding tariff τ^C, a marginally binding consistency constraint unambiguously improves welfare, but welfare may be reduced if the constraint is interpreted too strictly.*

Whether consistency improves welfare depends on whether it is binding and how strictly it is interpreted. In the model, consistency is binding if the domestic standard is zero, or if trade negotiators are myopic and $\tau^B < \bar{\tau}$. In reality, whether consistency is binding and how strictly it is interpreted depends on the adjudicators of WTO case law.

In *Salmon*, Australia was required to bring its illegal measure in line with other levels of protection on comparable goods, thereby suggesting a strict interpretation of consistency. Such strict interpretations may reduce welfare and make it difficult for offending countries to comply with decisions of the Dispute Settlement Body. While Australia relaxed its ban on salmon imports, it increased its regulation on ornamental finfish and bait. While the market access levels improved for salmon producers, it was reduced for exporters of finfish, like Japan.

The effects of consistency on θ and health are given by,

$$\bar{\theta}_s = Q_s^C[\bar{\theta}_x \bar{x}_Q + \bar{\theta}_Q] + q_s^C[\bar{\theta}_y \bar{y}_q + \bar{\theta}_q]$$

and are ambiguous.

The possible impact of consistency on tariff liberalisation remains to be discussed.

Stage One: For $\tau < \bar{\tau}$, the first-order condition for tariffs in stage one can be written as:

$$\bar{W}_{\tau}^{C} = W_{\tau} + (1 + c_q q_{\tau}^{c}) W_{\tau}^{*} = 0$$

where I have used the envelope theorem and $q_{\tau}^{c} = Q_{\tau}^{C}$. There are two opposing forces to consider. The first term reflects the costs of having one's standards being constrained and puts positive pressure on tariffs. While the second term would be positive absent consistency, it may be negative with consistency, thereby reflecting the possible gain from lower tariffs since the substitution towards import standards is dampened.

Proposition 4: *If negotiators are myopic, consistency has no effect on tariff bargaining ($\tau^{C} = \tau^{B}$) and may reduce welfare if too strict. If negotiators are forward-looking, consistency may have an effect on tariff bargaining ($\tau^{C} \leq \tilde{\tau}$) and leave welfare unchanged ($\tau^{C} = \tilde{\tau}$) or higher ($\tau^{C} < \tilde{\tau}$).*

Forward-looking negotiators choose the tariff level maximising welfare for a given s, and if s is too strict, negotiators prefer to remain at $\tilde{\tau}$. But myopic negotiators do not alter their tariff choices in response to s. Consistency is a rule designed to prevent the erosion of trade gains when negotiators are not forward-looking, but it is in this very case that welfare losses may result.

6 Conclusion and Further Research

This paper has shown that for some bound tariff levels, consistency results in a higher level of health protection on the domestic good and lower protection on the import good. If trade negotiators are forward-looking, consistency may encourage liberalisation beyond that which would occur when standards are not constrained by consistency in the second stage. If trade negotiators are myopic, consistency has no effect on the bound tariff which is always set at the Nash bargaining level. Whether consistency leads to welfare improvements, when negotiators are myopic, (by dampening the substitutions towards standards) depends on whether it is binding at the bound tariff and how strictly it is interpreted.

The task of interpreting consistency is given to the WTO Dispute Settlement Body (DS), which must decide, with incomplete information, whether the higher

levels of protection on imported goods are arbitrary and lead to disguised restrictions on trade. Differences in attitudes to risk across countries as well as demand, cost and risk dissimilarities across goods, make the task of distinguishing between legitimate and illegitimate SPS measures a difficult one. Moreover, the case law suggests a strict interpretation of consistency which may be excessively onerous.

The effects of consistency on health are ambiguous and complying with consistency may be difficult for governments responsive to health-conscious consumer lobbies. Including factors such as consumer fears to ascertain whether the inconsistent measure is a disguised restriction on trade might make sense from an economic perspective. (see Chapter 3).

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Appendix A

It can be shown that an interior solution in import instruments is never possible. First, by applying the Implicit Function Theorem to Π_t^*, $\bar{p}_q = c_q \bar{p}_\tau$ and $p_{qq} = p_{\tau\tau} = p_{\tau q} = 0$.

$$W_\tau = \bar{p}_\tau[\bar{U}_p] + \bar{y} \tag{2.15}$$

$$W_{\tau\tau} = (\bar{p}_\tau)^2[\bar{U}_{pp}] + 2\bar{p}_\tau[\bar{U}_{p\tau}] \tag{2.16}$$

where $\bar{U}_{p\tau} = y_p$.

$$W_q = \bar{p}_q[\bar{U}_p] - \bar{\theta}_q\hat{Z} = c_q[W_\tau - \bar{y}] - \bar{\theta}_q\hat{Z} \tag{2.17}$$

and $\bar{\theta}_q\hat{Z}$ is the direct effect of quality on θ independent of price changes.

$$W_{qq} = (\bar{p}_q)^2[\bar{U}_{pp}] + 2\bar{p}_q[\bar{U}_{pq}] = (c_q)^2[W_{\tau\tau} - 2\bar{p}_\tau[\bar{U}_{p\tau}]] + 2c_q\bar{p}_\tau[\bar{U}_{pq}] \tag{2.18}$$

where I used $\bar{U}_{pq} = -\bar{\theta}_{pq}\hat{Z}$ and $\theta_{qq} = c_{qq} = 0$.

$$W_{\tau q} = \bar{p}_\tau[\bar{U}_{pp}\bar{p}_q + \bar{U}_{pq}] + \bar{y}_q = c_q[W_{\tau\tau} - \bar{p}_\tau[\bar{U}_{p\tau}]] + \bar{p}_\tau[\bar{U}_{pq}] \tag{2.19}$$

where I used $\bar{y}_q = c_q\bar{y}_\tau$. It is straightforward to verify that $(W_{\tau q})^2 > W_{qq}W_{\tau\tau}$ if

$$(\bar{p}_\tau c_q\bar{U}_{p\tau} - \bar{p}_\tau\bar{U}_{pq}])^2 > 0$$

which is always true.

Similarly,

$$W_\tau + W_\tau^* = \bar{p}_\tau[\bar{U}_p] \tag{2.20}$$

$$W_{\tau\tau} + W_{\tau\tau}^* = (\bar{p}_\tau)^2[\bar{U}_{pp}] + \bar{p}_\tau[\bar{U}_{p\tau}] \tag{2.21}$$

$$W_q + W_q^* = \bar{p}_q[\bar{U}_p] - \bar{\theta}_q\hat{Z} - c_q\bar{y} = c_q[W_\tau + W_\tau^* - \bar{y}] - \bar{\theta}_q\hat{Z} \tag{2.22}$$

$$W_{qq} + W_{qq}^* = (\bar{p}_q)^2[\bar{U}_{pp}] + 2\bar{p}_q[\bar{U}_{pq}] - c_q\bar{y}_q \tag{2.23}$$

$$W_{\tau q} + W_{\tau q}^* = \bar{p}_\tau[\bar{U}_{pp}\bar{p}_q + \bar{U}_{pq}] \tag{2.24}$$

and $(W_{\tau q} + W_{\tau q}^*)^2 > (W_{qq} + W_{qq}^*)(W_{\tau\tau} + W_{\tau\tau}^*)$ always.

By (2.17), at $W_q = 0$, $W_\tau = w^\tau = \frac{\bar{\theta}_q\hat{Z}}{c_q} + \bar{y}$. At $W_\tau = 0$, $W_q = w^q = -\bar{\theta}_q\hat{Z} - c_q\bar{y}$. If $w^\tau > 0$, $w^q < 0$. That is, if

$$\frac{\bar{\theta}_q\hat{Z}}{c_q} + \bar{y} > 0$$

the tariff is sufficient and $q^N(\tau^N) = 0$. Concavity implies that at $W_q = 0$,

$$\left(\frac{\bar{\theta}_q\hat{Z}}{c_q} + \bar{y}\right)\partial\tau < 0$$

or

$$c_q p_\tau\left[\bar{U}_{pq} - c_q\bar{U}_{p\tau}\right] > 0$$

which means that $W_{qq} > W_{\tau q}c_q$ and

$$(1 + c_q q_\tau^n) < 0$$

By (2.22), the condition is identical for the Nash bargaining case and $q^B(\tau^B) = 0$.

Appendix B - Tariff Bargaining with Consistency

Consistency dampens the strategic relationship between import instruments because

$$q_\tau^n = \frac{-W_{\tau q}}{W_{qq}} < \frac{-W_{\tau q}}{W_{qq} + W_{QQ}} = q_\tau^c$$

Appendix C - An Example

Considering Home only and dropping time subscripts for simplicity where possible, the representative consumer's utility over both periods is given by:

$$U = y_1 - \frac{1}{2}y_1^2 + x_1 - \frac{1}{2}x_1^2 + m_1 + y_2 - \frac{1}{2}y_2^2 + x_2 - \frac{1}{2}x_2^2 + m_2 + \tau y_1 \tag{2.25}$$

where the budget constraint in each period is $m_1 = Z_1 - p_1 y_1 - P_1 x_1$ and $m_2 = Z^w - \theta\hat{Z} - p_2 y_2 - P_2 x_2$ respectively. Inverse demands with insurance are:

$$p = 1 - y \tag{2.26}$$

$$P = 1 - x \tag{2.27}$$

because consumers do not take account of their consumption choices on θ and consumption choices are independent of redistributed tariff revenue. Let:

$$\theta(y, x, q, Q) = (\frac{1}{2} - q)y + (\frac{1}{2} - Q)x \tag{2.28}$$

where $q, Q \in [0, \frac{1}{2}]$. Government instrument choices are not independent of θ or redistributed tariff revenue. Substituting (2.26) and (2.27) into (2.25) and (2.28), and taking the derivative with respect to p gives:

$$U_p = -1 + p - \tau + (\frac{1}{2} - q)\hat{Z}$$

First-period profits in Home are defined by:

$$\Pi = P(1 - P) + P^*(1 - P^*) - c(Q)(1 - P) - [c(Q^*) + \tau^*](1 - P^*)$$

where $c(Q) = \alpha Q$ and $c(q) = \alpha q$ and $\alpha > 1$. I impose the following conditions:

$$\frac{6\alpha}{2\alpha + 4} < \hat{Z} < \alpha \tag{2.29}$$

$$\begin{aligned} 1 &< \alpha < 2 \\ 1 &< \hat{Z} < \frac{3}{2} \end{aligned} \tag{2.30}$$

All conditions ensure that the welfare functions are concave in all three instruments and that the domestic standard is positive. (2.30) guarantees non-negative consumption in equilibrium. The following holds in equilibrium:

$$\bar{P}(Q) = \frac{1 + \alpha Q}{2}$$

$$\bar{p}(q, \tau) = \frac{1 + \alpha q + \tau}{2}$$

$$\bar{x}(Q) = \frac{1 - \alpha Q}{2}$$

$$\bar{y}(q, \tau) = \frac{1 - \alpha q - \tau}{2}$$

Utility and profits can be redefined as functions of instruments:

$$\begin{aligned} \bar{U}(q, \tau, Q) &= \frac{1}{8}(2 + \alpha^2 q^2 + \alpha^2 Q^2 + 2\tau - 3\tau^2 - 2\alpha q - 2\alpha q\tau - 2\alpha Q) \\ &\quad -\frac{\hat{Z}}{4}(2 - 2Q - \alpha Q + 2\alpha Q^2 - 2q - \alpha q + 2\alpha q^2 + 2q\tau - \tau) \end{aligned}$$

$$\bar{\Pi}_1(Q, Q^*, \tau^*) = \frac{1}{4}(2 + \alpha^2 Q^{*2} + \alpha^2 Q^2 + 2\alpha Q^* \tau^* + \tau^{*2} - 2\alpha Q - 2\alpha Q^* - 2\tau^*)$$

I have suppressed terms that are independent of instruments. Rewrite welfare as

$$W(q, \tau, Q, Q^*, \tau^*) = \bar{U}(q, \tau, Q) + \bar{\Pi}_1(Q, Q^*, \tau)$$

:

$$\begin{aligned} W_\tau &= \frac{1}{8}(2 - 6\tau - 2\alpha q + 2\hat{Z} - 4q\hat{Z}) \\ W_{\tau\tau} &= -\frac{3}{4} \end{aligned}$$

$$W_{\tau q} = -\frac{1}{4}\alpha - \frac{\hat{Z}}{2}$$

$$\begin{aligned} W_q &= \frac{1}{8}(-2\alpha - 2\alpha\tau + 2\alpha^2 q + 2\alpha\hat{Z} + 4\hat{Z} - 8\alpha q\hat{Z} - 4\tau\hat{Z}) \\ W_{qq} &= \frac{1}{4}\alpha^2 - \alpha\hat{Z} \end{aligned}$$

By (2.29) above, $W_{qq} < 0$.

Finally, $W^*_\tau = \bar{\Pi}^*_\tau = -\bar{y}$, $W^*_q = \bar{\Pi}^*_q = -\alpha\bar{y}$ and $W^*_Q = 0$:

$$\begin{aligned} W_\tau + W^*_\tau &= \frac{1}{8}(-2 - 2\tau + 2\alpha q + 2\hat{Z} - 4q\hat{Z}) \\ W_q + W^*_q &= \frac{1}{8}(-6\alpha + 2\alpha\tau + 6\alpha^2 q + 2\alpha\hat{Z} + 4\hat{Z} - 8\alpha q\hat{Z} - 4\tau\hat{Z}) \\ W_Q &= \frac{1}{8}(-6\alpha + 6\alpha^2 Q + 2\alpha\hat{Z} + 4\hat{Z} - 8\alpha Q\hat{Z}) \end{aligned}$$

It is straightforward to verify that $W_{\tau\tau} + W^*_{\tau\tau} < 0$, $W_{\tau q} + W^*_{\tau q} < 0$, $W_{qq} + W^*_{qq} < 0$ and $W_{QQ} < 0$.

Nash Bargaining:

At $W_\tau + W^*_\tau = 0$, $W_q + W^*_q = y(Z - \alpha) < 0$ and the Nash bargaining solution can be written as:

$$\begin{aligned} \tau^B &= \tau^{*B} = \hat{Z} - 1 \\ q^B &= q^{*B} = 0 \\ Q^B &= Q^{*B} = \frac{2\alpha\hat{Z} + 4\hat{Z} - 6\alpha}{8\alpha\hat{Z} - 6\alpha^2} \end{aligned}$$

$Q^B \in (0, \frac{1}{2})$ and $\tau^B > 0$. Let $q^b(\tau)$ be the solution to $W_q + W^*_q = 0$. It can be shown that $q^b(0) = Q^B$, while for $\tau > 0$, $q^b(\tau) < Q^B$.

Nash Equilibrium:

At $W_\tau = 0$, $W_q = y(Z - \alpha) < 0$ and the Nash Equilibrium (NE) can be written as:

$$\begin{aligned} \tau^N &= \tau^{*N} = \frac{\hat{Z} + 1}{3} \\ q^N &= q^{*N} = 0 \\ Q^N &= Q^{*N} = Q^B = Q^{*B} \end{aligned}$$

It can be shown that $\tau^B < \tau^N$. Let $q^n(\tau)$ be the solution to $W_q = 0$. Define $\bar{\tau}$ as the tariff where $q^n(\bar{\tau}) = Q^N$:

$$\bar{\tau} = \frac{2\alpha\bar{Z}(2-\alpha)}{(4\bar{Z}-3\alpha)(\alpha+2\bar{Z})} > 0$$

Since $q^n_\tau < 0$, for $\tau < \bar{\tau}$, $q^n(\tau) > Q^N$. Define $\tilde{\tau}$ as the tariff level where $q^n(\tilde{\tau}) = 0$:

$$\tilde{\tau} = \frac{\alpha\hat{Z} + 2\hat{Z} - \alpha}{2\hat{Z} + \alpha}$$

and it can be shown that $0 < \bar{\tau} < \tilde{\tau} < \tau^N$ and $\tau^B < \tilde{\tau}$. Whether $q^n(\tau^B) > Q^N$ depends on the values of α and $\hat{Z}$. For example, let $\alpha = 1.7$ and $\hat{Z} = \frac{7}{8}\alpha$.

$$\begin{aligned} \tau^B &= 0.4875 \\ \bar{\tau} &= 0.381\,82 \end{aligned}$$

Consistency is not violated at the efficient tariff because $q^n(\tau^B) < Q^N$.

Tariff Bargaining without Consistency:

Stage 2: Given the bound tariff level τ^T, optimal standards are $q^n(\tau^T)$ and Q^N.

Stage 1: $\tau^T = \tilde{\tau}$ because:

$$W_\tau + (1 + \alpha q^n_\tau)W^*_\tau > 0 \tag{2.31}$$

where $\alpha q^n_\tau = \frac{4\hat{Z}+2\alpha}{2\alpha-8\hat{Z}} < -1$.

