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ESSAYS ON STANDARDS, TRADE, AND AGREEMENTS

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TRUTH VS BEAUTY:
ESSAYS ON STANDARDS, TRADE, AND AGREEMENTS

By

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ABSTRACT

TRUTH VS BEAUTY: ESSAYS ON STANDARDS, TRADE, AND AGREEMENTS

By

Monika Tothova

As the WTO succeeded in reducing tariffs, non-tariff trade barriers (NTBs) seem to be on the rise. Among the NTBs, the premium position is occupied by discrepancies across countries' standards. Countries are guaranteed the right to choose standards they deem appropriate for human, animal, and plant health, assuming they do not serve as barriers to trade. This dissertation examines the role of standards in trade: it investigates interactions among countries with different standards and preferences. The borderline cases of standards considered are "Truth" (defined as the good having a certain attribute) and "Beauty" (defined as the good missing a certain attribute). From an individual country's perspective, standards are perceived as vertically differentiated (that is, the Home consumer feels Truth is superior to Beauty, but the Foreign consumer considers it inferior). However, from the global perspective, standards are not directly comparable in terms of their performance, and according to the WTO, goods that satisfy differing standards may be classified as "like products". The dissertation consists of three related essays and follows a traditional theoretical model-building track with an application to genetically modified foodstuffs.

The first essay, Standards as Strategic Policy Instruments, considers a problem where two pure exchange economies with different preferences each select standards while also trying to accommodate both domestic and foreign consumers (who have

different preferences) in order to obtain gains from terms of trade effects. Four different steady states are explored and compared: (1) the social optimum, (2) myopic equilibrium, (3) a Nash equilibrium game, and (4) a Nash bargaining solution.

The second essay, Differing Standards, Welfare, and Sub-global Agreements, explores endogenous standards-setting in a Krugman-like model of monopolistic competition to investigate formation of potential trade agreements when countries do not have an opportunity to compromise on their standards. Gains from trade arise from a larger number of available varieties. When a global agreement on prevailing standards (or any other NTB) is not feasible, countries resume forming trade agreements with partners that have similar preferences as an alternative way to secure some gains from trade.

In the third essay, Economies of Scale: Autarky, Harmonization, and Compromise, standards are modeled as tolerance levels. Gains from trade come from larger numbers of varieties available, as well as traditional economies of scale. In an open trade environment we study the impact of standards harmonization and compromise on the social welfare of each country, and conclude that unless the economies of scale are large enough to justify adjustments, countries are better off in autarky.

The essays are complemented with a case study of genetically modified foodstuffs (in reality the EU position lies close to the "Truth" boundary, while the North American position lies close to the "Beauty" boundary) and explores the policy struggles introduced by their commercial approval in 1992. Countries' positions suggest potential gains from trade are not sufficient to justify harmonization, and countries cluster into clubs based on similar preferences and actual or perceived gains from trade.

DEDICATION

To the memory of my grandparents:

Pavel Gyurka, Mici Kőberling, and Mária Stredová

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CHAPTER 1

INTRODUCTION

A sequence of struggles has accompanied global trade institutions ever since the earliest failed attempt to establish a world trade organization following the Second World War. While the jury is out on causality – whether lack of progress on the global level has been pushing countries into smaller arrangements, or efforts spent on the smaller agreements are inhibiting global advancement – sub-global[1] agreements are on the rise. Between 1948 and 1994, 124 trade agreements were signed among the contracting parties to the General Agreement on Tariffs and Trade (GATT). Since its creation in 1995, the World Trade Organization (WTO) was notified of over 130 different agreements covering goods and services.

Even as the GATT/WTO succeeded in reducing tariffs in most sectors, it has been faced with disputes related to non-tariff trade barriers (NTBs) – for example not yet fully addressed processes standards often resulting in production of "like" products[2]. In addition to the dispute over "dolphin-safe" tuna, among the most notorious cases are the gasoline environmental standards (brought by Venezuela against the US), meat hormones (the US vs. the EU), shrimp vs. turtle (India, Malaysia, Pakistan, Thailand vs. the US), etc. While believers in market forces claim that demand makes grades and standards redundant, in cases of indistinguishable like products some regulation has to be in place in order to facilitate the consumer's decision. Article 20 of the GATT allows

[1] Terminology: sub-global (also labeled as regional or preferential) trade agreements include arrangements between two and more countries but not all countries necessarily being within a regional proximity.
[2] Like products are defined as products with the same end use and identical tariff classification.

governments to act on trade to protect human, animal or plant life or health, provided they do not discriminate or use this as disguised protectionism. Countries' rights to adopt the standards they consider appropriate is also recognized by the two specific WTO agreements dealing with food safety and animal and plant health and safety (Agreement on Sanitary and Phytosanitary Measures), and with product standards (Agreement on Technical Barriers to Trade), assuming their use is justified and they are not used as barriers to trade (WTO, 2004). Thus, countries are allowed to set and require different standards as long as imported and domestic goods are treated equally.

This dissertation explores the relationship between countries' differences in standards, which are rooted in their preferences, and the increasing numbers of small trade agreements. It investigates the emergence of different standards across countries; the impact of standards altered to capture gains from trade on individual countries' welfare, and in some cases extends to the formation of trade agreements. Chapter Two considers a case of pure exchange economies and explores the differences of standards selection in different settings, allowing for different types of externalities imposed by a choice of standard. Chapters Three and Four develop a Krugman-esque model of monopolistic competition and trade. The model is amended so clear consumer preference leads to the endogenous formation of national standards. Our framework can account for both goods and processes standards – as long as they impact the cost of production with internal scale economies. Economies of scale and gains from trade (larger number of varieties available) motivate the endogenous formation of trade agreements, which may require modification of national standards. A global agreement can be formed on the basis of a uniform international standard or harmonization of national standards. In the

absence of concord on prevailing standards, countries cluster into sub-global agreements based on their preferences. The dissertation is complemented by a case study of biotechnology and genetically modified foodstuffs – an issue not yet fully attended to on the global level, and intensively stirring the trade relations between the EU and the US.

There appear to be two main reasons for harmonization of standards to occur in trade: (1) to synchronize upstream and downstream production if intermediate goods are traded or (2) to remove non-tariff (or technical) barriers to trade for end-use products, i.e. when a standard in question does not induce synchronization in the production. The dissertation considers the second case.

The preface introduces the institutional background and literature behind standards[3] and sub-global agreements. Descriptions, solutions and preliminary conclusions of different models are presented in chapters Two, Three, and Four. Chapter Five summarizes the findings of the theoretical essays, and applies them to the controversy on transgenetic crops and genetically modified foods. Appendices follow Chapter Five.

1.1. Standards

1.1.1. Institutional Background

Standards are the product of market forces or government intervention (Bhalla and Kennedy, 1998). In trade law a standard is a document approved by a recognized body (either governmental or non-governmental, e.g., the International Organization for

[3] We use standards as an example of non-tariff trade barrier (NTB) in its broadest sense. Indeed, the model can be extended to account for any other NTB, such as labeling, production process, etc.

Standardization[4]), that provides for common and repeated use, rules, guidelines or characteristics for products or related processes and production methods, with which compliance is not mandatory. A technical regulation is a document which lays down product characteristics or their related production processes; compliance is mandatory. A technical regulation is usually government imposed (Bhalla and Kennedy, 1998). Following the literature, we use the term "standard" to encompass both types of documents.

Wilson (2001) categorizes standards by function into product and process standards. Product standards refer to characteristics that goods should possess – for example, size, minimum nutrition content, maximum pesticide residue on agricultural products, etc. Process standards (often labeled as production processes methods – PPMs) refer to conditions under which products are manufactured, packaged, or refined[5]. PPMs may be targeted at production conditions that are not directly related to the final good (Wilson, 2001), such as labor and environmental standards. The GATT recognizes the concept of "like products" based on tariff classification and end use: if products fall into the same tariff classification category and are subject to the same end use, they are to be treated identically, and countries cannot discriminate on the basis of the PPM.

Standards are implemented as a solution to an asymmetric information problem contained in the goods whose attributes are known to the producer only. While potentially costly to launch, standards – once established – are non-excludable and non-

[4] The International Organization for Standardization (ISO) is a network of the national standards institutes of 146 countries, on the basis of one member per country, headquartered in Geneva. ISO standards are voluntary, as a non-governmental organization, ISO has no legal authority to enforce their implementation. Most of the ISO standards are technical, i.e., methods standards (http://www.iso.ch, last viewed on June 1, 2004).

[5] Examples of PPMs are meat radiation, hormone treatment, tomato ripening, "rainforest-safe bananas", "sweatshop-free textiles", "leg hold trap-free fur", "fair trade coffee", "sustainable harvested lumber"or "dolphin-safe tuna".

depletable, and exhibit characteristics of public goods. Due to their national character standards are often perceived as a domestic policy instrument imposed, to facilitate market exchange, smooth upstream and downstream interactions among industries, lower transaction costs among agents as a medium of information exchange, and utilize economies of scale[6].

1.1.2. Standards Setting within the WTO Framework

With the progressive elimination of tariff barriers, the debate on international trade policies has shifted to national differences on standards and regulations (Casella, 2001). In spite of the positives standards introduce, and the countries' rights to limit the entry of the products to the markets, these limitations are non-tariff barriers to trade providing economic benefits to domestic firms that produce import-competing goods (Kerr, 2003). Harmonization of standards in the manufacturing sector has been less troublesome than harmonization in agricultural and food sectors – perhaps due to larger perceived gains from harmonization in the industrial sector. Standards that differ between countries have the potential seriously to impede trade (Sampson, 2000) – as currently reflected by the example of U.S. corn exports to the EU[7]. After the Uruguay Round it was

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[6] With the increasing realization of network externalities, standards acquired a new role as a network facilitating instrument. Network externalities arise when the value of the network depends on the number of users in the network. Standards assist in exploring externalities in a single interconnected network, and open standards lessen the probability of lock-in (the potentially substantial cost of switching a technology once an investment in a different technology has been made, i.e., PC and Mac) (Shapiro and Varian, 1999). Some hold standards responsible for a potential loss of varieties (ditto). A repeated argument challenging standardization often cites a case of the QWERTY keyboard as being locked in an inferior technology (i.e., Shapiro and Varian, 1999; David, 1985). We pay attention only to the internal scale economies, and ignore probable network effects. We also overlook the details of institutional aspects of standard setting.

[7] "U.S. farmers estimate the European restrictions [on genetically modified foods] have cost them nearly $300 million a year in lost corn exports alone." (http://www.cnn.com/2003/WORLD/europe/07/02/eu.gm.crops/, last viewed on June 7, 2004). Under the rules passed by the European Parliament in July 2003,

hoped that harmonized international standards would evolve by the WTO recognizing three science-based institutions as having competence to develop international standards: (1) the Codex Alimentarius for food safety; (2) the International Office of Epizootics (animal health); and (3) the Secretariat for International Plant Protection Convention (plant health) (Kerr, 2003). Currently standards are becoming more widespread, but remain disordered. For example, tolerance levels for tetracycline in beef vary from 0.1 parts per million (ppm) in the EU and New Zealand, through roughly 0.2 ppm in Japan, Canada and Australia to 2.0 ppm in the United States. The level recommended by the Codex Alimentarius is 0.6 ppm. Wilson et al (2002) estimate that harmonization at the Codex standard would increase bovine meat trade by $3.2 billion (or 57%), and that the trade value at the Codex standard is $5.1 billion higher than the trade value under the most stringent standard (0.1ppm).

The Agreement on Technical Barriers to Trade (TBT) – a specific WTO agreement balances the ability of governments and the private sector to implement legitimate standards and the procedures for assessing product conformity with those standards against their unjustified use to protect a domestic industry (Bhalla and Kennedy, 1998). It does not cover services, sanitary and phytosanitary measures or governmental purchasing specifications. It does cover regulations and standards on PPMs to the extent that they relate to product standards characteristics, but not as they relate to pollution or externalities caused by PPMs (Bhalla and Kennedy, 1998). Article 2.1 of the TBT Agreement states that "Members shall ensure that in respect to technical regulations, products imported from the territory of any [WTO] member shall be accorded treatment

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products with more than 0.9 percent of biotech material would have to be labeled with the words: "This product is produced from GMOs". No similar legislation is in place in the U.S.

no less favorable than that accorded to like products (i.e., *with the same end use and tariff classification*) originating on any other country" (italics added).

The Agreement on Sanitary and Phytosanitary Measures (SPS) "allows countries [to] set their own standards assuming they are based on science to the extent necessary to protect human, animal or plant health and not arbitrarily or unjustifiably discriminate between countries where identical or similar conditions prevail" (WTO, 2003). Intense disputes exist on what are the appropriate standards to apply for the protection of health.

1.1.2.1. Scientific Basis and the Precautionary Principle

The concept of science-based rules for the establishment of trade barriers is "an attempt to de-politicize decision making in the complex areas of human, animal, and plant health as well as aspects relating to the environment" (Kerr, 2003). A crucial question of risk management (a scientific determination of the relationship between cause and effects in situations where adverse effects can occur) to human, animal, and plant life and health is deciding on the acceptable risk levels and the appropriate standards to adopt. It raises an infamous question of the relationship between risk and precaution. The Precautionary Principle states that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent the eventual outcome of risk, covering the gap between banning a product or procedure until science has proved it is harmless and not banning it until science has proved that there is a real risk (Sampson, 2000).

While there is general agreement on exercising precaution in the face of uncertainty, there is no agreement on how it should be operationalized for decision

making (Kerr, 2003). The most politicized is the debate over genetically modified (GM) products: U.S. regulators view them as not substantially different from the conventional variety, while the EU adheres to the "precautionary principle" and sees GM and conventional as differentiated products due to the perceived risks (Nielsen et al., 2002).

1.1.2.2. Conformity Assessment Procedures

While standards themselves undeniably are central in shaping trade relations, a subsequent problem is mutual recognition of similar standards as well as related conformity assessment procedures (CAP). Article 5.1.1 and 5.2.1 of the TBT Agreement provides for the MFN treatment on CAP. Countries – although discouraged from doing so - can choose to deny entry of foreign goods unless their conformity is reassessed (i.e., labeled with a consumer information label to fit domestic requirements). Obligation to comply with foreign standards requirements could result in increased cost for foreign producers, and includes all aspects of CAP, including laboratory accreditation and quality system registration. The minimum derogation principle (Art. 5.12) states that CAP "shall not be more strict or be applied more strictly than is necessary to give the importing member adequate confidence that products conform with the applicable technical regulations or standards taking into account the risk non-conformity would create". Similarly, countries are encouraged to recognize practices – which, albeit different – yield the same result, for example in testing for qualitative and quantitative characteristics. For the purposes of this paper we do not allow countries to mutually recognize their CAPs, and focus on standards per se.

1.1.2 Literature: Standards and Product Differentiation in Trade

The dissertation addresses standards regarding like products. Therefore, the usual reasons for standardized production to ensure compatibility of the upstream and downstream production processes are not relevant.

Standards in literature are frequently treated as reflections of domestic policies and preferences (Ederington et al., 2002) most frequently imposed for facilitation of market exchange. With decreasing tariff trade barriers, it is suspected that standards are also employed as a form of strategic trade policy (e.g., Dasgupta, 2000; Mattoo, 2001). Most of the up to date literature on standards and trade has dealt primarily with process standards, i.e. environmental and labor standards (e.g., Lynch, 2000; Griffin, 2000, etc); and standards in the context of development – such as exploring the impact of standards imposed by developed countries on their developing countries' suppliers, often on the farm level (Henson, 1999; Donovan et al., 2001; Hufbauer et al., 2002).

Not every paper is concerned with standards imposed as means of trade policy; rather, some investigate social dimensions of standards and their impacts on domestic markets.

The most comprehensive theoretical model of product standards in international trade is Casella (2001), explicitly recognizing the role of government in establishing general guidelines for standards. Contrary to the usual treatment considering standards a public good, Casella explicitly models standards as club goods while assuming a pure exchange economy, and accounting for the provision of the club goods as well. Clubs originate in private coalitions of firms as developers of exact specifications, and thus her model investigates the mechanics of potential harmonization from the bottom. The size of

national standard-sharing coalitions is determined by the trade-off between economies of scale, a proxy for the advantage of standardization, and the desire for variety.

Opponents of trade liberalization often fear standards would degrade to the lowest level. Garbo's (2002) international convergence in regulation in case of measurable standards shows that, even without acceptance of reciprocal minimum standards, a process of iterative adjustment may be triggered by the coexistence of foreign goods with high standard levels and domestic goods with relatively low standard levels. Focusing on the case of international heterogeneity of levels of a specific standard, he offers an intuitive counter-argument to the fear that free trade necessarily implies a "race to the bottom" of standard levels[8]. A similar motif of minimum quality standards appears in Lutz' (1996) partial-equilibrium model of vertical product differentiation and trade in which duopolistic firms face quality-dependent costs and compete on quality and price in two segmented markets. In an unregulated equilibrium, one firm sells high quality whereas the other sells low quality. Under full harmonization of standards, there always exists some minimum quality standard that will increase welfare in both regions. Alternative policy arrangements include national treatment, and mutual recognition. Under either alternative, standards are found that increase welfare in both regions. Mutual recognition is always better than no regulation.

[8] For more on the "race to the bottom", refer to Wilson, J.D, 1996; Levinson, 1996; and Klevorick, 1996.

1.2. Trade Agreements

1.2.1. Institutional Background

Paragraph 1 of the GATT 1947, Part I, the Article I on the General Most-Favored-Nation Treatment guarantees that "any advantage, favor, privilege or immunity granted by any contracting party to any product originating in or destined for any other country shall be accorded immediately and unconditionally to the like product originating in or destined for the territories of all other contracting parties," and in fact prevents formation of subglobal agreements. However, the WTO members are allowed to form sub-global agreements under the condition that duties and other trade barriers should be reduced on substantially all sectors of trade for all members of the agreement, and non-members should not find trade with members any more restrictive than before the agreement (WTO 2002)[9].

Among the advantages of a membership in a trade agreement are enhancement of terms of trade for members (relative to nonmembers) of an accord as a whole; trade creation; economies of scale; offset of eventual domestic monopoly power; increased levels of investments and technology transfers followed by industrialization, development, and increased rates of growth; increased bargaining power within a region as well as globally; and the means to consolidate domestic economic reforms and provide political stability in transition economies (Bhagwati et al 1998, Schiff and Winters 1997). The disadvantages include trade diversion; losses in tariff revenue following removal of trade barriers; necessary investment of resources needed to negotiate and implement an

[9] Rules for forming clubs among countries – individual political entities – are described by the WTO. On the other hand, forming agreements among profit maximizing firms resulting in cartels are prohibited in most countries in the world.

agreement; often confusing rules of origin; and additional issues of technical, administrative, and political nature arising from memberships in several overlapping treaties (Bhagwati et al 1998, Schiff and Winters 1997).

1.2.2. Literature: Trade Agreements

Research on trade agreements often assumes their exogenous formation. Whether modeling a new arrangement (i.e., Grossman and Helpman, 1995; Richardson, 1994; Levy, 1997) or modeling extensions of already existing agreements (i.e., Baldwin, 1993; Bond and Syropoulos, 1996; Yi, 1996; Andriamananjara, 1999), to our knowledge the idea of linking agreement formation to the existence of NTBs has not been entirely pursued.

The concepts of public and club goods provide an elegant framework for analyses of diverse trade arrangements. Public goods, whose benefits simultaneously affect a group of individuals, but cannot be divided among individuals, owing to nonrivalry of benefits and excludability problems, fit the portrayal of global trade agreements (the WTO). Club goods, characterized by congestion and excludable benefits (Cornes et al., 1996) express the workings of the sub-global agreements. Clubs as voluntary groups are justified in the literature by pure taste of association (maybe on historical grounds), cost reduction from scale economies or team production, sharing of public goods, and sharing of public factors (Cornes et al, 1996). In many definitions of clubs in the literature, club members share common characteristics, such as income level.

Sub-global agreements exclude the rest of the world; and free movement of goods and services within such an agreement is closer to a club good in Buchanan's sense than

to a non-excludable public good. Arrangements in globally multilateral organizations resemble a public good due to the non-excludability of benefits[10]. Studies using concepts from public economics in an international setting have been mostly concerned with security (Olson and Zeckhauser, 1966; Brauer et al., 2000), and lately with the environment (i.e., Pimbert, 1997; Carraro et al., 1993). A link between agreements and clubs does occur (i.e., Fratianni and Pattison, 2001; Keohane and Nye, 2001; Kerr, 2002 – none of them agrees on the meaning of a "club"), however, the literature seems largely to ignore public concepts to explain the trade agreements phenomena.

Fratianni et al (2001) use a simple club theory model to derive the optimum amount of cooperation while stressing the need for a dominant provider, but their paper contains mostly lessons from club theory applied to LTGs. Organizations with large and heterogeneous memberships offer less probability of success in international cooperation than smaller and homogeneous clubs led by a few players, keeping in mind "inter-block" differences and rivalries: i.e., EU, NAFTA, and Asia.

Keohane and Nye (2001) discuss a club model of multilateral cooperation. They use a "club model" as a *modus operandi*: international organizations operate as clubs of negotiators, often technically trained, bargaining with one another within specified issue areas. The club model is very convenient for officials negotiating agreements within issue areas as it keeps outsiders out: first, officials working on different issue-areas are excluded from the negotiations; and secondly, the public is confronted with a series of *faits accomplis*, making domestic politics easier to manage. Their model can be applied to negotiators representing heterogeneity and attributes of member countries, although

[10] In a multilateral agreement – "big club" – non-exclusion can be treated as a choice, rather than a necessity.

they do not necessarily position themselves in that way. With the "club of negotiators from the rich countries" still setting the agenda and leading negotiations, other countries might seek more homogeneous clubs to present their concerns, or – members not "selected to be in the decision making club are" likely to form their own clubs.

Finally, Kerr (2002) suggests that "since its inception the GATT, and subsequently the WTO, has been able to operate in a fashion that is more consistent with a club than an inclusive organization that encouraged the active participation of all its members", and its global club model might no longer be appropriate.

1.3. Standards and Trade Integration

1.3.1. Anecdotal Evidence: Standards (NTBs) and Agreements

How do standards and subglobal agreements link? While causality is open to discussion, anecdotal evidence shows there are a large number of bilateral and regional agreements aiming at harmonization or mutual recognition of national standards that also aim at facilitating trade between countries (i.e., Wilson, 1997). Successful agreements tend to be industry driven: for example, the World Wine Trade Group, consisting of Argentina, Australia, Canada, Chile, New Zealand, South Africa, and the United States, signed an agreement on mutual acceptance of oenological practices in 2002[11]. A similar agreement on a bilateral basis is being negotiated between the EU and Australia[12]. A further case: in 1995 the governments of Australia and New Zealand signed a Treaty

[11] Full text of The Agreement on Mutual Acceptance of Oenological Practices is available at http://www.ita.doc.gov/td/ocg/oenological.htm. Last viewed on July 7, 2004.
[12] From EU's Bilateral Trade relations. Available online at http://europa.eu.int/comm/trade/issues/bilateral/countries/australia/index_en.htm Last viewed on July 7, 2004

establishing a system for the development of joint food standards (Lindenmayer, 1999), following the Australia New Zealand Closer Economic Relations Trade Agreement signed in 1983[13].

A practical example of harmonization – in terms of eliminating NTBs – is seen in the current EU enlargement[14]. One of the first short- and medium-term priorities in each country was to establish and consolidate standardization and conformity assessment structures. While the concept of "deeper integration beyond abolition of import tariffs and quotas, to further measures to remove market segmentation and promote integration" (Venables, 2000) is by and large not questioned, critical views on potential losses of national standards harming national identity – i.e., what constitutes "rum", and how to address cheeses made from non-pasteurized milk – are seen as well.