Tariff Bargaining with Consistency:

Stage 2: With a binding constraint, the Home government maximizes welfare subject to $q(\tau^C) - Q = s$.

$$W^C_q = W_q + W_Q = \frac{1}{8}[2\alpha^2 q - 8\alpha - 2\alpha\tau^C + 4\hat{Z}\alpha + 8\hat{Z} - 8\hat{Z}\alpha q - 4\hat{Z}\tau^C + 6\alpha^2(q-s) - 8\hat{Z}\alpha(q-s)]$$

and we have the following solution:

$$\begin{aligned} q^C(\tau^C, s) &= \frac{s[6\alpha^2 - 8\alpha\hat{Z}] + 8\alpha + \tau^C(2\alpha + 4\hat{Z}) - 4\alpha\hat{Z} - 8\hat{Z}}{(8\alpha^2 - 16\alpha\hat{Z})} \\ Q^C(\tau^C, s) &= \frac{s[-2\alpha^2 + 8\alpha\hat{Z}] + 8\alpha + \tau^C(2\alpha + 4\hat{Z}) - 4\alpha\hat{Z} - 8\hat{Z}}{(8\alpha^2 - 16\alpha\hat{Z})} \end{aligned}$$

It is easily verified that

$$0 < q_s^C < 1$$

$$q_s^C - Q_s^C = 1$$

$$q_\tau^C = Q_\tau^C \leq 0$$

and

$$q_\tau^n < q_\tau^c < 0$$

Stage 1: The tariff under consistency is found as the solution to

$$W_\tau + (1 + \alpha q_\tau^C) W_\tau^*$$

It can be shown that if $\hat{Z} < \frac{5}{6}\alpha$ and $\alpha = 1.7$, $1 + \alpha q_\tau^C < 0$. The bound tariff with consistency is identical to the bound tariff without the constraint.

Chapter 3

Public Opinion, Product Quality Regulation and Trade *

1 Introduction

The WTO *Hormones* case[1] is a prime example of how public opinion concerning health risks can contribute to an international trade dispute. The dispute deals with a European Communities (EC) sales ban on meat and meat products treated with three natural and three synthetic growth hormones. The hormones, directly administered to humans, had been shown to be carcinogenic, but no scientific evidence existed linking the hormones administered to cattle to cancer in humans. Scientific experts were divided on the issue.

The Panel in *Hormones* found that the EC ban was a disguised restriction on trade because it *de facto* discriminated against United States (US) producers; compared to the EC, a larger proportion of US producers were hormone-using. The Appellate Body (AB) disagreed[2] . It took into account consumer fears relating to black-marketing scandals and previous health scares (BSE crisis, foot-and-mouth epidemic) and concluded that the *intent* behind the sales ban was not domestic profit protection, but an appeasement of those fears. Despite its finding on the intent behind the ban, the AB concluded that the ban violated Article 5.1 of the Agreement on Sanitary and Phytosanitary Measures (SPS Agreement) because it

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[1] *Hormones:* European Communities - Measures Affecting Meat and Meat Products WT/DS26/AB/R.

[2] Once a Panel decision has been rendered, both parties to a dispute have the right to appeal to the Appellate Body.

was not based on an assessment of the risks to humans from growth hormones administered to cattle - "...the results of the risk assessment did not sufficiently warrant the SPS measure at stake." The AB decision suggests that consumer fears can be used as a justification for a health measure that impacts on trade, but those fears must be associated with, albeit not necessarily correctly reflect, a scientifically proven risk.

As a result of the AB decision, the EC found itself between "a rock and a hard place". Due to domestic political pressure, the EC decided to maintain the ban. Consequently, the US and Canada suspended concessions against the EC amounting to US$116.8 million and US$8 million respectively. It could be argued that this outcome essentially reflects a breakdown in the political trading system. One interpretation of why this breakdown occurred is that the WTO agreements do no adequately take account of consumer preferences because they are built on the premise that consumers always benefit from trade. The EC has often called for negotiations to be reopened to include consumer preferences in the assessment of health measures.

From an economic perspective, *Hormones* leads one to ask several questions regarding the optimal design of trade agreements. First, should governments be forced to admit products that science, but not consumers, deems healthy? Or to put it another way, are consumer fears sufficient to justify a health measure having an impact on trade or must the fears be associated with a scientifically proven risk? To what extent can regulatory authorities exploit these fears to protect domestic profits? To what extent can (protectionist) measures influence or perpetuate the very the fears upon which the measures are based?[3]

This paper attempts to address these questions. In a one period model, a firm from country U Cournot competes with an E firm in the latter's domestic market. The U firm holds a patent to an innovation which reduces the cost of production and intensifies the competition between the two firms, but the innovation has uncertain health consequences. A government in E decides whether to ban or admit the innovative production technology. Government in E comes in two types: F, which maximises producer surplus and H which maximises welfare which is the sum of producer and consumer surplus. Despite lower domestic profits, a healthy innovation

[3] To avoid confusion between measures aimed at protecting consumers, measures aimed at protecting firms or measures that do both, *protectionist*, for the purposes of this paper, means any measure that has the sole intention of protecting domestic producer profits at the expense of foreign producer surplus.

has the potential to increase E welfare because of lower prices, but this potential depends on consumer opinion about the health attributes of the innovation.

To capture the notion of public opinion, I model rational consumers with imperfect information not only with respect to product quality, but also with respect to E government type. Consumers can not determine the country of origin of a unit of the good purchased and thus, do not know whether a unit purchased has been produced using the innovation. The U government may retaliate against a ban by raising tariffs on E exports to U. The extent of tariff retaliation depends on the type of trade agreement negotiated between the governments.

I show that an equilibrium may exist where the H government always bans the innovation regardless of its health attributes and where the F type is induced by tariff retaliation to always accept the innovation even if it is unhealthy. A "scientific assessment requirement" where the U government commits itself to retaliating against a ban only if the U export is healthy, forces governments to the *first-best* solution.

This model provides an example of a situation where banning a healthy, lower cost import is not illogical from an economic perspective, because consumer fear regarding the safety of the product prevents the full potential of welfare improvements from being realised. It also provides an example of where linking a trade measure rationally with a scientific assessment can generate *first-best*. However, I do not strive for generalities with the model set-up but rather aim at highlighting the complexities associated with this issue.

Next I discuss related literature. Sturm (2003) considers a political agency model where the government must decide under uncertainty whether to implement abatement technology on a (possibly dangerous) foreign good which competes with a domestic industry. Voters decide between an incumbent politician or a challenger. Sturm shows that an inefficient equilibrium exists where standards are excessively strict in the domestic country or excessively lax in the exporting country and that harmonization and mutual recognition have ambiguous effects on welfare. Damages in Sturm are a pure externality. My model differs in that consumers' willingness-to-pay depends on their beliefs about product quality.

Anderson *et al* (2004) construct a common-agency lobbying model where the more averse are domestic consumers to genetically-modified (GM) goods, and the greater the cost disadvantage to domestic firms from having to compete with foreign firms having adopted GM technology, the less (more) stringent are GM regulations in the foreign (domestic) country. The stringency of the domestic and foreign reg-

ulations are inversely related regardless of whether the GM technology is perceived to be associated with environmental benefits. Anderson *et al* (2004) ignore the role of trade agreements and assume that country-of-origin is observable by consumers substituting between foreign and domestic goods.

Calzolari and Immordino (2005) model trade in an innovative good where the innovation has uncertain health effects. By authorizing the innovative good, a country generates freely available information from the observation of consumption effects. They show that an interesting free-riding equilibrium exists where the innovative country bans the good when the traditional country accepts it. Given a government's decision consumers treat the two technologies as equal: they are not able to discriminate. I model a scenario where consumers do discriminate between the two technologies but cannot distinguish between them because country-of-origin is unobservable. Chang (2003) provides an excellent discussion of the issues surrounding public opinion and risk regulation.

Section 2 discusses the treatment of public opinion in WTO case law. Sections 3, 4 and introduce the basic model. In section 6 I show that an equilibrium exists where the H government bans the innovation even if it is healthy and the F government accepts it even if it is unhealthy. In sections 7 and 8 I show that the exporting country has an incentive to bind its retaliation strategy by a "scientific assessment of risks" requirement which forces governments to the solution that maximises global welfare. Country-of-origin labelling is discussed in section 9 before I conclude. An example of the results presented in the paper is found in Appendix B.

2 Treatment of Health Risks under WTO Law

2.1 Introduction to the Issues

The original international trading system began as the General Agreement on Trade and Tariffs (GATT) in 1947. It was premised on the understanding that if governments could commit to not relenting to protectionist demands from domestic producer interest groups, welfare gains from trade would accrue to consumers.

To achieve this mandate, the GATT was built upon the principle of non-discrimination espoused in Articles I and III. Article I (Most Favoured Nation) required that imports be accorded treatment no less favourable than that accorded to "like" imports sourced from another country. Article III (National Treatment) required that all imported goods be accorded treatment no less favourable than that accorded to

domestic "like" goods, where "like" in Article III(4) which relates directly to regulation, has since been interpreted as referring to "directly competitive or substitutable" (DCS) goods.[4] Case law has often understood DCS to mean products grouped according their end-uses or physical characteristics, or products corresponding to the same consumer preferences. From now on, the terms "like" and DCS shall be used interchangeably.

During the Uruguay Round of GATT negotiations (1987-1994), member states agreed to the establishment of the World Trade Organisation (WTO) which would administer the WTO Agreements including the original GATT along with various other agreements, such as the SPS Agreement. The principle of non-discrimination remained, and continues to remain, an important pillar in the international trading system.

Despite the importance of non-discrimination, it has since become evident that grouping products according to their end-use is problematic. Different production methods can alter the quality of the good, where *quality* refers to more than just a product's performance at the time of consumption, but may also reflect a product's health or environmental attributes. For example, imported and domestic Granny Smith apples are "like" if grouped according to their end-use, but if the imported Granny Smiths are grown using a harmful pesticide, "likeness" is less straightforward.

If the lower quality of an imported product is not observable at the time of purchase or consumption of the imported good implies negative externalities for third-parties, import purchases may be higher than socially desirable. Traditional gains from trade are no longer guaranteed and governments may be justified in intervening with health or environmental measures (such as minimum standards, bans) with an impact on trade that is detrimental to foreign producer profits. To the extent that consumers might be aware of the risks associated with imports, they may also, along with domestic import-competing lobbies, demand protection from imports.

If there are scientifically-proven risks associated with the consumption of traded goods, the WTO agreements allow members the opportunity of protecting themselves from such risks, in a manner that the members deem appropriate. Naturally, the intent behind the measure might be nothing more than domestic profit protection - governments might not care at all about consumer health or the environment.

[4] In Article III(2) disputes, "likeness" is interpreted as a strict subset of DCS. This paper is concerned with regulation, not internal taxation, and therefore Art. III(4) is the relevant article.

But intent in this case is unimportant. What is relevant are the real welfare gains accruing to consumers from health measures aimed at reducing the risks.

But assume that the imported Granny Smiths are identical to the domestic apples in every way, including the production process, but consumers erroneously believe the imports to be unsafe for themselves or the environment. Despite the fact that the imported apples are perfectly safe (or risk-free), real welfare losses are still possible because of consumption distortions associated with consumer misperceptions. Consumers might refrain from purchasing all types of Granny Smiths out of fear that they are purchasing the "risky" imports.

A welfare-enhancing role for a measure that has a negative impact on trade, but eliminates the consumption distortions associated with incorrect beliefs, still exists. Once more, the legitimacy of the measure should depend on its actual impact on welfare. Yet, without a well-defined, and therefore measurable, distortion, evaluating actual welfare improvements in a case of erroneous beliefs is exceedingly difficult. Moreover, perceptions based more on belief than on fact, or scientific evidence, are easier to manipulate for protectionist gain.

The challenge for any trade agreement (multilateral or bilateral) is to design rules treading the sometimes fine line between consumer protection and domestic producer protection. As two sides of the same coin, the rules must not only prevent measures aimed at consumer protection from being captured by producer lobbies, but they must also be sufficiently flexible to accommodate trade-distorting measures if such measures also reduce distortions associated with, *real or perceived*, risks.

An important aspect of the success of such trade rules is the extent to which the rules allow the exporting country to retaliate against an illegal measure with a negative impact on their exports. Retaliation, or a suspension of concessions as in *Hormones*, should serve as a deterrent to protectionist capture of health measures, but retaliation should also not be used so liberally as to make the burden of legitimate, or non-protectionist measures, unbearable.

As shown in the following sub-section, the SPS Agreement and the Technical Barriers to Trade (TBT) Agreement attempt to deal with this precarious balance by requiring that all measures claiming to protect consumers be based on a scientific assessment of the risks. That is, if a rational relationship between the measure and the risk exists, the measure is legal (assuming it meets the requirements of other rules in the relevant trade agreement) and the exporting country can not retaliate.

2.2 The WTO Case Law

It should be emphasised from the beginning that much of the initial discussion will focus on the treatment of "likeness" in the case law. While the interpretation of "like" is not the focus of this paper, and is not explored in the following model, the discussion is relevant in so far as it serves to highlight the manner in which this issue of real and perceived risks should be seen from an economic perspective.

While consumers might have perceptions regarding risks to the environment, the focus of this section is on risks to bodily health associated with consumption. This avoids consideration of when damage occurs extraterritorially, such as deforestation of the Amazon, or when it is trans-national, such as with air pollution.

With the scope of this section clearly defined, the WTO Agreements to be considered follow logically: the SPS Agreement, the TBT Agreement and the GATT. It is clear from the text of the SPS that it is *lex specialis* to the TBT. However, the SPS only covers foodstuffs for human or animal consumption and therefore only takes precedence over the TBT when trade measures on such products are at issue. Although the relationship between the GATT and the other two agreements has not yet been clarified, the argument can be made that adjudicating bodies should start with the SPS, move to the TBT if the SPS is not applicable (for example, if the measure does not involve foodstuffs) and then move to the GATT if the TBT is not applicable (Horn and Mavroidis, 2002).

I present the arguments of two cases below. In the first case, *Asbestos*[5] , the adjudicating bodies deferred to the GATT, instead of the TBT, because the Panel incorrectly concluded that the regulation, a ban on chrysotile asbestos fibres, was not a technical regulation. In the second case, *Hormones*, the adjudicating bodies deferred to the SPS Agreement.

2.2.1 The *Asbestos* Case

In *Asbestos*, Canada challenged a French ban on chrysotile asbestos fibres as a violation of Article III - non-discrimination. Both the Panel and the AB upheld the French ban on asbestos as legal, yet their approaches differed somewhat. In their paper, Horn and Weiler (2004) distinguish three methodologies exemplified by *Asbestos* for interpreting the ambit of Article III, but conclude that both the Panel and the AB approaches, although different, fall within the same methodology.

[5] *European Communities – Measures Affecting Asbestos and Asbestos-Containing Products* WT/DS135/AB/R February 2001

The Panel found that the ban violated Article III because France did not impose a restriction on the use of PCG fibres, which are "like" asbestos fibres. In their analysis of "like", the Panel considered the end-use, or functionality, of both products, which determined their substitutability and hence the degree to which the products were in actual or potential competition in the market place.

Because the ban had the effect of distorting competition between asbestos fibres and PCG fibres, in favour of PCG, the ban was found by the Panel to be in violation of III. The EC carried the burden of having to prove that its ban was legitimate under Article XX of the GATT which requires that

> Subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade, nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures:
>
> (a) necessary to protect public morals;
>
> (b) necessary to protect human, animal or plant life or health;
>
> .....

With sufficient scientific evidence pointing to the risks associated with asbestos, the EC was easily able to meet its burden under XX.[6] Commentators have referred to the Panel decision as "toxic logic" because "public health was left with the burden of proof" (Srinivas, 2001). The AB went some way in reversing this "toxic logic" by finding that the ban did not violate III, and therefore did not require justification under XX.

In its conclusion, the AB argued that,

> ...[the] dictionary definition of "like" does not indicate from whose perspective "likeness" should be judged. For instance, ultimate consumers may have a view about the "likeness" of two products that is very different from that of the inventors or producers of those products. (WT/DS135/AB/R, recital 92)

and:

[6] It is important to emphasise that unlike the SPS and TBT Ageements, Articles III and XX of the GATT do not require a scientific evidence of the risks.

> As products that are in a competitive relationship in the marketplace could be affected through treatment of imports "less favourable" than the treatment accorded to domestic products, it follows that the word "like" in Article III:4 is to be interpreted to apply to products that are in such a competitive relationship. Thus, a determination of "likeness" under Article III:4 is, fundamentally, a determination about the nature and extent of a competitive relationship between and among products. (WT/DS135/AB/R, recital 99)

and:

> If there is – or could be – *no* competitive relationship between products, a Member cannot intervene, through internal taxation or regulation, to protect domestic production. Thus, evidence about the extent to which products can serve the same end-uses, and the extent to which consumers are – or would be – willing to choose one product instead of another to perform those end-uses, is highly relevant evidence in assessing the "likeness" of those products under Article III:4 of the GATT 1994. (WT/DS135/AB/R, recital 117).