The issue of "lost national standards" repeats itself: in 1987 the EU (then European Community) published its visionary plan on new, standardized Europe of 1992; a gain of 7 per cent of European income was estimated from harmonization (Emerson 1988, p.6). Even then British were opposed to some parts of it, claiming "brilliant green mushy peas" and "pink sausages" are part of their national identity, and eventually succeeded in getting the necessary exemptions (Krugman and Obstfeld 2002). Although the harmonization issue has been on the tables in Brussels at least since the late 1980s, it yet has to be concluded. Over the years a "new" approach replaced the "old" one: instead of imposing technical solutions, the EU legislation is limited to establishing the essential requirements which products must meet (EC, 2003).

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[13] There are three areas of food standards excluded from the operation of the Australia – New Zealand joint system - the specification of maximum residue limits for agricultural and veterinary chemicals in foods, the specification of food hygiene practices and export requirements relating to third country trade.

[14] Countries joining the EU in May 2004 after the Accession Treaty is ratified are Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia (http://europa.eu.int).

The EU recognizes the removal of technical barriers to trade as a necessary prerequisite of a complete internal market. Rather than establishing definite technical norms and solutions on a case-by-case approach as it was the instance before 1985, the legislation now establishes minimal requirements products must meet. Harmonized European product legislation includes legislation covering conformity assessment bodies, accreditation bodies, standardization, and market surveillance. Regulations continue to be voluntary, manufactures therefore remain free to offer, on the Community market, products meeting other standards or not meeting any, provided that they satisfy the procedures for assessing conformity laid down by the appropriate Directive (EC, 2003).

The Commission also recognizes potential problems arising from the voluntary nature of its standards: in its 1998 report, the Commission emphasizes that the voluntary and independent nature of standards drafting can only be justified if the system is truly open and transparent and if the standard is supported by all major interested parties and applied in a uniform way throughout the Community. Consequently, European standardization is slower in the areas in which the market is not particularly supportive of standardization, for example in case of goods not suited to be transported, and thus are only consumed locally. The standardization process in the EU takes place in several "layers" of national and European standardization bodies mutually cooperating and informing each other of drafts standards and potential amendments. Where technical standards are not harmonized, the principle of mutual recognition of national rules applies (in line with the *Cassis de Dijon* judgment[15]).

[15]The *Cassis de Dijon* judgment ensures that "any product lawfully produced and marketed in one Member State must, in principle, be admitted to the market of any other Member State. For more on the Cassis de Dijon, please refer to http://europa.eu.int/comm/internal_market/en/goods/caasiscomm_en.pdf. Last viewed on July 8, 2004.

Standards are just one example of domestic regulatory policies. Their synchronization or at least convergence of positions does not differ from any other policy integration – or "actions by governments to reduce the market segmenting effect of differences in national regulatory regimes through coordination, harmonization, or mutual recognition of national laws, regulations, and enforcement mechanisms" (Hoekman et al, 1998). Some of the generic reasons why policies are integrated include, but are not limited to, lessening hostility; cultural dimension in choosing partners; political cooperation in spheres other than trade: water basin management, environment, and infrastructure; economies of scale in negotiating with the world and providing local public goods. In all cases where policy integration is being considered, the question of the optimal domain of inter-governmental cooperation is to be addressed. While in some instances the optimal domain will be regional (or *subglobal* – added), in many instances the optimal domain is global (Hoekman et al, 1998).

1.3.2. Literature: Standards and Coalitions

Several motifs are repeated in this literature: the most frequent ones are labor and environment, more recently intellectual property rights (IPR), often from the NAFTA perspective. For example, Esty (1994) examines the treatment of environmental considerations in the NAFTA, and concludes that it provides some useful first steps in efforts to make trade and environmental policies mutually supportive. In the same spirit Emerson and Nessman (1995) praise the NAFTA for shaping future regional and international trade negotiations by dealing with both boundary problems and common standards without dictating uniformity of standards or impinging greatly on each nation's

sovereign control over matters within its own borders. Ederington (2001) shows that in a repeated game framework, the enforcement of a free trade agreement may require some convergence in environmental standards across countries when trade is driven by differences in such standards. He also demonstrates it is more efficient to enforce a trade agreement by setting tariffs partially to offset differences in policy standards than to attempt to harmonize standards within environmental side agreements. In the labor arena, Singh (2002) finds the NAFTA labor side agreement had enjoyed moderate success in bringing labor concerns to the fore and that predicted negative effects of trade liberalization – namely the erosion of standards and the harmonization of labor laws to the lowest common denominator – did not materialize. Lai and Qiu (2003) build a multi-sectoral North ("developed") – South ("developing") trade model to analyze international IPR protection, and show both regions can gain from an agreement that requires the South to harmonize its IPR standards with those of the North, and the North to liberalize its goods market.

The concept of smaller "alliances" and standards also appears in Gandal and Shy (2001). Instead of harmonization they focus on a government's incentives to recognize foreign standards, and allow a game in which countries can form standardization unions. The outcome depends on the size of network and conversion costs.

Gaisford (2002) examines implications of the biotechnology production and regulations for the Free Trade Area of the Americas (FTAA), and recognizes that different countries in the area have different stakes as most of the biotechnology research was aimed at temperate climate crops. The FTAA may be tempted to take a minimalist approach, and defer biotechnology regulations to other relevant authorities, such as the

SPS and TBT agreements and the BioSafety Protocol, even though these outside authorities are, at present, neither fully up to the task posed by biotechnology nor even mutually consistent. A more ambitious approach, for the FTAA might be, therefore, to provide interim clarification on important issues, such as that GM and non-GM varieties need not to be treated as like products, and a short-term precaution.

1.4. Contribution to the Literature

This dissertation fills a gap in the literature in multiple accounts: (1) it focuses on standards for "*like-product*" as an illustration of non-tariff trade barriers, and (2) links sub-global agreements (not necessarily formalized) with countries' preferences and positions. We treat standards as representations of consumer preferences only – and leave out lobbying effects of domestic producers eager to establish their own platform as a prevalent standard. In all cases we assume launching and enforcement of standards is costless. Standards in the models are imposed to facilitate consumers' decision, take advantage of increased number of varieties, and to a certain extent economies of scale.

Extending the literature on strategic trade policy, Chapter 2 explores standards as strategic policy instruments by illustrating country's possibilities to influence terms of trade by changing the standard at which country offers parts of its endowment for trade.

Unlike other authors, we focus on the issue of like products (effectively indistinguishable products with the same end use): where usual motifs for standardization (other than smoothing trade) tend not to apply. However, recent trade disputes and consequent polarization into sub-global groups – has shown increased interest in process

standards, and in like products in general. We do not model standards in a duopolistic structure of limited number of goods, but extend the usual Krugman model of monopolistic competition and love of variety [in Chapters 3 and 4] to incorporate standards. Appending a simple, yet well established and commonly understood model allows us to concentrate on conclusions and implications of the model, rather than focusing on its mechanics.

The dissertation focuses on standards, and treats trade agreements as a "byproduct" – showing that optimal harmonization domain can be sub-global. After solving the case of standard selection between two countries, we extend the analyses to the multiple country case, and claim that provision of standards is more likely as a club good rather than a public good [unlike Casella who explicitly seeks to model standards as club goods]. We do not seek to model formation of sub-global trade agreements per se: formation of trade agreements is a natural consequence of lack of consensus on reaching a global standard, or, showing harmonization is disadvantageous when the differences between countries are too big. Such a formulation fits nicely with club theory and theory of social choice, and complements political economy contributions comparing international organizations with clubs.

Finally, last chapter applies conclusions from the theory essays to trade in genetically modified products.

CHAPTER 2

STANDARDS AS STRATEGIC POLICY INSTRUMENTS

Chapter 1 introduced a specific member from the family of non-tariff trade barriers: standards as an example of technical barriers to trade. It also suggested motifs for increased application of non-tariff barriers: with the tariff bound in the WTO negotiations, countries who wish to manipulate their terms of trade, protect domestic consumers, etc. are obliged to employ non-tariff measures as a back-door to prohibition of "traditional" trade barriers. While the practice is certainly discouraged, and often results in a dispute settlement procedure, current treaties (SPS, TBT, etc.) allow the application of non-tariff barriers in the name of the protection of human, animal, and plant health. The Chapter seeks to demonstrate different levels of welfare attainable with different standards depending on the policy scenario chosen.

In this essay we assume two pure exchange economies with heterogeneous preferences, and study mechanics of their standard selection under different scenarios balancing domestic preferences with gains from trade – effectively employing standards as some sort of a "strategic trade policy" instruments. Namely we consider four different trade cases[16]:

1. Case I: choice of standards in a social optimum employing an omnipotent social planner taking into account the externality imposed on the other country;
2. Case II: choice of standards in a "myopic" equilibrium without terms of trade effects;

[16] Due to CD structure of the preferences, autarky in which each country would consume own good only is not an equilibrium: regardless at what standard the domestic good would be offered.

3. Case III: choice of standards in a Nash equilibrium game in standards setting with terms of trade manipulation; and
4. Case IV: choice of standards in a Nash bargaining solution.

Trade literature defines strategic trade policy as a trade policy that conditions or alters a strategic relationship between firms, implying that strategic trade policy focuses primarily on trade policy in the presence of oligopoly. The key point is that strategic relationships between firms introduce additional motives for trade policy, over and above terms of trade and other effects that arise in all market structures (Brander in Grossman and Rogoff, 1995). Strategic trade policy also takes account of imperfect competition and increasing returns (Krugman and Smith, 1994). While standards selection per se does not consider anything from above specifically, it provides governments with a tool to balance two effects: consumption and terms of trade effects, and thus introduces strategic reasons into standards selection between countries (not firms). The choice of standards – effectively a trade policy – shifts the shares of goods consumed at the domestic and foreign markets – and results in different gains in the form of terms of trade effects.

The model corresponds to decisions countries are facing when trading *like* products (products with the same tariff classification and end use), or considering different production processes which impact countries' willingness to pay for goods.

2.1. Model Description

The chapter abstracts from production by assuming exogenously-given endowments of goods. Two goods are available in the world, and each country is

endowed with one good only: Home is endowed with X units of good X; Foreign is endowed with Y units of a good Y[17]. We will explore cases of identical and different endowments across countries. Endowments are fixed: the choice variable is the quality at which countries offer their endowments. The origin of the good (Home or Foreign) indicates two individual goods, rather than denoting geographical attributes of goods that would be otherwise substitutes to a certain degree (for example, wine from France and Italy). Trade is guaranteed by assuming a Cobb-Douglass structure of preferences in each country: utility in autarky with only one good consumed is zero. We consider a representative consumer problem in each country[18]. After a monotonic transformation, (the natural logarithm of) Home's utility function is given by:

(2.1A) $$U^H = \alpha_H \ln x_H + \beta_H \ln y_F$$

while the Foreign utility is given by

(2.1B) $$U^F = \alpha_F \ln x_F + \beta_F \ln y_F$$

where x and y stand for consumption of the Home and Foreign good, respectively. The subscript denotes the consumption point (Home or Foreign). Define exponents (or preference weights) as:

(2.2A) $$\alpha_H(h) = \frac{1}{1+(h-H)^2}$$

(2.2B) $$\alpha_F(h) = \frac{1}{1+(h-F)^2}$$

[17] In text upper case letters (X and Y) denote supply; lower case letters denote demands.
[18] Size considerations are addressed via endowment size.