The AB argued that asbestos fibres and PCG fibres were "unlike". In their analysis of "like", the AB included factors that the Panel had ignored such as consumer tastes and habits. They argued that although little evidence was presented on consumer tastes, the ample evidence on the risks associated with asbestos, and the fact that such risks were well-known, indicates that asbestos and PCG were not in a competitive relationship - the AB assumed that consumers would choose the healthy product over the carcinogenic one. The AB approach is an extension of the methodology adopted by the Panel because its determination of "likeness" is based on an assumption relating to market-factors and the competitive relationship between asbestos and PCG fibres.

The competitive-relationship methodology does not make much sense from an economic perspective. If consumers possess all relevant information regarding risks, there is no need for the government to intervene, because consumers substitute away from the unhealthy good. However, if there are information asymmetries so that consumers do not substitute away from the unhealthy good, or if there are externalities associated with consumption of the unhealthy good, purchases of the good will be higher than is socially desirable, necessitating government intervention.

That is, government intervention is required where a competitive relationship exists, where one would not exist if consumers were fully informed.

But what if the lack of information, instead of leading to socially undesirable levels of consumption of an unhealthy good, leads to socially undesirable consumption levels of a perfectly healthy good? This might occur for two reasons.

First, consumers might substitute away from a lower cost good they incorrectly perceived to be associated with a risk, towards a more expensive good they believed, either correctly or incorrectly, to be healthy. Second, consumers might reduce consumption of both the perceived unhealthy and healthy goods if they can not distinguish between them at the time of purchase, such that there is a risk associated with the purchase of the good. Consumers fear that they might be purchasing the perceived unhealthy good. In the next section, I discuss the *Hormones* case. This case explicitly deals with a scenario where, contrary to the prevailing scientific evidence, consumers believed that imports posed a risk to their health.

2.2.2 The *Hormones* Case

Article 5.1 of the SPS Agreement requires that

> Members shall ensure that their sanitary or phytosanitary measures are based on an assessment, as appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organizations.

Article 5.2 of the SPS Agreement provides an indication of the factors that should be taken into account in the assessment of risk:

> In the assessment of risks, Members shall take into account available scientific evidence; relevant processes and production methods; relevant inspection, sampling and testing methods; prevalence of specific diseases or pests; existence of pest- or disease-free areas; relevant ecological and environmental conditions; and quarantine or other treatment.

The AB in *Hormones* interpreted 5.1 as requiring that the results of the risk assessment must "sufficiently warrant" or "reasonably support" the SPS measure at stake. Or, there must be "a rational relationship between the measure and the risk assessment."

The AB interpreted "relevant process and production methods" in 5.2 to include the risks to human health associated with improper, illegal or black-marketing methods, but the EC did not present any evidence on the risks arising from the improper administering of hormones to cattle.

Since both the Panel and the AB interpreted the evidence on the proper use of hormones in beef production as supporting the notion that hormones are safe for human consumption, both had no choice but to conclude that the measure was not based on a risk assessment and thus violated WTO law. But the EC did not lift its ban. It argued that removing the ban was politically untenable due to the public's concern regarding the quality of beef on its domestic market and removing the ban would have been more costly to the EC than the costs associated with the suspension of US and Canadian concessions.

One can only speculate as to whether the gains from domestic profit protection or the gains from the elimination of consumer fear were the sole driving forces for maintaining the ban. In all likelihood, it was probably a combination of the two. Under either conclusion, the gains to the EC from the ban must have exceeded the loss from retaliation and the suspension of concessions did nothing more than transfer some of those gains from the EC to the US and Canada. It can not be said with certainty whether, compared to the case of no ban and no retaliation, consumers were left better or worse off as a result.

2.2.3 Economic Aspects of the "scientific assessment requirement"

In the remainder of this paper, I refer to the "scientific assessment criterion" as the criterion where the legality of a health measure is determined according to whether it is based on a scientific assessment of the risks, such as that included in 5.1 of the SPS agreement. To understand the role the criterion might play in promoting economic efficiency, it is useful to begin by analysing the way in which the Panel/AB methodology would handle a scenario where consumers erroneously perceived a scientifically-proven healthy import, to be unhealthy.

To the extent that the imported and healthy domestic good would not be in a competitive relationship, according to the Panel/AB methodology, it would be impossible for the government to intervene to protect domestic profits. Yet, there are several problems associated with this interpretation.

First, it ignores the fact that the lack of a competitive relationship is based on incorrect information. Moreover it ignores the extent to which these mis-perceptions

could have been created for protectionist intent. Second, absent any other information inefficiencies or externalities, consumers, based on the information they do possess, are optimising their consumption bundles by substituting away from the perceived unhealthy good. There is no need for government intervention other than to correct the information imperfections, if the imported good is cheaper and will imply gains for consumers if they knew the import to be safe. Therefore, an adjudicating body will have to ask themselves why the measure being challenged exists at all. That is, why would a government be imposing a health measure on a risk-free import if the import is not in a competitive relationship with a domestic substitute? The simple answer must be that the competitive relationship does exist. But this in itself does not mean that the measure is protectionist.

When might such a measure, in the absence of scientific evidence, be protectionist? It may be that the claimed consumer mis-perceptions do not really exist, or that a proportion of consumers are correctly informed. Or, the lower import price might be sufficient to compensate for the perceived differences in qualities, making the import an optimal substitute for the domestic good. In these examples, the "scientific assessment requirement" is an objective mechanism for determining the protectionist intent behind the measure, without having to rely on more subjective tests, such as tests attempting to directly determine the intent behind the measure.[7]

If governments know that they can justify a ban aimed at protecting the domestic producer surplus on the basis of consumer beliefs, because a scientific assessments is not a separate requirement, they might have an incentive to influence consumer information prior to adopting a measure. Moreover, even if consumer fears are not created by the government, a ban, by preventing consumers from learning the true quality of the imported good, may perpetuate the erroneous beliefs which are not *first-best* in a multi-period model if consumers could learn true quality from consumption..

On the other hand, the criterion may throw-out legitimate measures aimed at reducing welfare-deteriorating consumption distortions. A competitive relationship between the import and domestic good would exist if other information gaps existed,

[7] The difficulties associated with determining intent are highlighted in *Hormones* by the differing Panel and AB conclusions reached regarding Article 5.5. The Panel concluded that the ban was a disguised restriction on trade because it *de facto* discriminated against the US producers, the majority of which were hormone-using, and because the EC had large beef surpluses in its market after integration. The AB disagreed and concluded that the intent was not to protect domestic beef producers, but rather to reassure consumers regarding the quality of beef on their domestic markets, after scares relating to BSE, foot-and-mouth and black-marketing.

preventing consumers from distinguishing the perceived unhealthy import from the healthy domestic product, leading to inefficient consumption levels of both goods. For example, consumers might not be able to distinguish country-of-origin and stop purchasing both the domestic and the imported good for fear of buying the "risky" import. A measure reducing the perceived risk and encouraging consumption of the domestic good might have a clear, welfare-enhancing role.

Requiring governments, or adjudicating bodies, to consider the competitive relationship *as if* consumers have perfect information, does not eliminate the fact that the competitive equilibrium is determined based on imperfect information. By completely ignoring consumer beliefs not based on science, the costs associated with consumption distortions are also ignored.

But the criterion forces governments to find other solutions to the consumption distortions associated with consumer mis-perceptions rather than using a measure that impacts negatively on imports. Clearly, properly informing consumers is *first-best*. Yet, it may be that the governments can not properly inform consumers of the scientific evidence because consumers may not trust their leaders, the scientific experts or may not understand all the evidence.

In the model that follows, I consider an additional benefit of the "scientific assessment criterion". Until now I have ignored how consumer beliefs are formed. But in the model, I show that consumer beliefs crucially depend on consumer understanding of the political trading system. That is, if quality is not observable, consumers take into account the incentive for their government to allow an unhealthy good on their market. This incentive will depend on the extent to which their trading partners can retaliate against a measure on an unhealthy good. I show, that by allowing a foreign government the option of tariff retaliation against a measure imposed by a importing country on that foreign country' exports, only if the exports are healthy, consumers in the importing country do not have to fear that their government is being forced to accept an unhealthy import from that foreign country. There is no tariff retaliation on measures imposed on unhealthy imports.

The model is not intended to be general but rather provides an interesting example of where the "scientific assessment requirement" results in *first-best*. I also hope to highlight some of the complexities associated with this issue.

3 The Model

Assume a two-country, two-good partial equilibrium model. Countries are called E and U. One firm from each country produces a homogeneous product x sold and consumed in country E only. Conversely, one firm from each country produces a homogeneous product y sold and consumed in country U only. The two markets are segmented, and firms compete in Cournot fashion in each separate market. I will mainly focus on the market in country E, and when referring to the market for product y in country U I will use subscript y.

Recent technological innovations have resulted in a cost-saving technology in the x-producing U firm but the consequent health effects for E consumers from consuming the imported product are uncertain. It is common knowledge that the nature of the innovation, denoted θ, is either safe ($\theta = \overline{\theta}$) with probability α_0, or unhealthy ($\theta = \underline{\theta}$) with probability $1-\alpha_0$, where α_0 is exogenously determined. The U firm holds the patent to the innovation and the technology is available to it only.

At the outset, the government in E, which can be one of two types (governments discussed in more detail below), decides whether to ban or admit the new technology.

Consumers. There is a continuum of consumers on support $[0, 1]$ with unitary density, differing in their evaluation of the healthy product. Each consumer demands zero or one unit of the good. The gross utility of a consumer of type m when purchasing the heathy product is m, while it is $k < -1$ if purchasing the unhealthy product. Consumers vary in their appreciation of the safe product, but for simplicity, everyone experiences the same disutility when consuming the unsafe product.

Consumers do not observe θ or country-of-origin when a unit of the product is purchased, but they do know that only imported products are potentially beset with a health problem. Care must be taken to distinguish between a consumer's belief, α, that a unit of x produced by the U firm is safe and a consumer's belief, δ, that a unit purchased is healthy (because consumers do not observe whether they are purchasing a unit produced in E or U).

While α depends on α_0 and the equilibrium strategies of each type of E government and is updated according to Bayes Theorem (see below), δ is a function of α and consumer understanding regarding the proportion of U output in total x output sold by both firms (see below in the section on firms).

Consumers' willingness to pay is a function of δ. With the reservation expected

utility being 0, and the price of the product denoted p, all consumers for which

$$\delta m + (1-\delta)k \geq p$$

will purchase the product, that is, consumers with

$$\begin{aligned} m &\geq M(p,\delta,k) \\ &\equiv \frac{p}{\delta} - \frac{1-\delta}{\delta}k \end{aligned}$$

This yields a total demand $Q(p,\delta,k)$ which can be written as

$$Q(p,\delta,k) \equiv 1 - (\frac{p}{\delta} - \frac{1-\delta}{\delta}k)$$

Letting q_e and q_u be each firms Cournot output and $Q(p,\delta,k) = q_e + q_u$, inverse demand can be written as

$$p = \delta(1 + \frac{(1-\delta)}{\delta}k - q_u - q_e)$$

Firms. If the product produced by means of the innovative technology is banned, the U and E firms have marginal costs, denoted by $\tilde{c}_u > c_e > 0$. If the innovation is admitted, $c_u = 0$. Profits for each firm are given by

$$\begin{aligned} \Pi_e &= (p - c_e)\, q_e \\ &= (\delta + (1-\delta)k - \delta(q_e + q_u) - c_e)\, q_e \\ \Pi_u &= (p - c)\, q_u \\ &= (\delta + (1-\delta)k - \delta(q_e + q_u) - c)\, q_u \end{aligned}$$

where $c \in \{c_u; \tilde{c}_u\}$.

Firms choose output to maximise profits. Profits depend on both consumer perception of the probability of the product purchased being safe, as well as whether the innovative technology is permitted, since this affects costs in the U-firm.

Let $Q_u(\delta, c, c_e, k)$ and $Q_e(\delta, c, c_e, k)$ be each firm's equilibrium Cournot outputs. Then $r_u(\delta, c, c_e, k)$ is the equilibrium proportion of U output to total output:

$$r_u(\delta, c, c_e, k) \equiv \frac{Q_u(\delta, c, c_e, k)}{Q_u(\delta, c, c_e, k) + Q_e(\delta, c, c_e, k)}$$

For simplicity, I assume that if the innovation is banned, the U firm can not prof-

itably compete with the E firm which consequently holds a monopoly position in the market. That is, I restrict attention to the case where

$$\tilde{c}_u \geq \frac{1+c_e}{2}$$

and $Q_u^B(\delta, \tilde{c}_u, c_e, k) = r_u^B(\delta, \tilde{c}_u, c_e, k) = 0$ where the superscript refers to the decision to ban the innovation. Assuming that consumers rationally know the proportion of products being imported, it must be that

$$\delta^B = 1 - r_u^B(\delta, \tilde{c}_u, c_e, k) + \alpha r_u^B(\delta, \tilde{c}_u, c_e.k) = 1$$

Monopoly profits and output for the E firm under a ban are

$$\begin{aligned} Q_e^B(1, c_e) &= \frac{1}{2}(1 - c_e) \\ \Pi_e^B(1, c_e) &= \frac{1}{4}(1 - c_e)^2 \end{aligned}$$

The condition for positive E output under a ban is $c_e < 1$ which I assume to hold.

For simplicity, I assume that if the innovation is admitted, the E firm is driven out of the market. E's marginal costs are too high to profitably compete with the U firm, regardless of consumer beliefs. For this to be true, the following condition must be met

$$c_e \geq \frac{\delta + (1-\delta)k}{2}$$

which is increasing in δ and I restrict attention to the case where $c_e \in [\frac{1}{2}, 1)$.

If the innovation is accepted $Q_e^A(\delta, 0, c_e, k) = 0$ for all $\delta \in [0, 1]$, where the superscript refers to the decision to accept the innovation. Assuming that consumers rationally know that under an acceptance $r_u^A(\delta, 0, c_e, k) = 1$ for all $\delta \in [0, 1]$, it must be true that

$$\delta^A = 1 - r_u^A(\delta, 0, c_e, k) + \alpha r_u^A(\delta, 0, c_e.k) = \alpha$$

where α depends on α_0 and government equilibrium strategies. Monopoly profits and output for the U firm under an acceptance are

$$\begin{aligned} Q_u^A(\alpha, 0, k) &= \frac{1}{2\alpha}(\alpha + (1-\alpha)k) \\ \Pi_u^A(\alpha, 0, k) &= \frac{1}{4\alpha}(\alpha + (1-\alpha)k)^2 \end{aligned}$$

The condition for positive U output under an acceptance is

$$\alpha > \frac{-k}{1-k} \tag{3.1}$$

which I assume to always hold. By (3.1),

$$\frac{\partial \Pi_u^A(\alpha, 0, k)}{\partial \alpha} = \frac{1}{4\alpha^2}\left(\alpha + (1-\alpha)k\right)\left(\alpha - k(\alpha+1)\right) > 0$$

Governments. In country E, government comes in two types: "health-friendly" (H) and "firm-friendly" (F) . For ease of exposition, I assume that in country U government comes in one type only, namely type F.

An F government is only concerned with maximising profits of its domestic firms (in both sectors), while an H government maximises national welfare, defined as the sum of consumer and producer surplus. The E government knows its own type, but its type is unknown to consumers and to the U government. The probability of a government in E being of type F is λ, which is common knowledge. Crucial to the analysis, I assume governments in both countries know the state of nature or $\theta \in \left\{\underline{\theta}; \overline{\theta}\right\}$.

Government Policy Options. The aim of this paper is to try to determine under what conditions, if any, it is optimal for a non-protectionist (H) government to ban a healthy import. In this sense, the aim is to try to determine under what conditions consumption distortions associated with beliefs (based on imperfect information) about a products' quality, are sufficient to outweigh the cost savings implied by that import.

I show that opinion formation not only depends on the equilibrium behaviour of consumers' own government but also on the behaviour of the government exporting the product of uncertain health implications. This interrelation provides an economic rationale for the "scientific assessment requirement".

The complexity of such questions means that, for tractability, assumptions about the policies and possible equilibrium strategies available to each government must be made. Therefore, this paper does not strive for generalities but instead tries to pick out some interesting aspects of the consumption distortion problem.

I assume that the E government only has the policy tools "ban the innovation" or "accept the innovation" The strategies adopted by each E type, or when each E type decides to ban or accept the innovation, will depend on the state of nature, θ. I rule out tariffs in E if the innovation is accepted (the E government has no need

for tariffs if it bans the innovation). This latter assumption is mostly for tractability but it also fits the evidence. Most developed economies have bound tariff rates at very low levels, thus increasing the importance of non-tariff measures in their trade policy.

Let $\Pi_{ye}(\tau_u) > 0$ be the producer surplus of country E firm(s) selling good y in U. The size of $\Pi_{ye}(\tau_u)$ depends *inter alia* on market size, the competitive nature of the market and marginal costs of the firms (E and (possibly) U firms).

I do not explicitly model the y market but note that $\Pi_{ye}(\tau_u)$ is negatively related to τ_u, the tariff rate on imports of y; $\tau_u \geq 0$ is not prohibitive.

U has three strategies from which to choose. First, U can keep the tariff rate unchanged at τ_u regardless of whether E accepts the innovation and regardless of the state of nature. I refer to this first strategy as the *no-retaliation strategy.*

Second, if U adopts the *threat strategy*, it raises the tariff rate to $\tilde{\tau}_u > \tau_u$, if E bans the innovation regardless of the state of nature. This strategy can be interpreted as a threat to E never to ban U exports.

Third, U can choose to keep tariff rates at τ_u if E bans an unhealthy innovation, but choose to raise tariffs to $\tilde{\tau}_u > \tau_u$ if E bans a healthy innovation. This *health strategy* can be interpreted as U respecting E's choice to keep an unhealthy import from entering the market. Although U observes the state of nature when the innovation is developed, I assume that U must commit to one of these strategies *before* the state of nature is revealed.

The *threat strategy* can be formally written as:

$$\Pi_{ye}(\tau_u) = \Pi^A_{ye}(\tau_u) > \Pi^B_{ye}(\tilde{\tau}_u) \geq 0 \tag{3.2}$$

where $\Pi^A_{ye}(\tau_u)$ is E producer surplus without tariff retaliation (if E accepts the innovation) and $\Pi^B_{ye}(\tilde{\tau}_u)$ is E producer surplus if U tariff retaliates in response to a ban. Likewise, the *no-retaliation strategy* can formally be written as:

$$\Pi_{ye}(\tau_u) = \Pi^A_{ye}(\tau_u) = \Pi^B_{ye}(\tau_u) > 0$$

Finally, the *health strategy* can formally be written as

$$\Pi_{ye}(\tau_u) = \Pi^A_{ye}(\tau_u) = \underline{\Pi}^B_{ye}(\tau_u) > \overline{\Pi}^B_{ye}(\tilde{\tau}_u) \geq 0$$

where $\underline{\Pi}^B_{ye}(\tau_u)$ and $\overline{\Pi}^B_{ye}(\tilde{\tau}_u)$ indicate E producer surplus from exports of good y when E bans imports of an unhealthy and healthy innovation respectively. Moreover,

$\overline{\Pi}^B_{ye}(\tilde{\tau}_u) = \Pi^B_{ye}(\tilde{\tau}_u)$ indicating that the magnitude of retaliation is unaffected between strategies, but rather *when* retaliation is used (as a function of the state of nature) changes across strategies.

The strategy chosen by U will depend on their beliefs (λ) about E government type, the state of nature (θ) and consumer beliefs α. I assume that the following condition is always true:

$$\Pi^A_{ye}(\tau_u) - \Pi^B_{ye}(\tilde{\tau}_u) > \Pi^B_e \tag{3.3}$$

The following sections proceed as follows. First, taking U's strategy as given, I determine the equilibrium strategies adopted by each E government type. By fixing U's strategy I can show how public opinion (beliefs) not only depend on E government behaviour but also on U government behaviour.

I provide an example, where given U's strategy, it is optimal for an H government to ban a healthy import despite the cost saving implied by the innovation. Second, given each E type's response to U's behaviour and the consequent formation of consumer beliefs, I discuss U's incentive to adopt the strategies I treated as given in the previous sections. I show that U has an incentive to adopt the *health strategy*. This supports the inclusion of the "scientific assessment criterion" in trade agreements, such as Article 5.1 in the SPS Agreement.

4 Welfare in E Under an Import Ban

I made the assumption above that the U firm can not profitably compete under a ban and therefore exits from the E market. If consumers could not observe the marginal costs of each firm, they would not know that the U firm exits under a ban and would therefore have to use some other rule for determining δ^B. However, I assume that consumers do observe marginal costs and consequently have beliefs $\delta^B = 1$.

Under a ban, the equilibrium marginal consumer and the equilibrium price are equal and are given by

$$\begin{aligned} M^B(P^B(1, c_e), 1) &= P^B(1, c_e) = 1 - Q^B_e(1, c_e) \\ &= \frac{1}{2}(1 + c_e) \end{aligned}$$

Consumer surplus under a ban can be written as

$$\begin{aligned} S^B(1,c_e) &= \int_{M^B(P^B(1,c_e),1)}^{1} (m - P^B(1,c_e))dm \\ &= \int_{\frac{1}{2}(1+c_e)}^{1} (m - \frac{1}{2}(1+c_e))dm \\ &= \frac{1}{8}(1-c_e)^2 \end{aligned}$$

Welfare under the H government is defined as the sum of producer and consumer surplus or

$$\begin{aligned} W_H^B &= S^B(1,c_e) + \Pi_e^B(1,c_e) + \Pi_y^B \\ &= \frac{3}{8}(1-c_e)^2 + \Pi_y^B \end{aligned}$$

where $\Pi_y^B \in \left\{\Pi_{ye}^B(\tilde{\tau}_u); \Pi_{ye}^B(\tau_u)\right\}$ depending on the strategy adopted by the U government.

5 Welfare in E Under an Acceptance

Because consumers observe costs and know that the E firm must exit under an acceptance, $\delta^A = \alpha$. Regardless of the state of nature, the equilibrium price and marginal consumer under an acceptance equal

$$\begin{aligned} P^A(\alpha,0,k) &= \alpha(1 + \frac{(1-\alpha)}{\alpha}k - Q_u^A(\alpha,0,k)) \\ &= \frac{1}{2}(\alpha + (1-\alpha)k) \end{aligned}$$

$$\begin{aligned} M^A(P^A(\alpha,0,k),\alpha,k) &= \frac{P^A(\alpha,0,k)}{\alpha} - \frac{(1-\alpha)}{\alpha}k \\ &= \frac{1}{2\alpha}(\alpha + (1-\alpha)k) - \frac{1-\alpha}{\alpha}k \end{aligned}$$

Consumer surplus depends on the state of nature, which governments are assumed to know. The H government will evaluate consumer surplus taking the true safety of the product into consideration. Let $\overline{S}$ and $\underline{S}$ be consumer surplus given $\theta = \overline{\theta}$

and $\theta = \underline{\theta}$ respectively. It follows that

$$\begin{aligned}\bar{S}^A(\alpha,0,k) &= \int_{M^A(P^A(\alpha,0,k),\alpha,k)}^{1}[m - P^A(\alpha,0,k)]dm \\ &= \frac{(\alpha+(1-\alpha)k)}{8\alpha^2}\left(3\alpha - k - k\alpha - 2\alpha^2 + 2k\alpha^2\right)\end{aligned}$$

At $\alpha = 1$,

$$\bar{S}^A(1,0,k) > S^B + \Pi_e^B$$

for all $c_e \in [\frac{1}{2}, 1)$. A healthy innovation, that is perceived to be healthy by consumers, generates consumer surplus gains exceeding the loss in domestic monopoly profits. Moreover,

$$\frac{\partial \bar{S}^A}{\partial \alpha} = \frac{1}{2}k - \frac{1}{4} - \frac{1}{4}\frac{k}{\alpha^2} - \frac{1}{4}k^2 + \frac{2}{8}\frac{k^2}{\alpha^3}$$

$$\frac{\partial^2 \bar{S}^A}{\partial \alpha^2} = \frac{2}{4}\frac{k}{\alpha^3} - \frac{6}{8}\frac{k^2}{\alpha^4} < 0$$

and $\bar{S}^A(\alpha,0,k)$ is concave in the relevant range $\alpha \in (\frac{-k}{1-k}, 1]$. Let $\breve{\alpha}(k)$ be the solution to $\frac{\partial \bar{S}^A}{\partial \alpha} = 0$ where $\breve{\alpha}(k) \in (\frac{-k}{1-k}, 1)$. Consumer scepticism can lead to welfare gains when a healthy innovation is admitted, compared to the case where consumers believe the good to be healthy with probability one because

$$\bar{S}^A(\breve{\alpha}(k),0,k) > \bar{S}^A(1,0,k) > S^B + \Pi_e^B$$

The monopoly output and price both decrease with α. Initially the price decrease outweighs the decline in consumption, and because the consumers deriving the lowest utility exit first, a lower α increases consumer surplus. But eventually the decline in consumption exceeds the decline in price and consumers deriving relatively higher utility begin to exit. Consumer surplus begins to decrease if $\alpha < \breve{\alpha}(k)$.

$$\begin{aligned}\underline{S}^A(\alpha,0,k) &\equiv \int_{M^A(P^A(\alpha,0,k),\alpha,k)}^{1}[k - P^A(\alpha,0,k)]dm \\ &= \frac{(\alpha+(1-\alpha)k)}{4\alpha}\left(k - \alpha + k\alpha\right)\end{aligned}$$

and $\underline{S}^A < 0$ and $\frac{\partial \underline{S}_A}{\partial \alpha} < 0$ for all $\alpha \in (\frac{-k}{1-k}, 1]$. Welfare of the H government under an acceptance is defined as the sum of producer and consumer surplus or

$$W_H^A = S^A + \Pi_{ye}^A$$

where $S^A \in \left\{\underline{S}^A; \bar{S}^A\right\}$. Domestic profits are zero and there is no tariff retaliation under an acceptance.

6 Optimal Ban of a Healthy, Lower Cost Import

I initially treat the strategy adopted by U as given and determine an equilibrium in E strategies and consumer beliefs given that strategy. In this section I assume that U always adopts the *threat strategy* and that the government and consumers in E know this to be the case. In later sections I explore the incentive for U to adopt such a strategy. In this and all following sections, I consider only pure strategy equilibria.

Given U's *threat strategy*, I show that an equilibrium exists where H prefers to ban a healthy import, despite the resource cost associated with moving to the higher cost domestic firm. The ban is the result of consumption distortions associated with consumer beliefs α. Suppose that the (separating) equilibrium strategies of each E government type are:

$$F \text{ always accepts}$$
$$H \text{ always bans}$$

Given the equilibrium strategies, if consumers observe a ban, they know that the government type is H, but the information is not useful because consumer beliefs about import safety are irrelevant under a ban. Observing an acceptance indicates to consumers that an F government has admitted either a safe or an unsafe product. Based on the specified equilibrium strategies and Bayes rule, the equilibrium assessment of the probability of the imported product being healthy is simply

$$\begin{aligned} \alpha &= \frac{\lambda\alpha_0}{\lambda} \\ &= \alpha_0 \end{aligned}$$

where the denominator is the probability of observing an acceptance and the numerator is the probability of observing a healthy acceptance. That is $\delta^A = \alpha = \alpha_0$.

Assuming that F always accepts, it is optimal for H to always ban given the equilibrium assessment α_0 if:

$$S^B + \Pi_e^B + \Pi_y^B(\tilde{\tau}_u) \geq S^A(\alpha_0, 0, k) + \Pi_{ye}^A(\tau_u)$$

where H bans if the condition holds with equality. Given $S^A \in \left\{\underline{S}^A; \bar{S}^A\right\}$, the binding constraint for H to always ban is

$$S^B + \Pi_e^B - \bar{S}^A(\alpha_0, 0, k) \geq \Pi_{ye}^A(\tau_u) - \Pi_y^B(\tilde{\tau}_u) \tag{3.4}$$

(3.4) depends on α_0 and the extent of tariff retaliation. Since $S^B + \Pi_e^B < \bar{S}^A(1, 0, k)$, (3.4) can only hold if $\bar{S}^A(\alpha_0, 0, k) < \bar{S}^A(1, 0, k)$ which implies that $\alpha < \breve{\alpha}(k)$.

There are real resource costs from banning because of tariff retaliation and because domestic production costs are higher. But the domestic monopoly profits combined with the real gains in consumer welfare can justify a ban. That is, the distortions in consumption must reduce consumer surplus sufficiently to compensate for the losses from tariff retaliation and higher production costs.

Assuming that H always bans, it is optimal for F to always accept given the equilibrium assessment α_0 if

$$\Pi_{ye}^A(\tau_u) > \Pi_e^B + \Pi_{ye}^B(\tilde{\tau}_u) \tag{3.5}$$

(3.5) is independent of α_0 and is solely determined by the extent of tariff retaliation. By (3.3), (3.5) always holds. Combining constraints for both types of government, and given the *threat strategy* by U, the strategies "ban always" for H and "accept always" for F constitute an equilibrium if

$$S^B + \Pi_e^B - \bar{S}^A(\alpha_0, 0, k) \geq \Pi_{ye}^A(\tau_u) - \Pi_y^B(\tilde{\tau}_u) > \Pi_e^B \tag{3.6}$$

The loss in export profits exceeds Π_e^B. Therefore,

$$S^B - \bar{S}^A(\alpha_0, 0, k)$$

must exceed the net loss from lower producer profits in both sectors.

While (3.6) is a necessary condition for the equilibrium to hold, it is not sufficient. It must be the case that no type has an incentive to deviate. This is straightforward to show in the case of the F type. A deviation by F does not alter the size of profit losses however it may change consumer beliefs, that is α may no longer equal α_0 if F deviates. But (3.5) is independent of beliefs and F has no incentive to deviate.

The same is not true for an H deviation since (3.4) is a function of α. I have complete freedom to specify any out-of-equilibrium beliefs supporting the above separating equilibrium. For example, H has no incentive to deviate to the strategy

"ban if $\theta = \underline{\theta}$, accept if $\theta = \overline{\theta}$" if consumers believe that F accepts always but H accepts only if $\theta = \underline{\theta}$. But restricting beliefs to "reasonable beliefs" (Cho and Kreps, 1987) I can show that H may have an incentive to deviate to a strategy where it "bans if $\theta = \underline{\theta}$, accepts if $\theta = \overline{\theta}$" if

$$S^B + \Pi_e^B - \bar{S}_A(\tilde{\alpha}, 0, k) \geq \Pi_{ye}^A(\tau_u) - \Pi_y^B(\tilde{\tau}_u) > \Pi_e^B \tag{3.7}$$

where

$$\tilde{\alpha} = \frac{\alpha_0\lambda + (1-\lambda)\alpha_0}{\lambda + (1-\lambda)(\alpha_0)} > \alpha_0 \tag{3.8}$$

Consumers reasonably know that H has an incentive to deviate to an acceptance only *if* the deviation increases consumer surplus (and hence H's payoff). This is possible only if $\theta = \overline{\theta}$ and therefore the beliefs specified in (3.8) are "reasonable".

But H only deviates if the gains in consumers surplus are sufficiently large, that is if (3.7) holds. I have shown that $S^B + \Pi_e^B < \bar{S}^A(1, 0, k)$ and that (3.4) can only hold if $\bar{S}^A(\alpha_0, 0, k) < \bar{S}^A(1, 0, k)$. Therefore, a deviation generating $\tilde{\alpha} > \alpha_0$ must result in consumer surplus gains. But since the consumption distortions are not completely eliminated because there is still a risk of consumers observing an acceptance of an unhealthy innovation by the F type, the gains in consumer surplus may be insufficient to make the deviation worthwhile.

Proposition 1: *The more likely consumers are to perceive the acceptance to be that of the unhealthy good by the F government, the less incentive has H to accept a healthy innovation. (refer to the example in the Appendix).*

Proof: For all $\tilde{\alpha}$ such that $\alpha_0 < \tilde{\alpha} < \breve{\alpha}(k)$ and

$$S^B - \bar{S}_A(\tilde{\alpha}, 0, k) \geq \Pi_{ye}^A(\tau_u) - \Pi_y^B(\tilde{\tau}_u) - \Pi_e^B > 0 \tag{3.9}$$

the strategies where H always bans and F always accepts are optimal strategies given U adopting the *threat strategy*. For all $\tilde{\alpha} < \breve{\alpha}(k)$ where (3.9) does not hold or for all $\breve{\alpha}(k) \leq \tilde{\alpha} \leq 1$, H accepts if $\theta = \overline{\theta}$. But

$$\tilde{\alpha} = \frac{\alpha_0\lambda + (1-\lambda)\alpha_0}{\lambda + (1-\lambda)(\alpha_0)} \tag{3.10}$$

and $\frac{\partial\tilde{\alpha}}{\partial\lambda} < 0$ and $\frac{\partial(\tilde{\alpha}-\alpha_0)}{\partial(\lambda)} < 0$. END OF PROOF.

I have shown that a ban on a healthy import is not illogical from the point of view of a government maximising national consumer surplus given the *threat strategy*

adopted by U. I discuss U's incentive to adopt this strategy in the following sections.