(2.3A) $$\beta_H(f) = \frac{1}{1+(f-H)^2}$$

(2.3B) $$\beta_F(f) = \frac{1}{1+(f-F)^2}$$

where H and F stand for *exogenous* stable Home and Foreign quality preference parameters; h and f are *endogenous* Home and Foreign quality choice parameters (standards)[19]. Holding relative prices, x_i and y_i constant, and assuming $x_i > 1, y_i > 1$the utility in each country is increasing in α_i, β_i: $\frac{\partial U_i}{\partial \alpha_i} > 0$ and $\frac{\partial U_i}{\partial \beta_i} > 0$. Since x_i and y_i are chosen to maximize utility, allowing consumers to re-optimize after the change in α_i and β_i can only result in higher utility. Note that α_i terms (Equations 2.2A and B) depend only on the home's choice parameter h, while the β_i terms (II.3A and B) depend only on f. Quality parameters – call them standards – can be associated with quality attributes, food safety standards, etc. – that is, any attribute from which a diversion can be assessed.[20] For simplicity assume F and H are borderline points of an interval along a number line, with F being less than H (potential interpretation includes tolerance levels in the system). "Standards" are measured in terms of the Euclidian distance from the countries' respective borderline preference parameters: F for Foreign, and H for Home. We only consider cases where F and H are different: the case when F and H are identical is trivial, and countries would pick a standard identical with the common tolerance level. Setting a standard equal to the preference parameter (Home at H, Foreign at F) guarantees that weights (α and β) equal one. Moving away from domestic preferred "quality" parameter

[19] In text we will refer to F and H as preference parameters, and f and h as choice parameters.
[20] Presented model is not applicable to horizontally differentiated goods (none of the attributes is superior). While in the model we abstract from considering the potential superiority, it is true that in order for the model to work, it has to be possible to "measure" the difference between desired and offered standards.

causes the weight assigned to a consumption of a particular good to decrease. Figure 2.1 illustrates the behavior of α_H and α_F as a function of h: α_F reaches its maximum at $h = F$, α_H at $h = H$. Both curves intersect at $h = (F+H)/2$. Figure 2.2 provides the same graph for βs as a function of foreign choice parameter f.

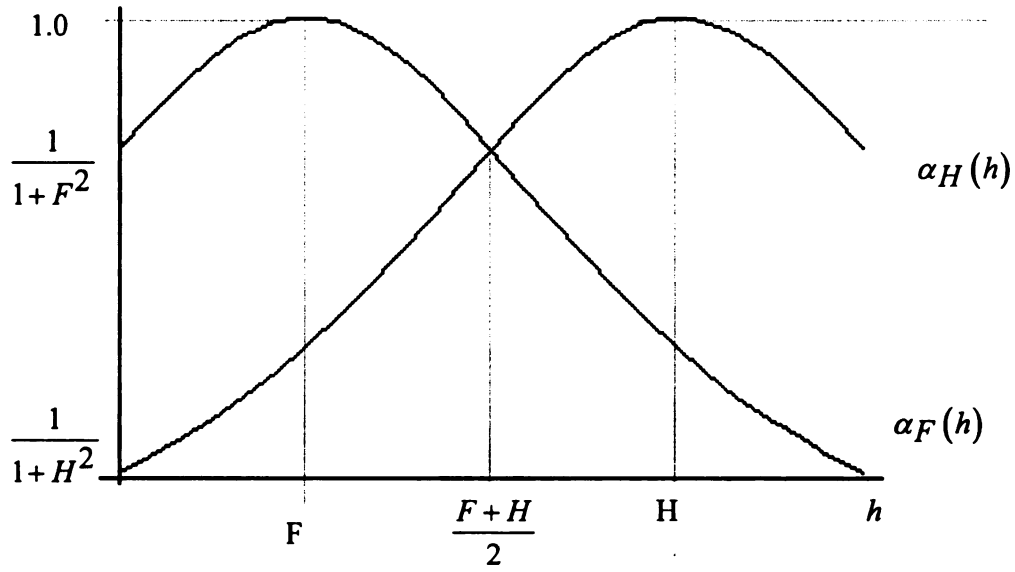


Figure 2.1: Behavior of α Exponents as a Function of h.

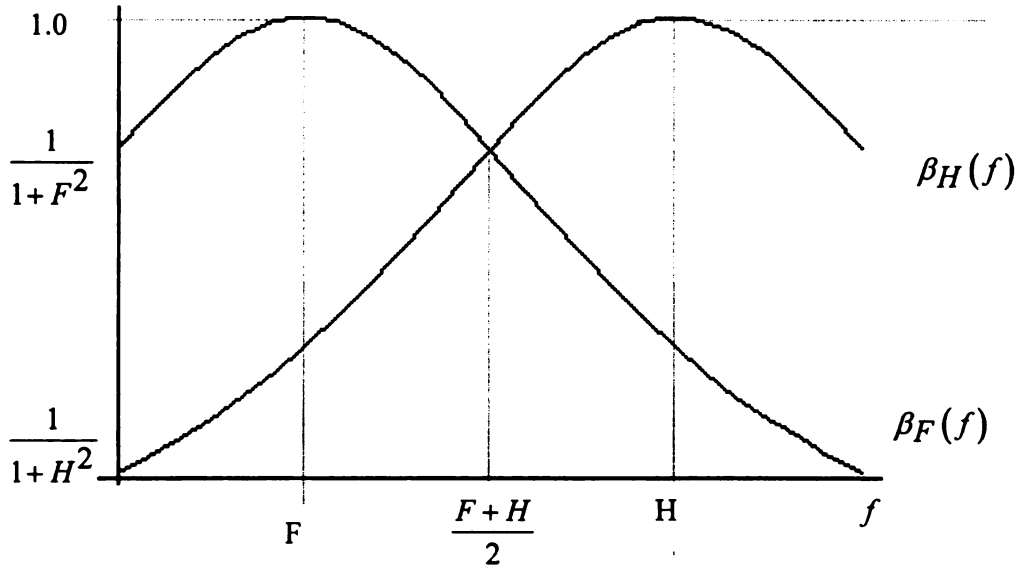


Figure 2.2: Behavior of β Exponents as a Function of f.

Choosing appropriate h and f constitutes a "strategic policy tool" in the case presented: by choosing h (at Home) and f (at Foreign) countries balances between domestic and foreign demands – and thus influence their "terms of trade" (TOT). We assume each country is obligated to choose one "standard" only (h or f) at which it will supply its endowments – and rule out cases of endowment segregation to tailor part of the endowment to suit taste in both countries. Substituting for weights in Equations 2.2A and B we obtain:

(2.4A) $$U^H = \frac{1}{1+(h-H)^2}\ln x_H + \frac{1}{1+(f-H)^2}\ln y_H$$

(2.4B) $$U^F = \frac{1}{1+(h-F)^2}\ln x_F + \frac{1}{1+(f-F)^2}\ln y_F$$

Normalize the price of the Foreign good to be the numeraire. Thus, representative consumers face a budget constraint of:

(2.5A) $px_H + y_H = E_H$ in the Home country

(2.5B) $px_F + y_F = E_F$ in the Foreign country

where p is the price of the domestic good, and E_H and E_F are values of their respective endowments:

(2.6A) $E_H = pX$

(2.6B) $E_F = Y$

By Cobb-Douglass preferences

(2.7A) $px_i = \theta_i E_i$

(2.7B) $y_i = (1-\theta_i)E_i$

where

(2.8) $$\theta_i = \frac{\alpha_i}{\alpha_i + \beta_i}$$

is the expenditure share for x, $i = H$ or F. Substituting for demands into Equations 2.4A and B, and simplifying the expression, the indirect utility function becomes:

(2.9) $$V_i(p, E_i) = \alpha_i \ln \theta_i + \beta_i \ln(1-\theta_i) - \alpha_i \ln p + (\alpha_i + \beta_i) \ln E_i$$

for $i = H, F$. Substitute values of endowments from Equations II.7A and B into II.8:

(2.10A) $$V_H(p, X) = \alpha_H \ln \theta_H + \beta_H \ln(1-\theta_H) + \beta_H \ln p + (\alpha_H + \beta_H) \ln X$$

(2.10B) $$V_F(p, Y) = \alpha_F \ln \theta_F + \beta_F \ln(1-\theta_F) - \alpha_F \ln p + (\alpha_F + \beta_F) \ln Y$$

Notice the Home's indirect utility (2.10A) is increasing in price, while the Foreign indirect utility (2.10B) is decreasing in price.

2.2. Case I: Social Planner

We commence with the social planner problem to account for "externalities" countries are imposing on each other by their selection of standards as an efficient benchmark case. Due to the structure of the preferences, to achieve positive utility, consumers in each country must consume some definite amounts of both goods regardless at what standards they are offered. The externalities take the form of consumption that is lower than it would be if a different set of standards was chosen. The social planner's selection chooses a set of standards that minimizes externalities countries would otherwise impose on each other.

The social welfare function consists of a sum of individual countries utilities across countries, assuming each country consists of a number of consumers (X consumers at Home, Y consumers in the Foreign country), each endowed with one unit of good[21]:

$$U = X\left(\alpha_H \ln x_H + \beta_H \ln y_H\right) + Y\left(\alpha_F \ln x_F + \beta_F \ln y_F\right) \tag{2.11}$$

Goods' markets clear:

$$Xx_H + Yx_F = X \tag{2.12A}$$

$$Xy_H + Yy_F = Y \tag{2.12B}$$

Consequently the demand functions are:

$$x_H = \frac{X\alpha_H}{X\alpha_H + Y\alpha_F} \tag{2.13A}$$

$$x_F = \frac{X\alpha_F}{X\alpha_H + Y\alpha_F} \tag{2.13B}$$

$$y_H = \frac{Y\beta_H}{X\beta_H + Y\beta_F} \tag{2.14A}$$

$$y_F = \frac{Y\beta_F}{X\beta_H + Y\beta_F} \tag{2.14B}$$

After substituting for demand functions from Equations 2.13A – 14B into 2.11, the social indirect utility function is:

$$W = X\left\{\alpha_H \ln\left[\frac{X\alpha_H}{X\alpha_H + Y\alpha_F}\right] + \beta_H \ln\left[\frac{Y\beta_H}{X\beta_H + Y\beta_F}\right]\right\} + Y\left\{\alpha_F \ln\left[\frac{X\alpha_F}{X\alpha_H + Y\alpha_F}\right] + \beta_F \ln\left[\frac{Y\beta_F}{X\beta_H + Y\beta_F}\right]\right\} \tag{2.15}$$

[21] Consideration of a non-weighted social welfare function of two representative agents and addressing the size considerations through the size of the endowment of each agent results in the social planner splitting the difference between the standards (that is, choosing both standards in the middle of the interval), and inevitably leads to large transfers from the larger to smaller country.

The social planner maximizes social welfare by choosing the choice parameters for both countries, while taking into account the externality the selection imposes on the other country. Thus, the FOC (simplified by incorporating definitions of exponents from 2.2A – 3B) are:

$$(2.16A)\frac{\partial W}{\partial h} = 2\left\{\alpha_H^2 (H-h) X \ln\left[\frac{X\alpha_H}{X\alpha_H + Y\alpha_F}\right] + \alpha_F^2 (F-h) Y \ln\left[\frac{X\alpha_F}{X\alpha_H + Y\alpha_F}\right]\right\}$$

$$(2.16B)\frac{\partial W}{\partial f} = 2\left\{\beta_H^2 (H-f) X \ln\left[\frac{Y\beta_H}{X\beta_H + Y\beta_F}\right] + \beta_F^2 (F-f) Y \ln\left[\frac{Y\beta_F}{X\beta_H + Y\beta_F}\right]\right\}$$

Notice that the social planer considers marginal impact on "one set" of exponents at the time: i.e., he weights the impact of the choice of h on αs independently from βs. Appendix A.1 lists the second order conditions for the problem when countries are endowed equally.[22] Whether the objective function is convex or concave on the interval bordered by Foreign and Home preference parameters depends on the Euclidian distance between them.[23] Thus, we prove two propositions depending on the respective distance.

Proposition 2.1: When endowments are the same across countries, and the difference between Home and Foreign preference parameters (F and H, respectively) is sufficiently *large*, the social planner splits the difference between Home and Foreign preference parameters, setting $f = h = (F+H)/2$.

Proof: When the endowments across countries are identical, the first order conditions (Equations 2.16A and B) reduce to:

[22] We briefly touch upon the social planner solution when endowments are different in Appendix A.2 by providing numerical examples and implying some conclusions.
[23] We ignore the case when the objective function is neither convex nor concave.