The question remains whether the ban is logical from a global perspective. Once more, I do not strive for generalities but ask the following simple question: *given that countries have bound their tariffs at zero (there is no retaliation) and consumers believe that if they observe an acceptance it can only be the F type accepting the innovation regardless of the state of nature, is a ban optimal from a global perspective?*

Global welfare is maximised under a ban if

$$S^B + \Pi_e^B - \bar{S}_A(\alpha_0, 0, k) - \Pi_u^A > 0$$

Proposition 2: *If consumers do not observe the state of nature, $\theta = \overline{\theta}$, and are sufficiently pessimistic regarding the quality of the goods on their market, a ban on a healthy, lower cost import can, under certain conditions, maximise global welfare by eliminating consumption distortions associated with consumer pessimism.*

The ban results in a resource cost to the economy because the lower cost U firm and its producer surplus are forced from the market and replaced by the higher cost E firm. However consumption distortions under an acceptance impose costs on the global economy in the form of lower profits for the U firm and lower consumer surplus than if $\alpha_0 < \alpha \leq 1$. In the example at the end of the paper, $\Pi_u^A(\alpha_0) < \Pi_e^B$ because the consumption distortions outweigh the gains to U profits from using the cost-saving innovation in the first place. But the U firm continues to use the innovation because without it it is forced out of the market anyway.

Given that it is the *threat strategy* adopted by U that leads to the beliefs $\alpha = \alpha_0$, one might want to include this in the evaluation of whether a ban is globally optimal. Tariff retaliation by U on its imports of y results in a transfer of rent from the E firm to U consumers, U firms (if any) or both. These transfers do not represent a welfare loss to the global economy. Rather the distortions in the efficient use of resources associated with a positive tariff would have to be taken into account. But these distortions might be sufficiently small to make banning the global optimum even if U retaliates with a positive tariff, that is

$$S^B + \Pi_e^B - \bar{S}_A(\alpha_0, 0, k) - \Pi_u^A + \Delta > 0$$

where Δ can be considered the efficiency loss associated with the use of tariff retaliation.

The result that a ban might be logical from an economic, or welfare, perspective, crucially depends on the equilibrium assessment $\alpha = \alpha_0$ which crucially depends on the assumption regarding the nature of U's retaliation strategy. It is the nature of the retaliation strategy that results in F always accepting. In the following section, I consider both the *no-retaliation strategy* and the *health strategy*.

7 Retaliation Strategies by U and the Decision to Ban

Assume that U adopts the *no-retaliation strategy*. Since $\Pi_e^B > 0$, it is straightforward to show that F always bans irrespective of the state of nature. F's optimal strategy continues to be independent of consumer beliefs and therefore independent of the strategy adopted by H. Given that F always bans, the optimal strategy for H must be to accept when $\theta = \overline{\theta}$ and ban when $\theta = \underline{\theta}$.

To see why, note that if F always bans, and if consumers observe an acceptance, they know that it must be the H government accepting. Since H never accepts an unhealthy good if there is no tariff retaliation the H type has no incentive to deviate from the strategy to accept when $\theta = \overline{\theta}$ and ban when $\theta = \underline{\theta}$ because

$$\underline{S}^A < \overline{S}^A(\alpha_0, 0, k) < S^B + \Pi_e^B < \overline{S}^A(1, 0, k)$$

Assume that U adopts the *health strategy*. The strategy choice by F continues to be independent of beliefs and therefore independent of the strategy adopted by H. However,because F's strategy depends on the tariff retaliation threat, F's strategy is now a function of the state of nature. It is straightforward to show that the optimal strategy adopted by F must have F banning when $\theta = \underline{\theta}$ and accepting when $\theta = \overline{\theta}$ because

$$0 < \Pi_e^B < \Pi_{ye}^A(\tau_u) - \Pi_y^B(\tilde{\tau}_u)$$

The optimal strategy for H must be identical to that for F since H never accepts an unhealthy good if there is no tariff retaliation. If consumers observe an acceptance, they understand it to be either the H or F government accepting a healthy good and $\alpha = 1$.

It remains to show that global welfare is maximised if U adopts the *health strategy*. Under the *health strategy* both E types accept a healthy innovation and ban an unhealthy innovation and neither has an incentive to deviate from this strategy

since they observe θ. Therefore,global welfare is maximised under the *health strategy* because

$$S^B + \Pi_e^B < \overline{S}^A(1,0,k) + \Pi_u^A(1,0,k)$$

and for all α in the relevant range it can be shown that

$$\underline{S}^A + \Pi_u^A(1,0,k) = \left(-\frac{1}{2}\right)\alpha^{-1}\left(k\alpha - \alpha - k\right)k < 0$$

Also,

$$\frac{\partial \Pi_u^A}{\partial \alpha} + \frac{\partial \overline{S}^A}{\partial \alpha} = \left(-\frac{1}{4}\right)\alpha^{-3}\left(\alpha - k + k\alpha\right)k > 0$$

The previous discussion should highlight that when there is an F government that does not take consumer health or surplus into consideration when making its decisions to ban or accept, the manner in which tariff retaliation is applied determines the extent of the inefficiencies in the global economy. If consumers do not observe θ, the interaction between the F types' optimal strategies and tariff retaliation, determine the optimal strategies for H through consumer beliefs or α.

The discussion also highlights the role that a "scientific assessment criterion" might play. In most of the literature looking at such a requirement in trade law, the authors emphasise the role played by the requirement in helping arbitrators to a dispute distinguish between a measure whose main aim is the protection of domestic profits, compared with one whose aim is the protection of consumer surplus. It is argued that the threat of tariff retaliation against a ban on a healthy import prevents a protectionist government from adopting a ban.

While this is recognised in this paper, the model goes one step further in recognising that if tariff retaliation is itself not constrained, this might force protectionist governments to adopt strategies that hurt their own consumers, for example, when a F type accepts an unhealthy import. In the following section, I consider U's incentive to adopt the *health strategy* and therefore implicitly accept to be bound by a "scientific assessment requirement".

8 U's Incentives to Adopt the *health strategy*

In the earlier sections I treated U's strategy as given and found that banning a healthy import is not illogical from an economic perspective if U adopts a *threat strategy*. In this section, I ask whether U ever adopts the *threat strategy*, knowing

that such a strategy affects consumer beliefs in a way that harms U profits.

U must commit to its strategy prior to learning the state of nature and U does not observe E's type. I assume that (3.7) holds, that is, λ is sufficiently high such that H bans a healthy innovation under a *threat strategy*.

In an equilibrium where U adopts the *threat strategy*, only F accepts the innovation and U earns expected profits of $\lambda\Pi_u^A(\alpha_0, 0, k)$. In an equilibrium where U adopts the *health strategy*, both F and H accept the healthy innovation and U earns expected profits of $\alpha_0\Pi_u^A(1, 0, k)$. In an equilibrium where U adopts the *no-retaliation strategy*, only H accepts the innovation if it is safe and U earns expected profits of $(1-\lambda)\alpha_0\Pi_u^A(1, 0, k)$.

The PBE concept governs beliefs "on the equilibrium path", but beliefs "off the equilibrium path" can be freely determined. Therefore it is conceivable that "off the equilibrium path" beliefs exist such that any of the equilibria in the previous paragraph constitute a PBE. However as is usual, I will refine beliefs by requiring that they be "reasonable".

Consider the PBE where U adopts the *no-retaliation strategy* but consumers observe a deviation to the *health strategy*. Consumers know that the F's strategy "accept if $\theta = \overline{\theta}$, ban if $\theta = \underline{\theta}$" is strictly dominant if U adopts the *health strategy*. F's strategy is independent of beliefs. Consumers also know that H never accepts an unhealthy strategy. Therefore, consumers should reasonably have beliefs $\alpha = 1$ and U has an incentive to deviate from the *no-retaliation strategy* to the *health strategy* because

$$\alpha_0\Pi_u^A(1, 0, k) > (1-\lambda)\alpha_0\Pi_u^A(1, 0, k)$$

Applying the same logic to a PBE where U adopts the *threat strategy*, U deviates to the *health strategy* if

$$\lambda < \frac{\alpha_0\Pi_u^A(1, 0, k)}{\Pi_u^A(\alpha_0, 0, k)}$$

Proposition 3: *If an exporting country commits to a retaliation strategy prior to observing the state of nature, the exporting country always chooses the health strategy where it tariff retaliates only if its healthy exports are banned. It never retaliates against a ban on an unhealthy export. This commitment prevents the inefficient outcome where a protectionist government accepts an unhealthy import or a "health friendly" government bans a healthy import and as a result consumption distortions associated with imperfect information are eliminated.*

Proof: The condition for the *threat strategy* to constitute a PBE is given by

$$\lambda > \frac{\alpha_0 \Pi_u^A(1,0,k)}{\Pi_u^A(\alpha_0,0,k)} \equiv \Omega(\alpha_0,0,k)$$

At $\alpha_0 = 1$, $\Omega(\alpha_0,0,k) = 1$ and the condition can not be met. Moreover,

$$\frac{\partial \Omega(\alpha_0,0,k)}{\partial \alpha_0} = (-2\alpha_0 k)\left(k\alpha_0 - \alpha_0 - k\right)^{-3}$$

which is negative for all α_0 in the relevant range. Therefore $\Omega(\alpha_0,0,k) \geq 1$ for all α_0 in the relevant range. END OF PROOF

The question remains whether U has an incentive to stick to this strategy once it observes the state of nature. Ignoring the gains to be made from tariff retaliation in the y market, U has no reason to deviate to another strategy if $\theta = \overline{\theta}$ because both types accept the innovation and U earns the maximum profit $\Pi_u^A(1,0,k)$. Let $\theta = \underline{\theta}$. Although by threatening tariff retaliation the F type is forced to accept, consumers deduce that $\theta = \underline{\theta}$ and opt out of the market, that is $\Pi_u^A(0,0,k) = 0$.

The"scientific assessment criterion" achieves two efficiency improvements. First, allowing U to retaliate against a ban when $\theta = \overline{\theta}$, forces the F government to accept a healthy good and limits its protection of domestic firms. Secondly, by preventing retaliation against a ban when $\theta = \underline{\theta}$, restores consumer faith in the quality of the good on their market because they know that F is not induced to accept an innovation for a profit motive, unless the import is healthy.

To conclude, I have provided a rationale for an exporting country to commit itself to a strategy where it retaliates against a ban on its exports only if its exports are healthy. In this model, consumers learn product quality from the strategies of both E government types and the strategy of the U government. There are no consumption distortions associated with consumer imperfect information and the E government never has an incentive to ban a healthy, lower cost import. This is true for the F government because of the threat of retaliation. It is true for the H government because welfare is higher if the innovation is admitted without consumption distortions. This result is supported by the inclusion of a "scientific assessment criterion" in trade agreements, such as Article 5.1 of the SPS Agreement.

Naturally, this model does not provide a full explanation for the political breakdown in the *Hormones* case. Although it can be argued that had the EC provided the requisite evidence that improper administration of the hormones was associated with health risks, evidence that apparently existed, the AB would have found in

favour of the EC, and the US and Canada would not have suspended concessions against the EC. With this interpretation, it is not Article 5.1 that failed, but rather the EC government which did not present its arguments properly.

Yet, it is unclear, and not answerable by the model presented in this paper, whether exporting countries should be held accountable for illegal activities within the importing country. The US would claim that its exports are healthy, but black-market smuggling within the EC, perhaps from non-American sources contributed to the risk associated with American goods. It is unclear whether an exporting country would, or should, continue to be bound by a "scientific assessment criterion" where the risk associated with their exports are the result of poor governance in the importing country.

9 Country-of-Origin Labelling

In the previous section I assumed that consumers could not observe country of origin. Mandatory country-of-origin labelling is legal under Article IX GATT 1947, which permits Members to enforce such labelling subject to the requirements that the disruptions to commerce are kept to a minimum and that due regard to the necessity of protecting consumers against fraudulent or misleading indications be taken into consideration.

As argued in section 2, WTO law requires that "a rational relationship between [a health] measure and the risk assessment" exist and I interpreted this in the model as a requirement that $\theta = \underline{\theta}$ for a health measure not to be subject to tariff retaliation. No such justification for a country-of-origin label is required. A country-of-origin label is legal, and not subject to tariff retaliation, regardless of the state of nature. In this section I show that by protecting the F government from the threat of tariff retaliation, country-of-origin labelling results in an inefficient equilibrium where a safe innovation is forced out of the market even if it is accepted by the E government. This equilibrium results even if U commits itself to a *health strategy* prior to the state of nature being revealed.

Assume that U commits itself to a *health strategy* prior to the state of nature being revealed. U also commits itself to not retaliating against mandatory country-of-origin labelling (COOL) by E on U exports. This is consistent with the fact that WTO members bind themselves by Article IX which legalises COOL for all states of nature.

Under COOL, consumers can distinguish a unit of x produced in E from a unit

of x produced in U. Consumers associate risk with U imports only. The consumer that is indifferent between consuming a risk-free unit produced by E and a risky unit produced by U is given by:

$$\begin{aligned} m_e^{cool} - p_e^{cool} &= \alpha_0 m_e^{cool} + (1-\alpha_0)k - p_u^{cool} \\ m_e^{cool} &= k + \frac{\left(p_e^{cool} - p_u^{cool}\right)}{(1-\alpha_0)} \end{aligned}$$

All consumers with $m \geq m_e^{cool}$ demand a unit of E firm output such that total demand for the domestic good is given by

$$q_e^{cool} = 1 - \left(k + \frac{\left(p_e^{cool} - p_u^{cool}\right)}{(1-\alpha_0)} \right) \tag{3.11}$$

Demand for the domestic good is zero if

$$\alpha_0 \geq 1 - \frac{(p_e^{cool} - p_u^{cool})}{1-k}$$

or if the price difference between the domestic and imported (risky) good is sufficiently large to compensate for the disutility from consumption of an unhealthy import. The consumer that is indifferent between purchasing a unit of U output and not purchasing at all is given by

$$\begin{aligned} \alpha_0 m_u^{cool} + (1-\alpha_0)k - p_u^{cool} &= 0 \\ m_u^{cool} &= \frac{p_u^{cool} - (1-\alpha_0)k}{\alpha_0} \end{aligned}$$

All consumers with m such that $m_e^{cool} > m \geq m_u^{cool}$ demand a unit of U firm output such that total demand for the imported good is given by

$$\begin{aligned} q_u^{cool} &= \left(k + \frac{\left(p_e^{cool} - p_u^{cool}\right)}{(1-\alpha_0)} \right) - \left(\frac{p_u^{cool} - (1-\alpha_0)k}{\alpha_0} \right) \\ &= \frac{\left(k(1-\alpha_0) - p_u^{cool} + \alpha_0 p_e^{cool}\right)}{(1-\alpha_0)\alpha_0} \end{aligned} \tag{3.12}$$

The equilibrium Cournot outputs can be written as (refer Appendix A)

$$\begin{aligned} Q_e^{cool} &= \frac{1}{2}\left(1 - c_e - \frac{1}{4-\alpha_0}\left(2k(1-\alpha_0) + \alpha_0(1+c_e)\right)\right) \\ Q_u^{cool} &= \frac{1}{4-\alpha_0}\left(\frac{2k(1-\alpha_0)}{\alpha_0} + 1 + c_e\right) \end{aligned}$$

COOL is equivalent to a ban on the innovation ($Q_u^{cool} = 0$) if:

$$c_e \leq \frac{-2k(1-\alpha_0)}{\alpha_0} - 1 < 1 \tag{3.13}$$

and the requirement $c_e \in [\frac{1}{2}, 1)$ implies the additional condition

$$\alpha_0 \leq \frac{-4k}{3-4k}$$

In the example in the Appendix, (3.13) holds true.

Unlike the case where consumers can not distinguish country-of-origin and the E firm is forced out of the market by an acceptance, COOL allows the E firm to profitably compete with the U firm.

The E government now has three strategies: ban, accept without COOL, accept with COOL. If E bans, the ban will trigger tariff retaliation by U if $\theta = \overline{\theta}$.

Consider the following equilibrium.

$$\begin{aligned} &F \text{ always accepts with COOL} \\ &H \text{ accepts with COOL if } \theta = \underline{\theta} \\ &H \text{ accepts without COOL if } \theta = \overline{\theta} \end{aligned}$$

If consumers observe an acceptance with COOL, their equilibrium assessment that a unit purchased from U is healthy is given by

$$\alpha^{cool} = \frac{\alpha_0\lambda}{(1-\alpha_0)(1-\lambda)+\lambda} < \alpha_0$$

The denominator is the probability of observing an acceptance, while the numerator is the probability of observing a healthy acceptance. Consumers do not observe government type or the state of nature and therefore do not know whether the acceptance is by an H type when $\theta = \underline{\theta}$. Assume that (3.13) holds. Then it must

be that

$$c_e \leq \frac{-2k(1-\alpha^{cool})}{\alpha^{cool}} - 1$$

and the U firm is forced out of the market. The E firm earns monopoly profits or $\Pi_e^{cool} = \Pi_e^B$ and consumers earn consumer surplus of $S^{cool} = S^B$.

If consumers observe an acceptance without COOL, the equilibrium assessment that a unit of x purchased is safe is given by

$$\alpha^{no-cool} = 1$$

because only an H government accepts without COOL and only if $\theta = \overline{\theta}$. Consumers earn a surplus of $S^{no-cool} = \bar{S}^A(1, 0, k)$ and the E firm earns profits $\Pi_e^{no-cool} = 0$ because all consumers prefer to buy the risk-free, imported good which is cheaper.

It remains to determine whether either of the types have an incentive to deviate. Given H's equilibrium strategy and no retaliation by U, always accepting subject to COOL is a dominant strategy for F because profits are at their maximum for c_e. Given F's equilibrium strategy and no retaliation by U, H has no incentive to deviate because

$$\underline{S} < S^{cool} + \Pi_e^{cool} < S^{no-cool}$$

If $\theta = \underline{\theta}$, a ban or an acceptance with COOL yield the same welfare. Accepting without COOL only yields a negative consumer surplus because the E firm is forced out of the market as in the previous section.

Proposition 4: *The "scientific assessment criterion" regulates health measures according to the state of nature. COOL is legal for all states of nature. The "scientific assessment criterion" is insufficient to generate the efficient outcome when COOL is available. COOL provides a protectionist government the option of forcing a healthy import from the domestic market without being subject to retaliation. A protectionist government can exploit consumer fears.*

10 Conclusions and Further Research

The legal literature tends to focus on the "scientific assessment criterion" as an objective test whereby protectionist health measures can be distinguished from legitimate ones. It is recognised that the criterion might throw-out legitimate measures, where consumer fears, not linked to science, lead to welfare-deteriorating consumption distortions.

Yet in this paper I provide an additional benefit of the "scientific assessment criterion". By focusing on how consumer beliefs (fears) are formed, I show that the criterion, by limiting tariff retaliation by the exporting country affected by the measure, can correct consumer mis-perceptions and result in the optimal outcome.

Consumer beliefs crucially depend on consumer understanding of the political trading system. That is, if quality is not observable, consumers take into account the incentive for their government to allow an unhealthy good on their market. This incentive will depend on the extent to which their trading partners can retaliate against a measure on an unhealthy good. I show, that by allowing a foreign government the option of tariff retaliation against a measure imposed by a importing country on that foreign country' healthy exports only, consumers in the importing country do not have to fear that their government is being forced to accept an unhealthy import from that foreign country. There is no tariff retaliation on measures imposed on unhealthy imports.

The *Hormones* case highlights that safety depends not only on the production process but also on the manner in which goods are packaged, processed and transported across borders. A good that leaves the exporting country as perfectly healthy, might arrive in the importing country as unhealthy. Further research should assess to what extent, if at all, exporting countries should be bound by the criterion, that is not retaliate against a health measure, even if the risk is associated with mismanagement in the importing country.

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Appendix A: Country-of-Origin Labelling

Rearranging (3.11) and (3.12) respectively, inverse demand curves for E and U firm outputs are given by the following,

$$p_e^{cool} = (1-\alpha_0)\left(1-k-q_e^{cool}\right) + p_u^{cool} \tag{3.14}$$

$$p_u^{cool} = (1-\alpha_0)\left(-\alpha_0 q_u^{cool} + k\right) + \alpha_0 p_e^{cool} \tag{3.15}$$

Substituting (3.15) into (3.14) gives the inverse demand for E output as a function of both country's output levels only

$$p_e^{cool} = \left(1 - \alpha_0 q_u^{cool} - q_e^{cool}\right)$$

which in turn defines the inverse demand for U output as

$$p_u^{cool} = k(1-\alpha_0) + \alpha_0(1 - q_e^{cool}) - \alpha_0 q_u^{cool}$$

Substituting the inverse demand curves into each firm's profit functions

$$\Pi_e^{cool} = \left[\left(1 - \alpha_0 q_u^{cool} - q_e^{cool}\right) - c_e\right] q_e^{cool}$$

$$\Pi_u^{cool} = \left[k(1-\alpha_0) + \alpha_0(1 - q_e^{cool}) - \alpha_0 q_u^{cool}\right] q_u^{cool}$$

it is possible to determine the equilibrium Cournot outputs which can be written

$$\begin{aligned} Q_u^{cool} &= \frac{1}{4-\alpha_0}\left(\frac{2k(1-\alpha_0)}{\alpha_0} + 1 + c_e\right) \\ Q_e^{cool} &= \frac{1}{2}\left(1 - c_e - \frac{1}{4-\alpha_0}\left(2k(1-\alpha_0) + \alpha_0(1+c_e)\right)\right) \end{aligned}$$

Appendix B: An example

This section provides an existence proof of the results presented in the text. However, as mentioned previously, the aim of this paper is not to strive for generalities but rather to highlight the complexities associated with these issues. Assume the following:

$$k = -2.9,\ c_e = \frac{1}{2},\ \lambda > 0.973\,51,\ \alpha_0 = 0.75$$

The monopoly profits and output for the E firm under a ban are

$$\begin{aligned} Q_e^B(1, c_e) &= \frac{1}{4} \\ \Pi_e^B(1, c_e) &= \frac{1}{16} \end{aligned}$$

The monopoly profits and output for the U firm under an acceptance, given the

equilibrium assessment α, are

$$\begin{aligned} Q_u^A(\alpha, 0, k) &= \frac{1}{\alpha}(1.95\alpha - 1.45) \\ \Pi_u^A(\alpha, 0, k) &= \frac{1}{4\alpha}(3.9\alpha - 2.9)^2 \end{aligned}$$

At α_0,

$$\Pi_u^A(\alpha_0, 0, k) - \Pi_e^B(1, c_e) = -6.2292 \times 10^{-2} < 0$$

and the gains from innovating (lower costs) are eliminated by consumption distortions. For $Q_u^A(\alpha, 0, k) > 0$, it must be that

$$\alpha > \frac{-k}{1-k} = 0.74359 \tag{3.16}$$

which is true at $\alpha_0 = 0.75$.

Welfare in E Under an Import Ban

The resulting equilibrium price and marginal consumer under a ban are

$$P^B(1, c_e) = M^B(P^B(1, c_e), 1) = \frac{3}{4}$$

Consumer surplus under a ban can be written

$$\begin{aligned} S^B &\equiv \int_{M^B(P^B(1,c_e),1)}^{1} (m - P^B(1, c_e))dm \\ &= \frac{1}{32} \end{aligned}$$

Welfare of the H government under a ban is defined as the sum of producer and consumer surplus or

$$\begin{aligned} W_H^B &= S^B + \Pi_e^B + \Pi_y^B \\ &= \frac{3}{32} + \Pi_y^B \end{aligned}$$

where $\Pi_y^B \in \left\{\Pi_{ye}^B(\tilde{\tau}_u); \Pi_{ye}^B(\tau_u)\right\}$.

Welfare in E Under an Acceptance

Regardless of the state of nature, the equilibrium price and marginal consumer under an acceptance are

$$P^A(\alpha, 0, k) = 1.95\alpha - 1.45$$

$$M^A(P^A(\alpha,0,k),\alpha,k) = \frac{2.9}{\alpha}(1-\alpha) + \frac{1}{\alpha}(1.95\alpha - 1.45)$$

Let $\overline{S}^A$ and $\underline{S}^A$ be consumer surplus given $\theta = \overline{\theta}$ and $\theta = \underline{\theta}$ respectively. It follows that

$$\begin{aligned}
\bar{S}^A(\alpha,0,k) &\equiv \int_{M^A(P^A(\alpha,0,k),\alpha)}^{1} [m - P^A(\alpha,0,k)]dm \\
&= \int_{\frac{2.9}{\alpha}(1-\alpha)+\frac{1}{\alpha}(1.95\alpha-1.45)}^{1} [m - 1.95\alpha + 1.45]dm \\
&= \frac{1}{\alpha^2}(0.4875\alpha - 0.3625)\left(5.9\alpha - 7.8\alpha^2 + 2.9\right)
\end{aligned}$$

$$\begin{aligned}
\underline{S}^A(\alpha,0,k) &\equiv \int_{M^A(P^A(\alpha),\alpha)}^{1} [k - P^A(\alpha,0,k)]dm \\
&= \int_{\frac{2.9}{\alpha}(1-\alpha)+\frac{1}{\alpha}(1.95\alpha-1.45)}^{1} [k - 1.95\alpha + 1.45]dm \\
&= \frac{1}{\alpha}(-3.9\alpha - 2.9)(0.975\,\alpha - 0.725\,)
\end{aligned}$$

and $\underline{S}_A < 0$ for all $\alpha > \frac{-k}{1-k}$. Welfare under an acceptance is defined as the sum of producer and consumer surplus or

$$W_H^A = S^A + \Pi_{ye}$$

where $S^A \in \left\{\underline{S}^A; \bar{S}^A\right\}$. Domestic profits are zero and there is no tariff retaliation under an acceptance.

A PBE in E where H Bans if $\theta = \overline{\theta}$

Given the specified equilibrium strategies

U adopts *threat strategy*

F always accepts

H always bans

$\alpha = \alpha_0 = 0.75$ and (3.6) can be written

$$\begin{aligned}
&\frac{3}{32} - \left(\frac{1}{\alpha^2}(0.4875\alpha - 0.3625)\left(5.9\alpha - 7.8\alpha^2 + 2.9\right)\right) \\
\geq\ & \Pi_{ye}^A(\tau_u) - \Pi_y^B(\tilde{\tau}_u) > \frac{1}{16}
\end{aligned}$$

Substituting $\alpha_0 = 0.75$ into the expression above gives the necessary condition for the strategies above to be equilibrium strategies:

$$7.743\,1 \times 10^{-2} \geq \Pi^A_{ye}(\tau_u) - \Pi^B_y(\tilde{\tau}_u) > \frac{1}{16}$$

At $\alpha = 0.75$,

$$\frac{\partial \overline{S}^A}{\partial \alpha} = 2.470\,1 > 0$$

and H may have an incentive to deviate to the strategy "accept if $\theta = \overline{\theta}$" if by altering consumer preferences, consumer surplus increases under an acceptance.

Assume F accepts always and H deviates to "accept if $\theta = \overline{\theta}$". Assuming "reasonable beliefs",

$$\tilde{\alpha} = \frac{(0.75)\lambda + (1-\lambda)(0.75)}{\lambda + (1-\lambda)(0.75)} > \alpha_0$$

but for $\lambda \geq 0.973\,51$, $\tilde{\alpha} \leq 0.755$.

Let $\tilde{\alpha} = 0.755$. H does not deviate because

$$6.537\,0 \times 10^{-2} \geq \Pi^A_{ye}(\tau_u) - \Pi^B_y(\tilde{\tau}_u) > \frac{1}{16}$$

It remains to show that it is optimal on a global level to ban *given consumer distrust* (or $\alpha = 0.75$):

$$S^B + \Pi^B_e - \bar{S}_A(\tilde{\alpha}) - \Pi^A_u = 7.721\,6 \times 10^{-2} > 0$$

That the "scientific assessment requirement" forces governments to the efficient outcome has already been shown in the text.

Finally, at α_0

$$\lambda < \frac{\alpha_0 \Pi^A_u(1,0,k)}{\Pi^A_u(\alpha_0,0,k)} = 900$$

and U commits to the *health strategy*.

Country-of-Origin Labelling

Consistent with the findings in the text, the following holds:

$$Q^{cool}_u = \frac{1}{4-\alpha_0}\left(\frac{2k(1-\alpha_0)}{\alpha_0} + 1 + c_e\right) = 0$$

and the import is forced out of the market regardless of its health attributes

because,

$$c_e \leq \frac{-2k(1-\alpha_0)}{\alpha_0} - 1 = 0.933\,33 < 1$$

$$\alpha_0 \leq \frac{-4k}{3-4k} \leq 0.794\,52$$

Chapter 4

Asymmetric Information and Country-of-Origin Labelling *

1 Introduction

Nations claim the right to protect consumers from low quality imports where quality is not observable at the time of purchase. Examples of such products include fresh produce, apparel or spare parts for cars. Relatedly, because consumers often believe the quality of a good to be a function of its origin, demands for country-of-origin labels are made, based on the "right-to-know" mantra. Many governments have responded to these demands. The United States Farm Security and Rural Investment Act of 2002, requires that beef, pork, lamb, fish, peanuts, fruits, and vegetables, be labelled as to their country of origin. Japan and the European Union require mandatory country-of-origin labelling for fresh produce.

Many producers voluntarily undertake schemes to guarantee product quality; amongst these are geographical indications which, identify a good as originating in a region where a given quality is essentially attributable to its geographical origin. Examples include Czech crystal, Swiss watches and Indian carpets.

Mandatory country-of-origin labelling is allowed under Article IX GATT 1947, which permits Members to enforce such labelling subject to the requirements that the disruptions to commerce are kept to a minimum and that due regard to the necessity of protecting consumers against fraudulent or misleading indications be

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taken into consideration. Article 22 of the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), places a general obligation on WTO Members to protect legitimate geographical indications and prevent the presentation of a good that would mislead the public as to its geographical origin or constitute an act of unfair competition.

Developing countries generally regard mandatory mark-of-origin requirements as non-tariff barriers, or protectionist, on the basis that consumer perceptions of quality are based less on fact than on stereotype. Moreover, the direct costs of enforcement, which include *inter alia* the costs of segregating and tracking product origins by retailers and compliance costs by suppliers, can lead to some foreign products being taken off the retail shelves (Carter and Zwane, 2003).

Geographical indications are also not free from the claims of protectionism as witnessed by the dispute between South Africa and the European Union (EU). Article 23 of TRIPS provides an enhanced level of protection for geographical indications for wines and spirits, even if misuse would not cause the public to be misled. A regional trade agreement between the EU and South Africa requires South African wine producers to phase out the use of the terms "port" and "sherry", which are generally associated with wines originating in Portugal and Spain.

While I do not debate that mandatory country-of-origin labelling and geographical indications can be exploited as protectionist devices, this paper provides a mechanism where such labelling can enhance efficiency by eliminating "beggar-thy-neighbour" trade when adverse selection is an international problem.

To capture a situation where the need for regulation stems from an asymmetric information problem between producers and consumers, I develop the model in Grossman-Horn (1988). In this model, domestic firms can choose between producing high or low quality. Those choosing low quality take advantage of adverse selection problems, while those choosing high quality do so to establish reputations and earn positive profits in subsequent periods when information is perfect. Grossman-Horn show that with imperfect consumer information, the lack of reputation puts domestic latecomers at a disadvantage relative to the foreign firm, whose quality and reputation is already established, but that infant-industry protection may exacerbate the welfare losses associated with information asymmetries.

I extend the Grossman-Horn model by allowing markets in both the domestic and foreign countries (North and South, respectively) and evaluate the welfare effects of trade when countries differ in the relative cost of producing high quality. I show that when countries trade, welfare in the North, which has a lower relative cost

of producing high quality, decreases. Northern consumers' willingness-to-pay diminishes as imports from the South reduce the average quality of the good available on the Northern market. The opposite is true in the South, where the possibility of imports of higher average quality from the North increases price and welfare.

I introduce welfare-maximizing governments and analyse their incentive to adopt mandatory country-of-origin labelling, or protect a geographical indication within their domestic market. Article IX GATT 1947 and Article 22 of TRIPS allow North the opportunity to protect itself from "beggar-thy-neighbour" trade with the South.

Other literature related to the discussion of information asymmetries as a possible rationale for trade policy includes Bagwell and Staiger (1989), Bond (1984), Falvey (1989) and Jansen and Lince de Faria (2002). In Bagwell and Staiger, adverse selection acts as a barrier to trade and a two-period export tax/subsidy program can enable high quality producers to profitably export to markets where information asymmetries prevent them from selling at prices reflecting their true quality.

In a model where the incentive to produce higher quality arises out of a reputation premium built into prices and the costs of reputation building depend on production costs, Falvey (1989) concludes that origin-labelling has an important role in providing information that is useful to consumers. Without labelling, the price incentive for high quality producers increases as low quality firms milk their reputations by importing cheaper imports. The model in my paper differs from that in Falvey (1989) in several important ways.

Falvey (1989) considers the effects of trade when reputations have already been independently established in each country. I focus on the effects of trade when firms are *reputationless* and moral hazard and adverse selection are international problems. Unlike Falvey (1989), trade does not necessarily minimize production costs and there is no gain to consumers from importing lower cost goods because all consumer surplus is extracted by firms.

Haucap *et al* (1997) and (2000) discuss the relationship between country characteristics and country-of-origin quality reputation. They argue that location choice can act as a signaling device for product quality. High country-specific costs signal high product quality, so a "Made in X" label allows high quality firms to receive the price reflecting their true quality. High quality firms separate from low quality firms if the former locate in a high-cost country. High-cost countries export high-quality goods and import low-quality goods. My model differs in that firms cannot choose production location and high quality types cannot rely on country characteristics to separate from low quality types. Countries do not specialize in specific quality, but

trade in average qualities.