(2.17A) $$\frac{\partial W}{\partial h} = 2X\left\{\alpha_H^2 (H-h)\ln\left[\frac{\alpha_H}{\alpha_H+\alpha_F}\right] + \alpha_F^2 (F-h)\ln\left[\frac{\alpha_F}{\alpha_H+\alpha_F}\right]\right\}$$

(2.17B) $$\frac{\partial W}{\partial f} = 2X\left\{\beta_H^2 (H-f)\ln\left[\frac{\beta_H}{\beta_H+\beta_F}\right] + \beta_F^2 (F-f)\ln\left[\frac{\beta_F}{\beta_H+\beta_F}\right]\right\}$$

By assumption $(H-h)>0$, and $(F-h)<0$. Therefore, for the first order condition with respect to Home choice parameter (h) to hold (Equation 2.17A), it has to be true that:

(2.18) $$\alpha_H^2 \left|(H-h)\right| \ln\left[\frac{\alpha_H}{\alpha_H+\alpha_F}\right] = \alpha_F^2 \left|(F-h)\right| \ln\left[\frac{\alpha_F}{\alpha_H+\alpha_F}\right]$$

When $h = \frac{F+H}{2} \Rightarrow |H-h| = |F-h|$. Consequently from Equation 2.2A and B, $\alpha_H = \alpha_F$. Thus, $\frac{\alpha_H}{\alpha_H+\alpha_F} = \frac{\alpha_F}{\alpha_H+\alpha_F}$, and $\alpha_H^2 = \alpha_F^2$. A similar line of reasoning holds for β_H and β_F: $\beta_H = \beta_F$ when $f = (F+H)/2$. Second order conditions are in the Appendix A.1.

Proposition 2.2: When endowments are the same across countries, and the difference between Home and Foreign preference parameters (F and H, respectively) is sufficiently *small*, the social planner choice of social welfare maximizing standards (choice parameters) coincides with countries' preference parameters: that is, $h = H$ and $f = F$.

Proof: The simplified first order conditions for the welfare maximization problem (Equations 2.17A and B) apply. However, based on the exposition of the second order conditions in the Appendix A.1 when the difference between the Home and Foreign preference parameters (F and H) is "small", the critical point in the middle of the interval

is welfare minimizing, as the social welfare function is convex on the interval. Other critical points lie outside the $\langle F, H \rangle$ interval, and thus are prohibitive based on economic intuition. Therefore, countries' preference parameters are identical with their choice parameters.

2.3. Case II: Myopic Equilibrium

By myopic (antonym to a perfect foresight) equilibrium we mean a situation where each country is maximizing its indirect utility function without considering the impact of a change in the standard on the terms of trade – or, it assumes price is constant.

Proposition 2.3: In the myopic equilibrium the social welfare maximizing standard is identical with the country's preference parameter (at Home: $h = H$, in Foreign: $f = F$)

Proof: Addressing choice of the Home country first we take the first derivative with respect to h (the domestic choice parameter) of the Home's indirect utility function (Eq. 2.9A), and simplify the notation using Equations 2.2A – 8 to obtain:

$$\frac{dV_H}{dh} = -2(h-H)\alpha_H{}^2(\ln\theta_H + \ln X) \tag{2.19}$$

Setting the first order condition equal to zero (keeping in mind α_H, θ_H are functions of h), we solve for the following stationary point:

$$h = H - \sqrt{-2-(f-H)^2 + X + (f-H)^2 X} \tag{2.20}$$

(2.21) $$h = H + \sqrt{-2 - (f - H)^2 + X + (f - H)^2 X}$$

(2.22) $$h = H$$

Appendix A.3 evaluates the relevant second order conditions, concluding that Home's indirect utility function without terms of trade effects reaches its maximum at $h = H$, and minima at the other two stationary points. Figure 2.3A schematically graphs the behavior of Home's indirect utility function taking price and Foreign's choice of standard as given.

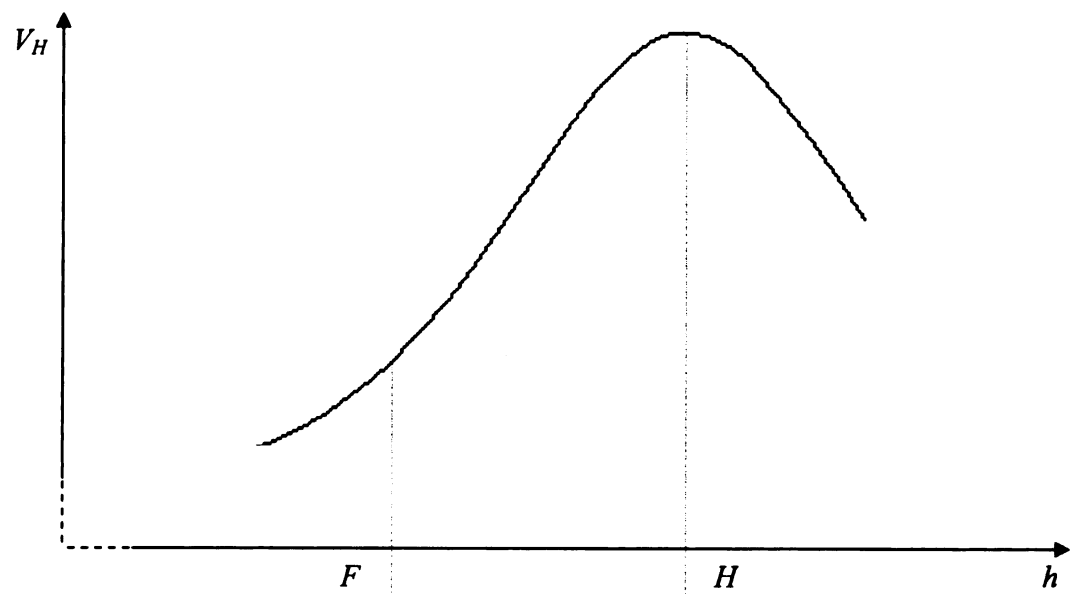


Figure 2.3A: Home: Indirect Utility Function without Terms of Trade Effects.

In the Foreign country the FOC (differentiating Equation 2.10B) becomes:

(2.23) $$\frac{dV_F}{df} = -2(f - F)\beta_F^2 \left(\ln[1 - \theta_F] + \ln Y\right)$$

Solving for stationary points, we obtain:

(2.24) $$f = F - \sqrt{-2 - (h - F)^2 + Y + (h - F)^2 Y}$$

(2.25) $$f = F + \sqrt{-2 - (h-F)^2 + Y + (h-F)^2 Y}$$

(2.26) $$f = F$$

As in the case of Home country, the Foreign indirect utility function reaches a maximum at $f = F$, and minima at the other two stationary points (SOCs are evaluated in the Appendix A.3). Figure 2.3B illustrates the behavior of foreign indirect utility function without terms of trade effects (without considering the effect on price).

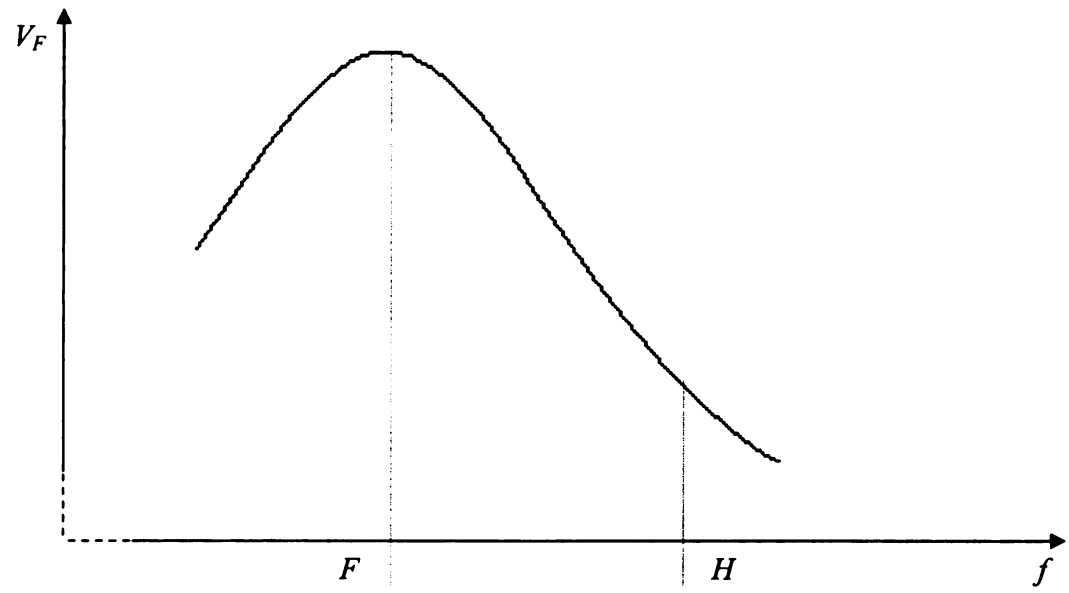


Figure 2.3B: Foreign: Indirect Utility Function without Terms of Trade Effects.

Thus, in the myopic equilibrium – defined as countries ignoring their potential impact on price, and forsaking terms of trade effects, countries identify their choice parameters with their preference parameters. *QED.*

2.4. Equilibrium Price

By Walras' Law, we only need to look at one market. For the Home-good (X) market to clear, the sum of individual country demands has to equal world supply:

(2.27) $$x_H + x_F = X$$

Substitute for individual country demands to obtain:

(II.28) $$\frac{\theta_H}{p} E_H + \frac{\theta_F}{p} E_F = X$$

From Eq. 2.6A and B substitute values of endowments for incomes:

(II.29) $$\theta_H X + \frac{\theta_F}{p} Y = X$$

and finally derive an expression for equilibrium price defined as a price of the Home good (with a safety parameter h) in terms of a numeraire – that is the Foreign good (with a safety parameter f).:

(2.30) $$p = \frac{\theta_F}{1-\theta_H} \frac{Y}{X}$$

Price is a function of expenditure shares (θs) multiplied by relative endowments. Recall the θ_i represent expenditure shares (Eq. 2.8), and are defined as:

(2.31A) $$\theta_F = \frac{\alpha_F(h)}{\alpha_F(h) + \beta_F(f)}$$

(2.31B) $$\theta_H = \frac{\alpha_H(h)}{\alpha_H(h) + \beta_H(f)}$$

Starting at $h = H$, a small change in h has a second order effect on α_H (at $h = H$, $\frac{d\alpha_H}{dh} = 0$): $\frac{d\alpha_F}{dh} < 0$. So, a small reduction in h causes α_F (and therefore θ_F) to increase

but does not change θ_H. Therefore, price (p) increases. The situation is reversed at $h = F$. Here, a small increase in h does not affect α_F (and therefore θ_F), but does increase α_H (and therefore θ_H). With higher θ_H, price increases. Appendix A.4 evaluates the FOCs if the price at each border point. Since the price of the foreign good serves as a numeraire, terms of trade from the Home perspective improve as the price of its good increases (thus, p increases). Foreign's terms of trade improve as p decreases ($1/p$ increases).

Figure 2.4A graphs price (Equation 2.30) as a function of Home's choice parameter (h) given the Foreign standard (f). Similarly, Figure 2.4B graphs price as a function of f given h. The precise location of stationary points and intersection points depend on the other country's choice of standard (f or h), as well as relative endowments across countries.

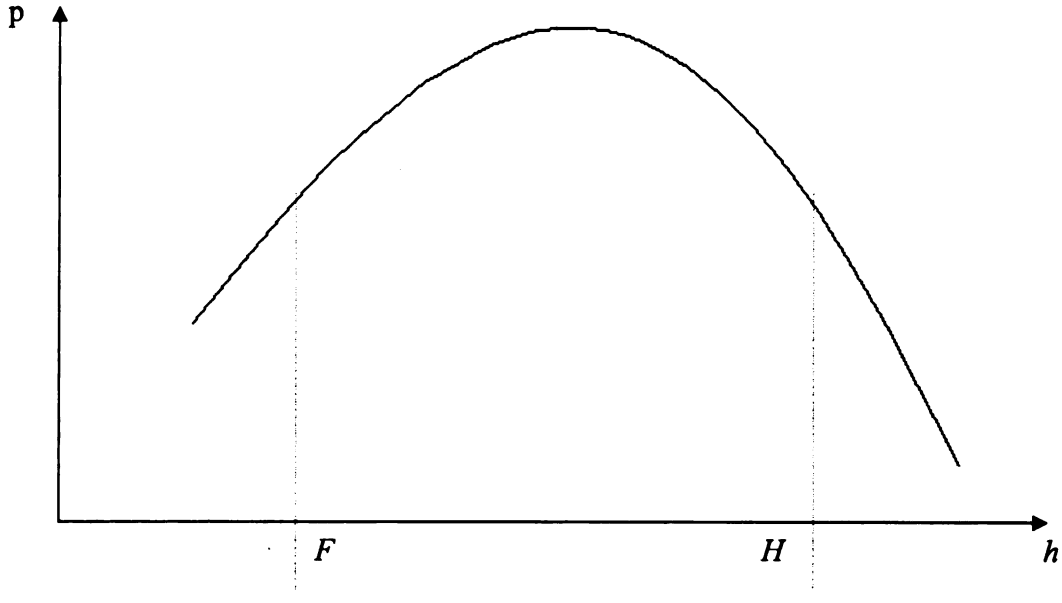


Figure 2.4A: Price as a Function of h.

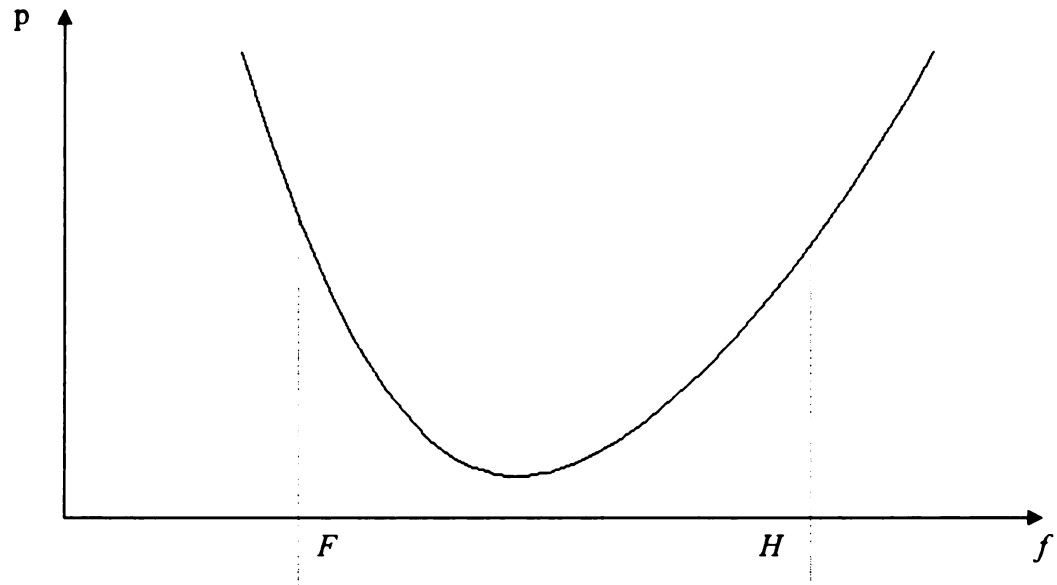


Figure 2.4B: Price as a Function of f.

Substituting for price (from Equation 2.30) in the indirect utility functions (Equations 2.10A and B), we obtain indirect utility functions with terms of trade effects:

(2.32A) $$V_{Ht}(f,h) = \alpha_H \ln\theta_H + \beta_H \ln\theta_F + \alpha_H \ln X + \beta_H \ln Y$$

(2.32B) $$V_{Ft}(X,Y) = \alpha_F \ln(1-\theta_H) + \beta_F \ln(1-\theta_F) + \alpha_F \ln X + \beta_F \ln Y$$

where the subscript t indicates incorporation of terms of trade effects.

2.5. Case III: Nash Game

In a Nash game we consider the Home and Foreign countries to be players choosing h and f, respectively (choice parameters as strategies) from a continuum of potential strategies to maximize their payoff function, consisting of their indirect utility function with terms of trade effects, in a one shot simultaneous game given the strategy

of the other country. Nash cooperation strategy requires moving away from "free trade" – that is without terms of trade affects. Such a move decreases the indirect utility without terms of trade effects, while on the other hand improves the terms of trade.

We solve the first order conditions simultaneously. Instead of stationary points, we focus out attention on demonstrating that (1) potential equilibrium candidates lie between *F* and *H*, border points excluded; (2) if endowments across countries are the same, countries' choice parameters will lay in an identical distance from their preference parameters; and (3) if the endowments differ, countries' choice parameters position relative to their preference parameters will change to reflect the difference in endowments. The Appendix A.5 (Tables A.4 and 5) shows numeric examples sharpening the intuition gained from the models. We start with proving Nash Equilibrium is on the *(F,H)* interval.

Proposition 2.4: Regardless the countries' sizes, the candidates for Nash Equilibrium in both countries lie on the open interval (F,H).

Proof: Note that in a general form the indirect utility (Equation 2.10A) is a function of:

(2.33) $$V_H = V_H(h, f, p, E_H)$$

where E_H was defined in 2.6A as $E_H = pX = px_H + y_H$. Price (2.30) itself is a function of endogenous choice parameters and exogenous endowments (which can be left out)

(2.34) $$p = p(h, f)$$

In a stationary point a total derivative of the objective function (indirect utility with the "TOT effect") is zero:

(2.35) $$\frac{dV_{Ht}}{dh} = 0$$

The total derivative equals a summation of partial derivatives:

(2.36) $$\frac{\delta V_H}{\delta h} + \frac{\delta V_H}{\delta p}\frac{\delta p}{\delta h} + \frac{\delta V_H}{\delta E_H}\frac{\delta E_H}{\delta p}\frac{\delta p}{\delta h} = 0$$

Rearrange the terms to obtain:

(2.37) $$\frac{\delta V_H}{\delta h} + \left(\frac{\delta V_H}{\delta p} + \frac{\delta V_H}{\delta E_H}X\right)\frac{\delta p}{\delta h} = 0$$

Apply Roy's identity:

(2.38) $$\frac{\delta V_H}{\delta p} = -\frac{\delta V_H}{\delta E_H}x_H$$

and substitute to 2.37:

(2.39) $$\frac{\delta V_H}{\delta h} + \left(\frac{\delta V_H}{\delta E_H}X - \frac{\delta V_H}{\delta E_H}x_H\right)\frac{\delta p}{\delta h} = 0$$

Finally rearrange to:

(2.40) $$\frac{\delta V_H}{\delta h} + \frac{\delta V_H}{\delta E_H}(X - x_H)\frac{\delta p}{\delta h} = 0$$

Preference points F and H divide the number line into several subintervals. The indirect utility function is always non-decreasing in income. Earlier we showed that keeping everything else constant, the first expression in the Equation 2.40 (indirect utility function without terms of trade effects, Figure 2.3A) is maximized at $h = H$, and price (Figure 2.4A) is increasing at $h = F$, and decreasing at $h = H$. Table 2.1 evaluates Equation 2.40 on each potential subinterval.

Table 2.1: Location of a Nash Equilibrium Candidate: Home Country

HOME	$\frac{\delta V_H}{\delta h}$	$+\frac{\delta V_H}{\delta E_H}$	$(X - x_H)$	$\frac{\delta p}{\delta h}$	$= 0$
$h \in (0, F)$	+	+	+	+	NO
$h = F$	+	+	+	+	NO
$h \in (F, H)$	+	+	+	?	YES
$h = H$	**0**	+	+	-	NO
$h \in (H, \infty)$	-	+	+	-	NO

Based on Table 2.1, it is clear the only potential subinterval where the indirect utility with terms of trade effects can reach its stationary points is on the open interval (F, H).

Following the same framework for the Foreign country (keeping in mind $E_F = X_F$) we derive:

(2.41) $$\frac{\delta V_F}{\delta f} - \frac{\delta V_F}{\delta X_F}(x_F)\frac{\delta p}{\delta f} = 0$$

The Foreign indirect utility function without terms of trade effects (Figure 2.3B) is maximized at $f = F$. The Foreign country seeks to minimize the price (recall the Foreign good serves as a numeraire): thus price (Figure 2.4B) is decreasing at $f = F$, and increasing at $f = H$. The results are summarized in Table 2.2.

As in the Home country, in the Foreign country we showed that any equilibrium candidates will be from an open (F, H) interval. *QED.*

Table 2.2: Location of a Nash Equilibrium Candidate: Foreign Country

FOREIGN	$\frac{\delta V_F}{\delta f}$	-	$\frac{\delta V_F}{\delta X_F}$	x_F	$\frac{\delta p}{\delta f}$	$=0$
$f \in (0,F)$	+	-	+	+	-	NO
$f = F$	**0**	-	+	+	-	NO
$f \in (F,H)$	-	-	+	+	?	YES
$f = H$	-	-	+	+	+	NO
$f \in (H,\infty)$	-	-	+	+	-	NO

2.4.1. Nash Equilibrium with Identical Endowments

In the world of identical endowments, we conjecture and prove the Nash Equilibrium is symmetric (that is, equal distances from the border points). Numeric simulations are provided in Table A.4, Appendix II.5.

Proposition 2.5: Returning to a specific functional form with terms of trade effects (Equations 2.32A and B), when endowments across countries are identical, the Nash equilibrium standards (that is, standards chosen by the government) will be in equal Euclidian distances from the border points (and "myopic" equilibrium points) F and H.

Proof: The FOCs reduce to:

$$(2.42A)\ \frac{dV_{Ht}}{dh} = 2\left\{(1-\theta_F)\alpha_F\beta_H(F-h)+\alpha_H^2(H-h)\left[(1-\theta_H)+\ln\theta_H+\ln X\right]\right\}$$

$$(2.42B)\frac{dV_{Ft}}{df} = 2\left\{\theta_H \alpha_F \beta_H (H-f) + \beta_F^2 (F-f)\left[\theta_F + \ln(1-\theta_F) + \ln Y\right]\right\}$$

Notice parts of each FOC are identical with the first derivative of the indirect utility function without terms of trade effects (Equations 2.11 and 15). We showed earlier the indirect utility function without the terms of trade effect is maximized in their respective border points: Home's indirect utility in $h = H$, and Foreign indirect utility in $f = F$ (Figures 2.3A and B). Additional parts of the derivative (Equations 2.42A and B) come from inserting the price to the indirect utility function. We have shown earlier in the general setting that the stationary point optimizing the indirect utility function with the terms of trade effects must lie between the border points of F and H, and will "balance" the marginal loss in welfare with the marginal gain in terms of trade for both Home and Foreign countries.

Due to the nonlinearity of the first order conditions, (h and f entering in more than one argument, preventing the use of inverse functions), standard algebraic solution techniques do not lead to a closed-form solution for the stationary point.

The larger the countries' endowments get in the absolute terms, the closer the choice parameters (f, h) approach the preference parameters (F, H). The solution remains interior. Suppose for example that $X \to \infty$. Then $\frac{dV}{dh} = 0 \Rightarrow (H-h) \to 0$. Similarly, with the increasing difference between the preference parameters, countries' choice parameters approach their preference parameters. When $(H - F)$ is large, the distance between F and h increases as well. To balance the first order condition when the effect of preference and choice parameters on the exponents of the utility is balanced by identical endowments, $(H-h) \to 0$.