Bond (1984) and Jansen and Lince de Faria (2002) focus on heterogeneity in tastes for quality. Bond (1984) allows the average quality of a product to differ across countries and shows the welfare effects of trade to depend on trade dynamics and heterogeneity in tastes for quality. Origin-labelling guarantees that both countries are better off after trade because the variety of products available to consumers expands but there is also better matching between consumers and products. The focus of my paper is the mechanism by which average qualities differ across countries. Because consumers have homogeneous tastes, origin-labelling leaves the lower average quality country worse-off and global welfare effects are ambiguous and depend on relative country size.

Jansen and Lince de Faria (2002) show that governments have different incentives to label quality in autarky which transmits negative international externalities when countries trade because the lower label crowds out the higher label. Bose and Kemme (2002) model the effect of liberalization on product quality and industrial activity in transition economies.

Section 2 introduces the basic model under perfect information. In Section 3, I introduce information asymmetries and show that autarky equilibrium price and average quality are higher in the North than in the South. In Sections 4 and 5, I let countries trade and show that trade is welfare deteriorating (improving) for the North (South). In Section 6, I show that the option of mandatory origin-labelling or the protection of a domestic geographical indication is always preferred by the North. Section 7 concludes.

2 The Model

Assume a two-period, two-country model where the two countries are indexed by $j = N, S$ for North and South**,** respectively. Initially, assume that countries do not trade and that all agents have perfect information.

In each country in period 1, firms of type t enter the market and can produce a homogeneous good of quality θ_n with $n = h, l$ and $\theta_h > \theta_l$. Define X^j as the total number of firms that enter. Firms choose quality once-and-for-all at the beginning of period 1.[1] A firm of type t, choosing quality θ_n, has a per-period constant marginal cost function $tc^j(\theta_n)$ with $c^j(\theta_h) > c^j(\theta_l)$. A firm's type can be interpreted as an

[1] This assumption eliminates the incentive to cheat in period 2 under information asymmetries.

efficiency parameter and is identical across countries. I assume t to be uniformly distributed (IID) with the cumulative distribution function $F(t)$ on support $[0, T]$ where

$$F(t) = \begin{cases} 0 & \text{for } t < 0 \\ \frac{t}{T} & \text{for } 0 \leq t < T \\ 1 & \text{for } T \leq t \end{cases},$$

and the marginal density function $f(t) = \frac{1}{T}$. For a given t, North has comparative advantage in the production of high quality:

$$\frac{c^N(\theta_h)}{c^N(\theta_l)} < \frac{c^S(\theta_h)}{c^S(\theta_l)}$$

Each firm can produce up to one unit of the good. A firm of type t that chooses quality θ_n can enjoy profits over both periods of

$$\pi_n^j(t) = (p_{1n}^j - tc^j(\theta_n)) + \delta(p_{2n}^j - tc^j(\theta_n)),$$

where $0 < \delta < 1$ is the discount rate and p_{in}^j the price of a unit of the good of quality θ_n in period i.

In each country, there is a continuum of consumers on support $[0, M^j]$. Consumers are homogeneous in tastes within and across countries. A representative consumer in country j demands a unit of the good and has the following per-period utility function

$$U^j = \begin{cases} \theta_n - p_{in}^j & \text{if buys one unit of quality } \theta_n \\ S & \text{otherwise} \end{cases},$$

where $\theta_l > S$ and S is the consumer's reservation utility and is identical for all consumers within and across countries. With perfect information, the maximum price the consumer is willing to pay for a unit of each quality, leaves her indifferent between consuming high quality, low quality and not at all. Consequently, the per-period equilibrium prices for a unit of high and low quality are $p_{ih}^j = \theta_h - S$ and $p_{il}^j = \theta_l - S$, respectively, and $\pi_h^j(0) > \pi_l^j(0)$ at the equilibrium prices. In equilibrium, the measure of consumers in country j buying a unit of quality θ_h is $F(t_h)X^j$ where t_h is the solution to $\pi_h^j(t_h) = \pi_l^j(t_h)$:

$$t_h = \frac{(\theta_h - \theta_l)}{[c^j(\theta_h) - c^j(\theta_l)]}$$

The measure of consumers in country j buying a unit of quality θ_l is $[F(t_l) - F(t_h)]X^j$, where t_l is the solution to $\pi_l^j(t_l) = 0$:[2]

$$t_l = \frac{(\theta_l - S)}{c^j(\theta_l)}$$

Those firms for which their type is $t_l < t \leq T$, do not produce or sell a unit of the good. I assume $M^j > F(T)X^j$ such that even if all types (and therefore all firms) sell a unit, there are always consumers who do not buy. All firms produce up to capacity and firms are always able to extract all consumer surplus. Under perfect information, a firm's output and pricing decisions are independent of the actions of other firms and the equilibrium is identical across both periods.

Lemma 1: *Under perfect information, and assuming small trade costs τ, countries do not trade.*

If $\tau = 0$, a firm producing quality θ_n receives the identical price in both markets and trade is possible. That is, firms are indifferent regarding in which market they sell and there are enough consumers in both markets such that their pricing decisions are independent of that of other firms. If $\tau > 0$, the price that firms receive in the foreign market relative to their domestic market is lower and they prefer to sell their unit in the domestic market. In the following sections, I assume that consumers cannot observe quality at the time of purchase and show that trade occurs for a small τ.

3 Introducing Asymmetric Information

Assume that quality is not observable when consumers buy a unit of the good in period 1 but that in period 2, all is revealed and consumers know which firms are selling what quality.[3] Therefore, the period 2 equilibrium is identical to the per-period perfect information equilibrium. I go on to show that if in period 1, consumers are willing to pay $\theta_l - S < p < \theta_h - S$ for a unit of expected quality, some

[2] For $t_l > t_h$, it must be that

$$\frac{c^j(\theta_h)}{c^j(\theta_l)} > \frac{\theta_h - S}{\theta_l - S}$$

[3] Goods are assumed to be non-storable. Firms cannot save products and sell them in the second period.

types that would choose to produce a unit of θ_h under perfect information, have an incentive to instead choose θ_l. These firms have an incentive to "cheat" because their costs are lower and because p may be sufficiently high to compensate for the lower price in period 2 when all is revealed. Some types continue to produce a unit of θ_h because of the higher price in period 2. "Reputable types" and "θ_h types" are used interchangeably in the following sections. Unless specifically stated otherwise, the following analysis concerns period 1 and time subscripts are dropped. Initially, assume that countries do not trade.

The equilibrium concept is Perfect Bayesian equilibrium (PBE). I restrict attention to pure-strategy equilibria. There are two possible types of equilibrium in prices. In pooling equilibria, both reputable and θ_l types charge the same price. In separating equilibria, reputable firms set a different price to θ_l firms and signal quality.

I start by evaluating the pooling equilibria where both reputable and θ_l types in country j charge the same price**,** denoted p^j. A reputable firm's profit over both periods is

$$\pi_R^j(t) = p^j + \delta(\theta_h - S) - (1+\delta)tc^j(\theta_h)$$

A θ_l type earns profits

$$\pi_F^j(t) = p^j + \delta(\theta_l - S) - (1+\delta)tc^j(\theta_l)$$

Since $\pi_R^j(0) > \pi_F^j(0)$, the type, t_R^j, that is indifferent between being reputable and being low-quality for a given p^j, solves $\pi_R^j(t_R^j) = \pi_F^j(t_R^j)$. Firms in the interval $[0, t_R^j]$ are reputable. In country j,

$$t_R^j = \frac{\delta(\theta_h - \theta_l)}{(1+\delta)[c^j(\theta_h) - c^j(\theta_l)]} < t_h \tag{4.1}$$

which is independent of p^j. Some types that would choose θ_h under perfect information, choose θ_l when information is incomplete. The type (t_F^j) that is indifferent between producing a unit of quality θ_l and not producing at all is the solution to $\pi_F^j(t_F^j) = 0$. In country j,

$$t_l \leq t_F^j = \frac{p^j + \delta(\theta_l - S)}{(1+\delta)c^j(\theta_l)} \tag{4.2}$$

and firms in the interval $(t_R^j, t_F^j]$ are θ_l types. More types enter as low quality producers in response to a higher period 1 price. The proportion of reputable firms

to θ_l types in country j is

$$\frac{\int_0^{t_R^j} f(t)dt}{\int_{t_R^j}^{t_F^j} f(t)dt} = \frac{F(t_R^j)}{F(t_F^j) - F(t_R^j)} \tag{4.3}$$

The proportion of reputables to θ_l types is inefficiently low compared with perfect information.

The equilibrium pooling price in each country in autarky depends on how consumers form their beliefs about the average quality available on the market. Consumers observe costs and the distribution of types, but not each firm's type. I assume rational expectations. Let $\bar{\theta}^j$ be the actual average quality available in market j and $\bar{\theta}^{ej}$ consumers' expected quality. Under rational expectations $\bar{\theta}^{ej} = \bar{\theta}^j$ and

$$\begin{aligned} \bar{\theta}^j &= \frac{1}{F(t_F^j)} \left\{ \theta_h \left[F(t_R^j) - F(0) \right] + \theta_l \left[F(t_F^j) - F(t_R^j) \right] \right\} \\ &= \frac{F(t_R^j)}{F(t_F^j)} (\theta_h - \theta_l) + \theta_l \end{aligned} \tag{4.4}$$

A consumer buys a unit of the good of unknown quality if $p^j \leq \bar{\theta}^j - S$ and $p^j \in (\theta_l - S, \theta_h - S)$. Equilibria where the inequality is strict exist, because rational expectations govern equilibrium prices (determine beliefs in equilibrium) but say nothing about consumer beliefs off the equilibrium path. Assume an equilibrium $\tilde{p}^j < \bar{\theta}^j - S$. This can be supported as an equilibrium if firms have no incentive to deviate to a price $p^d > \tilde{p}^j$ because at p^d, consumers are overly pessimistic about the average quality of the type of firm that deviates and they will not buy.

Using the Intuitive Criterion in Cho and Kreps (1987), it can be argued that these types of overly pessimistic beliefs are "unreasonable" and that all equilibria except $p^j = \bar{\theta}^j - S$ can be ignored. First, consumers should rule out the possibility that the firm offering p^d is a firm of type $\frac{p^d + \delta(\theta_l - S)}{(1+\delta)c^j(\theta_l)} > t_F^j$ because that firm is making losses and would rather exit at that price. Second, a firm has an incentive to deviate *if and only if* the consumer will buy at that price. But if the consumer buys at that price, then all firms have an incentive to deviate, not just low-quality producers. Because both reputable and θ_l firms have the possibility of increasing their profits if they deviate, a consumer must have the beliefs that assign a positive probability to both types deviating. Consumers can evaluate the average quality offered on the market at p^d and as long as $p^d \leq \bar{\theta}^j - S$, there is no reason for the consumer not to accept the price and buy the unit. When a consumer's beliefs are restricted to

"reasonable" beliefs, $p^j < \bar{\theta}^j - S$ can be ignored.

To conclude, the pooling equilibrium price and average quality in autarky are given as the solution to $p_A^j = \bar{\theta}_A^j(p_A^j) - S$ where $\bar{\theta}_A^j(p_A^j)$ is average quality at price p_A^j. A measure $F(t_F^j)X^j$ of consumers buy a unit of average quality $\bar{\theta}_A^j(p_A^j)$, where t_F^j is the solution to $\pi_F^j(t_F^j) = 0$ at the equilibrium price p_A^j.

Lemma 2: *Autarky equilibrium price and average quality are higher in the North than in the South.*

Proof: Refer to Appendix A.1.

In Appendix A:2 I show that there are no separating equilibria or no equilibria with $p_h \neq p_l$.[4]

In the next section, I let countries trade and show that South can increase its welfare at North's expense. Assuming that consumers cannot distinguish a good's country of origin, Southern firms can exploit Northern adverse selection, which is less severe than in the South. Southern low-quality types cannot only pretend to be reputable in period 1, but can also pretend to be Northern. Although this is predicted by consumers, Southern types still receive a higher price relative to autarky, while the opposite is true for Northern types.

4 The Trading Equilibrium

Let countries trade. Firms can sell their unit output anywhere in either period and the average quality sold in market j is given by $\bar{\theta}_T^j$, which is sold at a price p_T^j. The average quality sold in market j is now a function of the average quality sold by North and South firms which are (possibly) active in that market. Consumers observe the distribution of types and the costs of producing θ_h and θ_l in both countries, but they cannot determine a product's country-of-origin. Consumers are assumed to be rational.

Firms cannot choose location of production and there is no feature in this model allowing high quality firms to separate from low quality firms.[5] Rational expecta-

[4] There are still no separating equilibria if the assumption of fixed unit output is dropped, as long as the firm's variable output is not observable by consumers. In Grossman-Horn (1988), investment in capacity, which is observable by consumers, can signal quality. Pooling equilibria under capacity investment are qualitatively the same as pooling equilibria with no capacity investment.

[5] If firms had to sell in the same market in period 2 as in period 1, then the result that reputable firms cannot separate from low-quality firms in period 1 would not necessarily be robust to heterogenous preferences across countries.

tions are necessary to avoid results hinging on stereotypes. Dropping the assumption of rational expectations would open a Pandora's Box with regard to the determination of equilibrium average quality and prices, and any results regarding the usefulness of origin-labelling would crucially hinge on consumer perceptions of a country's general quality level. Rather, in this paper rational expectations capture (although in a stark manner) the idea that consumers do have some idea about costs and quality across countries and can make partially informed decisions based on those ideas.

As in autarky, a consumer in market j is willing to buy a unit of the good if $p_T^j \leq \bar{\theta}_T^j(p_T^j) - S$. In any trade equilibrium, arbitrage requires that a consumer's expected utility be equal across markets, or

$$S \leq \bar{\theta}_T^N(p_T^N) - p_T^N = \bar{\theta}_T^S(p_T^S) - p_T^S,$$

but to ensure that firms have no incentive to deviate, it must be that $p_T^N = p_T^S = p_T$, which, in turn, requires $\bar{\theta}_T^N(p_T) = \bar{\theta}_T^S(p_T) = \bar{\theta}_T(p_T)$. I eliminate $p_T < \bar{\theta}_T(p_T) - S$ using the Intuitive Criterion as previously. Equilibrium average qualities and prices are identical in both countries. Global average quality as a function of price can be written as:

$$\bar{\theta}_T = \frac{F(t_R^N)X^N + F(t_R^S)X^S}{F(t_F^N)X^N + F(t_F^S)X^S}(\theta_h - \theta_l) + \theta_l$$

where $\bar{\theta}_T$ is decreasing and convex in p_T (see Proof B:1).

Southern firms can pretend to be Northern because consumers do not observe country-of-origin. But consumers rationally expect this and are only willing to pay a price that equals the expected average quality given the distribution of types and costs across both countries.

Proposition 1: *Average quality and price in the trading equilibrium in period 1 are such that*:

$$\begin{aligned} p_A^S &< p_T < p_A^N \\ \bar{\theta}^S(p_A^S) &< \bar{\theta}_T(p_T) < \bar{\theta}^N(p_A^N) \end{aligned}$$

Proof: See Proof B:2

The average quality supplied by Northern (Southern) firms increases (decreases) as exiting Northern θ_l types are replaced by entering Southern types. Because consumers do not observe country of origin, it is their perceived average quality

that is of importance for price determination. The actual average quality consumed in each country will depend on the way firms distribute sales across countries, which is not observable by consumers. It is conceivable that all active firms sell in one market only**,** because global average quality and prices are independent of actual trade flows.

As in autarky, both countries produce both θ_h and θ_l in both periods, a result which differs from Falvey (1989) where reputations have already been established. Specialization according to country is not possible in this model for two reasons. In period 1, when reputations have not been established, adverse selection makes it possible for less efficient firms in both countries to choose θ_l. But even in period 2 when all is revealed, less efficient types from both countries which chose θ_l in period 1 continue to make profits. Firms sell to capacity, act independently of other firms and all consumer surplus is extracted. For this reason, trade does not necessarily minimize production costs.

Global average quality is lower after trade as compared with autarky if there is a net increase in the number of low quality firms. The condition for lower global average quality is given by

$$\left[\frac{p_A^N - p_T}{p_T - p_A^S}\right] < \frac{c^N(\theta_l)X^S}{c^S(\theta_l)X^N}$$

The larger are X^N and $c^S(\theta_l)$ compared with X^S and $c^N(\theta_l)$ respectively, the less likely is global average quality to decline relative to autarky. The larger the North market size is, the greater the weighting it has in global average quality. Although $\bar{\theta}_T$ increases in $c^N(\theta_l)$, global average quality is likely to diminish after trade the lower $c^S(\theta_l)$ is in relation to $c^N(\theta_l)$ because Southern types enter the market at a relatively faster rate than Northern low quality types exit. In the following section I discuss the implications that trade has for welfare in each country.