For an analytic proof define:

(2.43A) $$|F-f|=|H-h|=|m|$$

(2.43B) $$|F-h|=|H-f|=|n|$$

Due to the structure of exponents (Equations 2.2A – 3B), it is true that:

(2.44A) $$\alpha_H=\beta_F=c$$

(2.44B) $$\alpha_F=\beta_H=d$$

Identical exponents translate into the Home's expenditure share on home good being equivalent to Foreign's expenditure share on the foreign good, and vice versa:

(2.45A) $$\theta_H=\frac{\alpha_H}{\alpha_H+\beta_H}=\frac{\beta_F}{\alpha_F+\beta_F}=1-\theta_F=e$$

(2.45B) $$\theta_F=\frac{\alpha_F}{\alpha_F+\beta_F}=\frac{\beta_H}{\alpha_H+\beta_H}=1-\theta_H=g$$

Substitute shorthand labels from Equations 2.43A – 45B into Equations 2.42A and B:

(2.46A) $$\frac{dV_{Ht}}{dh}=2\left\{ed^2|n|+c^2|m|[g+\ln e+\ln X]\right\}$$

(2.46B) $$\frac{dV_{Ft}}{df}=2\left\{ed^2|n|+c^2|m|[g+\ln e+\ln Y]\right\}$$

Notice Equations 2.46A and B are identical except the size of the endowment. We use proof by contradiction. Assume countries with different endowments would choose their standards to be in the same distance from the domestic preference parameters. However, if indeed the equilibrium points are positioned equivalent distances from the border points, then it has to be true that the Home and Foreign endowments are identical in order for the FOC in both countries to be zero, and welfare – consisting of indirect utility function adjusted for terms of trade effects – is maximized. *QED.*

2.4.2. Nash Equilibrium with Different Endowments

Now we deliberately keep the endowments unequal. Table A.5 in the Appendix A.5 shows numerical simulations. They suggest the country with larger endowment has more gravity, and its choice parameter gravitates towards its preference parameter. That is, country with the smaller endowment is choosing its standard to be positioned a larger Euclidian distance from its preference parameter than the country with larger endowment is doing relative to own preference parameter. Therefore,

(2.47A) $X < Y \Rightarrow |H-h| > |F-f|$

(2.47B) $X > Y \Rightarrow |H-h| < |F-f|$

Graphically both situations are illustrated on Figure 2.5.

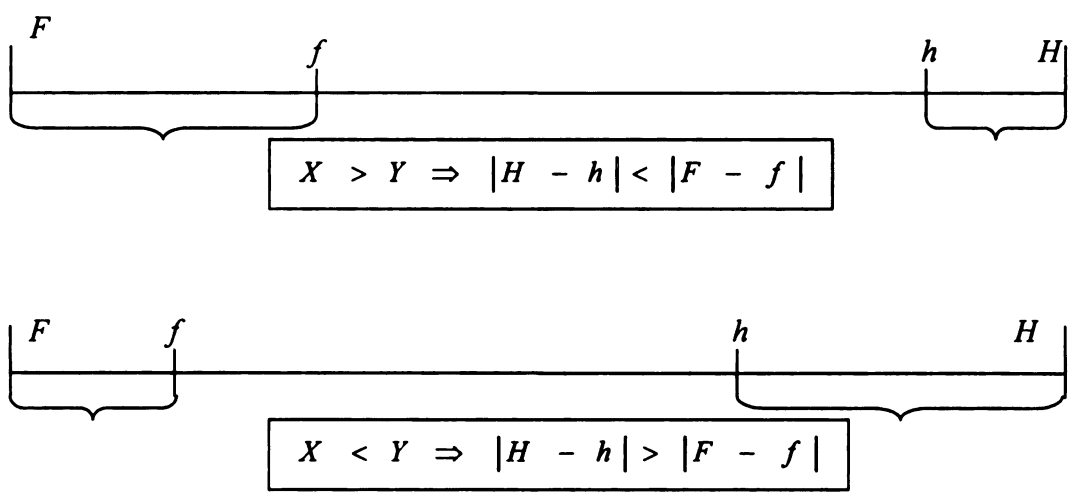


Figure 2.5: Nash Equilibrium with Country-variant endowments. (not drawn to scale).

Proposition 2.6: When endowments differ across countries, in a Nash game the Euclidian distance between choice and preference parameters of respective countries differ, with the more well-endowed country positioning its choice parameter closer to its preference

parameter relative to the other country (as outlined in Equation 2.47A and B, and Figure 2.5).

Proof: Based on Tables 2.1 and 2.2, despite the countries' relative size, the Nash Equilibrium occurs in an open interval (F, H). None of the FOC – Home or Foreign – are maximized in the border point of the interval, and both countries gain as the they move away from their reference points. Transforming unequal endowments into the price equation (2.30) consisting of a ratio of preference weights multiplied by the ratio of endowments, differently sized endowments imply the price changes directly with the ratio of endowments. Assume Home endowment exceeds the Foreign endowment N times:

(2.48) $$X = NY, \quad N > 1$$

Consequently, taking the natural logarithm of both sides,

(2.49) $$\ln X = \ln(NY) = \ln N + \ln Y$$

For a more instructional proof, we use FOCs which have not been treated by substituting for parameters based on Equations 2.2A – 3B and 2.8, allowing a more detailed exploration of changes in f and h. After substitution from Equation 2.49, the "untreated" FOCs are:

(2.50A)

$$\frac{dV_{Ht}}{dh}=\frac{\left(\ln\left(1+(H-f)^2\right)-\ln\left(2+(H-f)^2+(H-h)^2\right)+\ln Y+\ln N\right)(H-h)}{\left(1+(H-f)^2\right)^2}+$$

$$\frac{F-h}{\left(1+(H-f)^2\right)\left(2+(F-f)^2+(F-h)^2\right)}+\frac{H-h}{\left(1+(H-h)^2\right)\left(2+(H-f)^2+(H-h)^2\right)}$$

(2.50B)

$$\frac{dV_{Ft}}{df}=\frac{\left(\ln\left(1+(F-h)^2\right)-\ln\left(2+(F-f)^2+(F-h)^2\right)+\ln Y\right)(F-f)}{\left(1+(F-f)^2\right)^2}+$$

$$\frac{F-f}{\left(1+(F-f)^2\right)\left(2+(F-f)^2+(F-h)^2\right)}+\frac{H-f}{\left(1+(F-h)^2\right)\left(2+(H-f)^2+(H-h)^2\right)}$$

By construction ($H > F$, and $f,h\in(F,H)$ and referring to Figure 2.5, it follows that:

(2.51A) $F-f=A<0$

(2.51B) $H-h=a>0$

(2.52) $$|F-f|>|H-h|$$
$$|A|>|a|$$

Similarly, for the relationship across own preference and "foreign" choice parameter:

(2.53A) $F-h=B<0$

(2.53B) $H-f=b>0$

(2.54) $$|F-h|>|H-f|$$
$$|B|>|b|$$

For now ignore that $|A|>|a|$ and $|B|>|b|$. Rewrite the FOC for Home (2.50A) such that:

$$\text{(2.55A)}\qquad \frac{A\ln N}{\left(1+A^2\right)^2}+\frac{A\left(\ln\left(1+B^2\right)-\ln\left(2+A^2+B^2\right)+\ln Y\right)}{\left(1+A^2\right)^2}+\frac{A}{\left(1+A^2\right)\left(2+A^2+B^2\right)}+\frac{b}{\left(1+B^2\right)\left(2+a^2+b^2\right)}=0$$

And for the Foreign:

$$\text{(2.55B)}\qquad \frac{a\left(\ln\left(1+b^2\right)-\ln\left(2+a^2+b^2\right)+\ln Y\right)}{\left(1+a^2\right)^2}+\frac{a}{\left(1+a^2\right)\left(2+a^2+b^2\right)}+\frac{B}{\left(1+b^2\right)\left(2+A^2+B^2\right)}=0$$

Investigating the FOCs above (2.50A and B), we recognize that if $|a|=|A|$ and $|b|=|B|$, as it was the case earlier, the Home's FOC (2.55A) contains an additional term enclosing the relative difference in the size of endowments between the Home and Foreign countries. Thus, even if the FOC in (2.55B) for Foreign was satisfied, the Home's FOC contains an additional positive term, and therefore cannot be satisfied. Consequently, if both first order conditions are to hold simultaneously, the equality between a and A does not hold, and indeed the countries will choose their choice parameters in an unlike distance from their preference parameters. Now we show that $|a|<|A|$ and consequently $|b|<|B|$. Rewrite the inequalities such that:

$$\text{(2.56A)}\qquad A=a+\Delta a$$

$$\text{(2.56B)}\qquad B=b+\Delta b$$

where $A < 0$, $B < 0$. Consider a and b to be actual differences between the points on the number line, not absolute values or Euclidian distances. Rewrite the FOCs (2.55A and B) to incorporate the substitution:

(2.57A)

$$\frac{(a+\Delta a)\ln N}{\left(1+(a+\Delta a)^2\right)^2}+\frac{(a+\Delta a)\left(\ln\left(1+(b+\Delta b)^2\right)-\ln\left(2+(a+\Delta a)^2+(b+\Delta b)^2\right)+\ln Y\right)}{\left(1+(a+\Delta a)^2\right)^2}$$
$$+\frac{(a+\Delta a)}{\left(1+(a+\Delta a)^2\right)\left(2+(a+\Delta a)^2+(b+\Delta b)^2\right)}+\frac{b}{\left(1+(b+\Delta b)^2\right)\left(2+a^2+b^2\right)}=0$$

(2.57B)

$$\frac{a\left(\ln\left(1+b^2\right)-\ln\left(2+a^2+b^2\right)+\ln Y\right)}{\left(1+a^2\right)^2}+\frac{a}{\left(1+a^2\right)\left(2+a^2+b^2\right)}$$
$$+\frac{(b+\Delta b)}{\left(1+b^2\right)\left(2+(a+\Delta a)^2+(b+\Delta b)^2\right)}=0$$

Rearrange the terms in the FOC for Foreign country (2.52B) such that:

(2.58)

$$\left\{\frac{a}{\left(1+a^2\right)}\right\}\left[\frac{\ln\left(1+b^2\right)-\ln\left(2+a^2+b^2\right)+\ln Y}{\left(1+a^2\right)}+\frac{1}{\left(2+a^2+b^2\right)}\right]$$
$$+\frac{(b+\Delta b)}{\left(1+b^2\right)\left(2+(a+\Delta a)^2+(b+\Delta b)^2\right)}=0$$

Recall by definition $a > 0$. If $Y > 2$ (as we already imposed earlier), then

$\ln\left(1+b^2\right)-\ln\left(2+a^2+b^2\right)+\ln Y$ is positive. To show it, consider a borderline case when a^2 and b^2 attain their maximum values (representing the entire $\langle F,H\rangle$ interval). The expression then becomes $\ln\left(1+(F-H)^2\right)-\ln\left(2+(F-H)^2+(F-H)^2\right)+\ln Y$, which reduced to $-\ln 2+\ln Y$. If $Y > 2$, the expression above positive. If $|a|$ and $|b|$ do not stretch over the entire $\langle F,H\rangle$ interval, the expression is greater than earlier, and is positive as well. Further analyzing the foreign FOC in terms of signs:

$$\{+\}[+]+\frac{(b+\Delta b)}{\left(1+b^2\right)\left(2+(a+\Delta a)^2+(b+\Delta b)^2\right)}=0 \tag{2.59}$$

For the equality to hold, $\frac{(b+\Delta b)}{\left(1+b^2\right)\left(2+(a+\Delta a)^2+(b+\Delta b)^2\right)}$ must be negative. However, by definition, $b > 0$. Therefore, Δb must be negative, and in fact in absolute value exceeding the absolute value of b. Recall that $F-h=B<0$ and $H-f=b>0$. If $B=b+\Delta b$, then $\Delta b<0$. Consequently, if $|b| < |B|$, then by construction $|a| < |A|$, and countries choose their respective choice parameters in different Euclidian distances from their preference parameters. *QED.*

2.6. Case IV: Nash Bargaining Solution

Unlike the Nash Equilibrium, the Nash bargaining solution satisfies additional set of conditions – Pareto efficiency, symmetry, invariance, and independence of irrelevant alternatives (i.e., Mas-Colell, Whinston, and Green, 1995). In the model presented, the

Nash Bargaining Solution without weights is a bilateral bargaining problem between two countries, Home and Foreign, choosing their choice parameters (h and f, respectively), to maximize their Nash product (NP):

(2.60) $$NP = \left(VH\left(f,h\right) - A\right)\left(VF\left(f,h\right) - B\right)$$

where *VH(f, h)* and *VF(f, h)* are identical with social welfares (equivalent to an indirect utility function with price effects, Equation 2.32A and B) of the Home and Foreign countries in the Nash Bargaining Solution. A is a Home country's threat point; B is a Foreign country's threat point. Under certain conditions the threat point would be autarky utility – however, due to the structure of the utility function considered in the model, we consider the following threat points:

(2.61A) $$A = VH\left(h = H\right)$$

(2.61B) $$B = VF\left(f = F\right)$$

That is, in the threat point each country sets its choice standard to be equivalent to its preference standard regardless other country's actions.