5 Welfare Effects of Trade

Welfare in country j can be defined as the sum of consumer and producer surplus, $W^j = CS^j + PS^j$, where $CS^j = (1+\delta)M^jS$ and

$$\begin{aligned} PS^j &= X^j \int_0^{t_R^j} [p_T^j + \delta(\theta_h - S) - (1+\delta)tc^j(\theta_h)]dF(t) \\ &\quad + X^j \int_{t_R^j}^{t_F^j} [p_T^j + \delta(\theta_l - S) - (1+\delta)tc^j(\theta_l)]dF(t) \end{aligned} \tag{4.5}$$

Proposition 2: *Trade is "beggar-thy-neighbour". South is better off at North's expense.*

Proof: Consumer surplus and $F(t_R^j)$ are independent of price and are unchanged in both countries after trade.

$$\frac{\partial PS^j}{\partial p_T^j} = F(t_F^j)X^j > 0$$

END OF PROOF.

Northern producer surplus and welfare is lower because $F(t_F^N)$ is lower and $p_T < p_A^N$. Southern producer surplus and welfare is higher because $F(t_F^S)$ is higher and $p_A^S < p_T$.

Corollary: *Quality-labelling, where consumers are fully informed of a unit's actual, not average, quality is efficient at the global level.*

Quality-labelling may not be available to the North for two reasons. First, perfectly and costlessly monitoring a firm's actual quality may not be possible. Second, WTO law disciplines quality-labelling in the form of Article III.4 GATT, the WTO Agreement on Technical Barriers to Trade (TBT Agreement) and the WTO Agreement on Sanitary and Phytosanitary Measures (SPS Agreement).

Article III.4 (National Treatment) requires that all foreign products be accorded at least as favorable treatment as that accorded to domestic "like" goods. Quality-labelling must not be discriminatory. The TBT and SPS Agreements recognize that even non-discriminatory regulation can disguise restrictions on trade and proceed one step further than Article III.4 by imposing additional restrictions. These restrictions include *inter alia* requirements that measures not be maintained without sufficient scientific evidence as to the risks for health, or that they be the least-trade restrictive measure available.

If quality-labelling is not available, there is also a role for tariffs. As long as $p_T - \tau > p_A^S$, Southern firms can still sell in the North. Evaluated at $\tau = 0$, $\frac{\partial W_T^N}{\partial \tau} > 0$ because $F(t_F^S)$ decreases in tariffs. Tariffs may also not be available as a policy tool; they may be bound under a trade agreement and may be at their bound level, not below.

In the next section, I assume that tariffs are bound and quality labelling is not possible. I consider the role of country-of-origin labelling (COOL), which is not subject to the same disciplines as quality-labelling. Determining a unit's country-of-origin, rather than its actual quality level, may be easier and less expensive. Most of the costs of COOL can be transferred to the South, while quality-labelling imposes costs on both Northern and Southern firms.

6 Country-of-Origin Labelling

In this section, COOL is taken to refer to a government mandated mark-of-origin or a geographical indication voluntarily adopted by Northern firms to distinguish their products from Southern output. I show that the Northern government always mandates mark-of-origin labelling, or guarantees to protect the Northern geographical indication from Southern firms which might use it fraudulently, if there are no costs associated with such enforcement.

Assume that under Article IX GATT 1947, North adopts a policy that all goods of origin x carry a label stating "Made in x". Since there are only two countries, it suffices that production from only one country carries the label. I assume that Northern consumers fully trust the enforcement of the law.

Northern consumers form their expectations such that for every p, $\bar{\theta}^{eN} = \bar{\theta}^N(p)$ and $\bar{\theta}^{eS} = \bar{\theta}^S(p)$. Since $\bar{\theta}^N(p) > \bar{\theta}^S(p)$ for all p, all consumers (or more realistically, the middlemen undertaking arbitrage) understand that no Northern types have an incentive to sell in the South where marks of origin are not protected. Consequently, the equilibrium price and the average quality in the South are given by

$$p_A^S = \bar{\theta}_A^S(p_A^S) - S.$$

Define p^{NN} and p^{NS} as the prices paid for Northern and Southern goods sold in the North. In equilibrium

$$\bar{\theta}_A^N(p^{NN}) - p^{NN} = S = \bar{\theta}^S(p^{NS}) - p^{NS}$$

and $p^{NS} = p_A^S$ and $p^{NN} = p_A^N$. The origin-labelling equilibrium is identical to autarky**,** except that Southern goods are possibly sold in the North.

Proposition 3: *If COOL is enforced in either country, autarky equilibrium prices, average qualities and welfare are replicated in both countries.*

To conclude, COOL is not *first-best* because it does not eliminate the information problems within Northern production, that is some Northern types producing low quality, pretend to be producing high quality. But, COOL allows North the opportunity of protecting itself from "beggar-thy-neighbour" trade.

7 Conclusion

Although origin-labelling and geographical indications may be abused as non-tariff barriers, particularly when consumer perceptions are based on stereotypes or when quality differences are not obvious (such as in the case of wines and spirits), this paper provides a mechanism where origin-labelling is welfare enhancing for a country with a limited array of available policy measures with which to mitigate "beggar-thy-neighbour" trade.

When there are quality differences reflecting underlying cost structures, and consumers have a general idea of this underlying cost structure, then origin-labelling can be a very important tool for dealing with cross-border adverse selection problems.

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Appendix A - Autarky

PROOF A:1

$F(t_R^j)$ is independent of price. I impose the condition that for all $p^j \in (\theta_l - S, \theta_h - S)$, $t_F^j < T$ and $F(t_F^j) \in (F(t_R^j), 1)$. Average quality $\bar{\theta}^j$ is decreasing and convex in p^j

$$\frac{\partial \bar{\theta}^j}{\partial p^j} = \frac{-F(t_R^j)f(t)}{[F(t_F^j)]^2(1+\delta)c^j(\theta_l)}(\theta_h - \theta_l) < 0$$

$$\frac{\partial^2 \bar{\theta}^j}{\partial (p^j)^2} = \frac{2F(t_R^j)}{[F(t_F^j)]^3}\left[\frac{f(t)}{(1+\delta)c^j(\theta_l)}\right]^2(\theta_h - \theta_l) > 0$$

$F(t_F^j) < 1$ for all p^j in the relevant range implies that $\frac{t_R^S}{t_F^S} < \frac{t_R^N}{t_F^N}$ or

$$\frac{\delta(\theta_h - \theta_l)}{\left(\frac{c^S(\theta_h)}{c^S(\theta_l)} - 1\right)(p^j + \delta(\theta_l - S))} < \frac{\delta(\theta_h - \theta_l)}{\left(\frac{c^N(\theta_h)}{c^N(\theta_l)} - 1\right)(p^j + \delta(\theta_l - S))}$$

and $\bar{\theta}^S(p^j) < \bar{\theta}^N(p^j)$. Let p_A^j refer to the autarky equilibrium pooling price in country j. By strict monotonicity of $\bar{\theta}^N$ in the relevant range, $p_A^S < p_A^N$ because the pooling price leaves consumers indifferent between consuming a unit of average quality and not consuming at all or

$$\bar{\theta}^N(p_A^N) - p_A^N = S = \bar{\theta}^S(p_A^S) - p_A^S$$

To conclude, $\bar{\theta}^S(p_A^S) < \bar{\theta}^N(p_A^N)$.

PROOF A:2

Assume that a separating equilibrium with $p_h^j \neq p_l^j$ does exist. It must be the case that

$$p_h + \delta(\theta_h - S) - (1+\delta)tc^j(\theta_h) \geq p_l + \delta(\theta_h - S) - (1+\delta)tc^j(\theta_h),$$

or $p_h^j \geq p_l^j$ and

$$p_l + \delta(\theta_l - S) - (1+\delta)tc^j(\theta_l) \geq p_h + \delta(\theta_l - S) - (1+\delta)tc^j(\theta_l),$$

or $p_l^j \geq p_h^j$. These two conditions cannot be met for $p_h^j \neq p_l^j$.[6]

[6] As a commentator pointed out, separating equilibria with $p_h^j = p_l^j = \theta_l - S$ and voluntary disclosure of quality is possible. Firms have no incentive to lie about quality and all active firms can sell their output at that price. But as in the case of pooling equilibria, this equilibrium is not

Appendix B - Trade

PROOF B:1

In a trading pooling equilibrium for $\theta_l - S < p_T < \theta_h - S$, it must be that:

$$[F(t_R^N)X^N + F(t_R^S)X^S] < [F(t_F^N)X^N + F(t_F^S)X^S] < X^N + X^S,$$

otherwise all firms are reputable and $p_T = \theta_h - S$**,** which is not possible as some types have an incentive to choose to produce θ_l at that price.

$$\frac{\partial \bar{\theta}_T^j}{\partial p_T^j} = \frac{-[F(t_R^N)X^N + F(t_R^S)X^S]}{[F(t_F^N)X^N + F(t_F^S)X^S]^2}\left[\frac{f(t)X^N}{(1+\delta)c^N(\theta_l)} + \frac{f(t)X^S}{(1+\delta)c^S(\theta_l)}\right](\theta_h - \theta_l) < 0$$

$$\frac{\partial (\bar{\theta}_T^j)^2}{\partial \left(p_T^j\right)^2} = \frac{2[F(t_R^N)X^N + F(t_R^S)X^S]}{[F(t_F^N)X^N + F(t_F^S)X^S]^3}\left[\frac{f(t)X^N}{(1+\delta)c^N(\theta_l)} + \frac{f(t)X^S}{(1+\delta)c^S(\theta_l)}\right]^2(\theta_h - \theta_l) > 0$$

$\bar{\theta}_T^j$ is decreasing and convex in p_T^j.

PROOF B:2

Global average quality can equivalently be written as $\bar{\theta}_T(p_T) = \beta\bar{\theta}^N(p_T) + (1 - \beta)\bar{\theta}^S(p_T)$**,** where

$$\beta = \frac{F(t_F^N)X^N}{F(t_F^N)X^N + F(t_F^S)X^S}.$$

$\beta \in (0, 1)$ is independent of price:

$$\frac{\partial \beta}{\partial p} = \frac{f(t)X^N X^S}{(1+\delta)}\left[\frac{F(t_F^S)}{c^N(\theta_l)} - \frac{F(t_F^N)}{c^S(\theta_l)}\right] = 0.$$

It follows that:

$$\bar{\theta}_T(p_A^S) - p_A^S > \bar{\theta}^S(p_A^S) - p_A^S = S$$

and

$$\bar{\theta}_T(p_A^N) - p_A^N < \bar{\theta}^N(p_A^N) - p_A^N = S,$$

which both imply the existence of $p_T \in (p_A^S, p_A^N)$, such that $\bar{\theta}_T(p_T) - p_T = S$ and p_T is uniquely defined by strict monotonicity of $\bar{\theta}_T(p)$ in the relevant range. Moreover,

$$\bar{\theta}_T(p_T) - p_T = \bar{\theta}^S(p_A^S) - p_A^S = S$$

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robust to the belief refinements based on the Intuitive Criterion.

and

$$\bar{\theta}_T(p_T) - p_T = \bar{\theta}^N(p_A^N) - p_A^N = S,$$

which implies that

$$\bar{\theta}_T(p_T) - \bar{\theta}^S(p_A^S) = p_T - p_A^S > 0$$

and

$$\bar{\theta}_T(p_T) - \bar{\theta}^N(p_A^N) = p_T - p_A^N < 0.$$

For a given p_T, $\bar{\theta}_T$ increases (decreases) in $c^j(\theta_l)$ ($c^j(\theta_h)$:

$$\frac{\partial \bar{\theta}_T}{\partial c^S(\theta_l)} = \frac{\partial \beta}{\partial c^S(\theta_l)}(\bar{\theta}^N - \bar{\theta}^S) + (1-\beta)\frac{\partial \bar{\theta}^S}{c^S(\theta_l)} > 0$$

$$\frac{\partial \bar{\theta}_T}{\partial c^N(\theta_h)} = \beta\frac{\partial \bar{\theta}^N}{c^N(\theta_h)} < 0 \text{ and } \frac{\partial \bar{\theta}_T}{c^S(\theta_h)} = (1-\beta)\frac{\partial \bar{\theta}^S}{c^S(\theta_h)} < 0$$

$$\frac{\partial \bar{\theta}_T}{\partial c^N(\theta_l)} = \left[\frac{\frac{\partial F(t_R^N)}{\partial c^N(\theta_l)}\left(F(t_F^N)X^N + F(t_F^S)X^S\right) - \frac{\partial F(t_F^N)}{\partial c^N(\theta_l)}\left(F(t_R^N)X^N + F(t_R^S)X^S\right)}{\left(F(t_F^N)X^N + F(t_F^S)X^S\right)^2}\right](\theta_h - \theta_l)$$

and $\frac{\partial \bar{\theta}_T}{\partial c^N(\theta_l)} > 0$.

PROOF B:3

In autarky, $p_A^j = \bar{\theta}^j - S$. Substituting $p_A^j = \bar{\theta}^j - S$ into the welfare function and taking derivatives with respect to t_F^j shows that welfare is concave in t_F^j

$$\frac{\partial W_A^j}{\partial t_F^j} = \frac{\partial \bar{\theta}^j}{\partial t_F^j}(t_F^j) + \bar{\theta}^j - S - t_F^j c^j(\theta_l)$$

$$\frac{\partial^2 W_A^j}{\partial (t_F^j)^2} = \frac{\partial^2 \bar{\theta}^j}{\partial (t_F^j)^2}(t_F^j) + 2\frac{\partial \bar{\theta}^j}{\partial t_F^j} - c^j(\theta_l) < 0$$

which are derived using $\frac{\partial \bar{\theta}^j}{\partial t_F^j} = \frac{-(\bar{\theta}^j - \theta_l)}{t_F^j}$ and $\frac{\partial^2 \bar{\theta}^j}{\partial (t_F^j)^2} = \frac{2(\bar{\theta}^j - \theta_l)}{(t_F^j)^2}$ (average quality is decreasing and convex in t_F^j as we would expect from Appendix A:1 above). The solution to $\frac{\partial W_A^j}{\partial t_F^j} = 0$ is $\tilde{t}_F^j$ where

$$\tilde{t}_F^j = \frac{\theta_l - S}{c^j(\theta_l)} < \frac{p^j + \delta(\theta_l - S)}{(1+\delta)c^j(\theta_l)} = t_F^j$$

Welfare is maximized if low quality firms receive a price that reflect their true quality. But

$$\theta_l - S < p^j = \bar{\theta}^j - S$$

and welfare is reduced under asymmetric information in autarky. If North and South trade,

$$\begin{aligned}\frac{\partial W_T^S}{\partial t_F^S} &= \frac{\partial \bar{\theta}_T}{\partial t_F^S}(t_F^S) + \bar{\theta}_T - S - t_F^S c^S(\theta_l) \\ &= \beta(\bar{\theta}_T - \theta_l) + (\theta_l - S) - t_F^S c^S(\theta_l) = 0\end{aligned}$$

$$\frac{\partial^2 W_T^S}{\partial (t_F^S)^2} = \frac{\partial \beta}{\partial t_F^S}(\bar{\theta}_T - \theta_l) + \beta \frac{\partial \bar{\theta}_T}{\partial t_F^S} - c^S(\theta_l) < 0$$

where use is made of the fact that

$$\frac{\partial \bar{\theta}_T}{\partial t_F^j} = \frac{-(\bar{\theta}_T - \theta_l)X^j}{[t_F^N X^N + t_F^S X^S]}$$

The solution to $\frac{\partial W_T^S}{\partial t_F^S} = 0$ is $\breve{t}_F^S$

$$\tilde{t}_F^S < \breve{t}_F^S = \frac{\beta(\bar{\theta}_T - \theta_l) + (\theta_l - S)}{c^S(\theta_l)}$$

Increasing the number of types producing low quality after trade opens, increases welfare because part of the costs of a lower average quality and price are transferred onto North. But $\breve{t}_F^S < t_F^S$ if

$$\beta(1+\delta)(\bar{\theta}_T - \theta_l) + (1+\delta)(\theta_l - S) < (\bar{\theta}_T - S) + \delta(\theta_l - S)$$

It is ambiguous whether t_F^S is inefficiently high or low. Low quality entrants do not internalise the costs of their entry on domestic high quality entrants, but neither do they internalise the gains from shifting some of these costs onto North.

$$\begin{aligned}\frac{\partial W_T^N}{\partial t_F^N} &= \frac{\partial \bar{\theta}_T}{\partial t_F^N}(t_F^N) + \bar{\theta}_T - S - t_F^N c^N(\theta_l) \\ &= (1-\beta)\bar{\theta}_T + \delta(\theta_l - S) + \beta\theta_l - S - t_F^N c^N(\theta_l) = 0\end{aligned}$$

the solution to which gives

$$\breve{t}_F^N = \frac{(\bar{\theta}_T - S) + \beta(\theta_l - \bar{\theta}_T) + \delta(\theta_l - S)}{c^N(\theta_l)}$$

Part of the costs of increasing t_F^N are shifted onto South but also onto high-quality Northern firms that receive an even lower price for their output. It is possible that $\breve{t}_F^N < \tilde{t}_F^N$ and lowering the number of types producing low quality when trade opens

up increases welfare.

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