Due to complexity of the first and second order conditions we do not address the problem analytically, and present the problem based on the numerical simulations listed in the Appendix A.6, Tables A.6 and 7.

The simulations suggest that, like in the social planner problem, when the differences between countries' preference parameters are small and/or the endowments are small, the Nash product is maximized in the respective preference points (H and F). In all other cases the Nash bargaining solution is achieved in the identical Euclidian distance from the respective preference parameters. However, the equilibrium points approach the center of the interval – the outcome of the social planner problem – more

closely than in the regular Nash equilibrium. Often we observed "overshooting": that is, while keeping the Euclidian distance between countries' preference and choice parameters identical ($|H-h|=|F-f|$), this Euclidian distance exceeded the midpoint between the preference parameters. In case of differing endowments, the outcomes of the simulations differ depending on the gap between preference parameters as well as the ratio of the endowments. When the gap between the parameters is sufficiently large, distance between the choice parameter of the smaller country from its preference parameter is larger than a similar distance for the larger country (schematically graphed on Figure 2.6). Nevertheless, both choice parameters approach the midpoint.

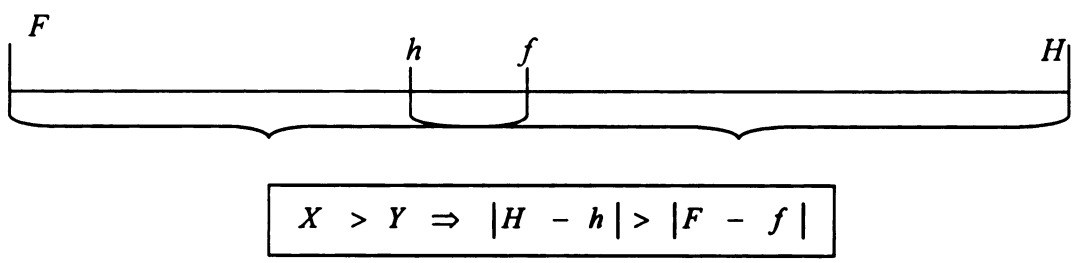


Figure 2.6: Nash Bargaining Solution, Country-variant Endowments (not drawn to scale).

2.7. Chapter Conclusions

This chapter explored application of standards as a strategic trade policy instrument between countries endowed with different goods wishing to trade. It investigated four different cases: (1) social planner choosing a Pareto optimal allocation recognizing the externality countries impose on each other by their standard selection; (2) countries seeking to maximize their welfare without exploiting terms of trade effects in a

myopic equilibrium; (3) countries seeking to maximize their welfare in a Nash type game recognizing the strategic interaction and power they exercise on terms of trade effect, and finally (4) countries maximizing Nash product without weights in a complete Nash bargaining solution.

In the first case – an omnipotent social planner maximizing welfare – the welfare maximizing point depends on the difference between countries' preference parameters. When the difference between countries' parameters is small, social welfare is maximized in the border points. However, when the difference between countries' parameters is large, the social planner sets standards that split the difference. In the myopic equilibrium countries choose their choice parameters to be identical with their exogenous preference parameters. The outcome of the third case – welfare maximization with terms of trade effects using Nash equilibrium – depends on the relative endowments of the countries. When the endowments are identical across countries, countries choose their standards (choice parameters) in the same Euclidian distance from their preference parameters (border points). When the endowments differ, the country with the abundant good exercises more power in selecting the standard, and places its standard closer to its reference point of its preference parameter relative to the location of the country with scarce good. Finally, in the Nash bargaining solution, depending on the gap between preference parameters, and the ratio of endowments, in general the choice parameters approach the midpoint between the preference parameters.

CHAPTER 3

DIFFERING STANDARDS, WELFARE, AND SUB-GLOBAL AGREEMENTS

The chapter explores endogenous standards-setting in a Krugman-like model of monopolistic competition with constant elasticity. Consumers desire more varieties to less, but also discount consumption of "qualitatively" different brands ("love of variety" combined with "ideal quality" approach). We consider two questions: (1) potentially welfare worsening consequences of (unilateral) harmonization and (2) differences in standards necessitating formation of small trade agreements as a second best option when common standard is required to conduct trade.

The model is consumer-focused: consumers in autarky have access to the same number of equally priced varieties regardless which attribute they prefer. We explore the nuances of standard setting in a two-country world, and demonstrate non-standardized trade always improves welfare, while standardization to only one quality might be inferior to autarky. Imposed standardization in a multiple country setting may result in countries searching for alternative ways to secure (at least some) gains from trade and forming agreements with partners with similar preferences.

3.1. General Model Setup

We build a general equilibrium model of country-variant standards based on a conventional monopolistic competition framework (i.e., Dixit and Stiglitz, 1977 or Krugman 1979, 1980). Products are differentiated not only in the variety space, but also

in the standards space[24]. For simplicity assume "discreteness" of the standard: i.e., 0 or 1: the product either does or does not have a certain attribute. Each variety can be produced in two specifications, i.e. with one of the two mutually exclusive characteristics. For example, fruit can have the attribute "organic" or it can have the attribute "blemish-free", with "organic" and "blemish-free" being mutually exclusive consequences of the production process used (organic or conventional fruit production). Standards are modeled as a *vertical* distinction within a variety; a "higher" standard represents a higher quality in the domestic quality ranking, although with different utility functions foreign consumers will have different relative valuations of the high- and low-quality goods (e.g. Gabszevicz et al., 1981)[25]. From an individual country perspective a preferred standard implies an enhanced product, and standards with goods can be qualitatively ranked (Helpman and Krugman, 1985). However, such comparisons are subjective: indeed another country might have the exact opposite interpretation – it prefers the good that does not possess certain characteristics, and considers having a certain attribute as inferior. For example, in the U.S. beef is butchered so that many cuts contain parts of more than one muscle; in other parts of the world the tendency is for different cuts to contain only one muscle per cut. To avoid using normative labels to describe a standard, we use "*Truth*" and "*Beauty*".[26] Finally, we note that this assumption is not critical to the results: any formulation in which the home country has a greater relative preference

[24] In the text words "standard", "quality", "attribute", "characteristics", and some specific examples are used as synonyms, and shall be understood in a broader connotation.
[25] An opposite of vertical differentiation is horizontal differentiation, in which goods are depicted as different without better/worse comparisons. Examples of horizontal differentiation are electrical plugs across the globe, three (incompatible) video program formats – NTSC, PAL, and SECAM, etc.
[26] Although *"Truth"* and *"Beauty"* labels are borrowed from the physics literature on quarks, it is useful to think of traditionally produced foods as visually appealing(e.g., blemish free), and the *Truth* label as representing food produced with no transgenetic techniques and as few pesticides as possible.

(marginal rate of substitution) for one attribute than does the foreign country suffices to drive the model.

To pin down this modeling idea, consider the case of food safety as the attribute. Different countries may interpret food safety differently: France may feel that irradiation leads to safer foods, the U.S. may not; the U.S. may feel that genetically modified foods require less pesticides and hence are safer, the U.K. may feel differently. Each level of food safety requires some fixed cost. Each country prefers to consume a broad variety of foods. Every time a new variety is introduced, the quantity produced of each variety declines and the cost of production rises, but the consumers gain from greater variety, ceteris paribus. Once trade opens, each country produces a set of varieties, and wants to import others with similar levels of safety. Love for variety is present in the model; however, love of variety for food safety is missing, i.e., consumers in each country want a certain level of food safety across all varieties of food they consume. Thus, variety within food is desirable, while variety within the attribute of safety is not. Trade is driven by the love of variety (and potential economies of scale); it is limited by differing food safety restrictions. The benefits of free trade are greater if there is a way to standardize food safety requirements among countries.

The model presented is static, and instantaneous adjustments are made when needed. Countries have equal access to technologies, and differ only in consumer preferences. All agents have perfect information. Issues related to asymmetric and hidden information are assumed away. Consumers are able to distinguish between qualities at no cost to them if standards for like products are in place. There are neither lobbying, government intervention, nor network effects present in the model. Transportation and

standards are costless. We will think of the differentiated goods as food, but the model formulation is general enough so that these goods could include computer chips, cell phones, automobiles, or any other good for which consumers prefer to have the good meet certain standards or regulations. Assume a large number of potential varieties. Firms in the model enjoy free entry and exit, and consequently do not earn any excess profits, and government does not impose any taxes. Since due to zero profit assumption producers are indifferent as to what standard is demanded from them, the standard is set at a level determined endogenously by the consumers' utility maximizing decision. The "consumer decides" model seems to be better suited to describe growing role of consumer concerns in trade, although current WTO policies still reflect more of the producers interests while discounting consumer requests due to differences in concentration of interests.

Each country, possibly of different size, consists of like individuals, has access to the same production technology, and differs in preference for certain attributes (in a way that will be made precise momentarily). We start with a basic Krugman model where goods are differentiated in the variety space only. Each consumer has the utility function:

$$U = \left(\sum_{j=1}^{N} \left(d_j \right)^{\theta} \right)^{\frac{1}{\theta}} \quad \text{where} \tag{3.1}$$

$$\theta = \left(1 - \frac{1}{\sigma} \right), \sigma > 1 \tag{3.2}$$

σ represents elasticity of substitution between varieties, assumed to be constant across pairs of varieties; d denotes consumption of the differentiated goods; and the subscript j implies the variety. The consumer derives utility from a large number of varieties

(indexed one to N). With scarce labor and positive fixed costs, it may be that only $n < N$ varieties are actually produced. All varieties enter the utility function symmetrically. No capital is present: income consists entirely of wage earnings. The entire stock of labor is used in production; consumers do not derive any utility from leisure. The demand for the differentiated good is obtained through maximization of the CES utility subject to the budget constrained by ownership of one unit of labor and wage normalized to one:

$$\text{(3.3)} \qquad \underset{\{d_j\}_{j=1}^{N}}{\text{Max}} \left(\sum_{j=1}^{N} (d_j)^{\theta} \right)^{\frac{1}{\theta}} \quad s.t. \quad \sum_{j=1}^{N} p_j d_j = 1$$

Assuming an interior solution, the first-order conditions (FOCs) are:

$$\text{(3.4)} \qquad \left(\sum_{i=1}^{N} (d_i)^{\theta} \right)^{\frac{1-\theta}{\theta}} (d_i)^{\theta-1} = \phi p_i$$

$$\text{(3.5)} \qquad \sum_{i=1}^{N} p_i d_i = 1$$

where ϕ is a Lagrange multiplier. Solving the FOCs yields the demand for variety i:

$$\text{(3.6)} \qquad d_i = \frac{p_i^{-\sigma}}{\sum_{i=1}^{n} p_i^{1-\sigma}}$$

σ represents the elasticity of substitution between pairs of varieties of the same product (i.e., food). In a symmetric equilibrium, $p_i = p \forall i \Rightarrow d_i = d \forall i$, and it is optimal

to purchase all varieties available in equal quantities. The price elasticity of demand faced by producers is:

$$\sigma + \frac{p_i^{1-\sigma}}{\sum_{i=1}^{n} p_i^{1-\sigma}}(1-\sigma) \tag{3.7}$$

As n (the number of actual varieties produced[27]) is large, we make the commonly-used assumption that the firm disregards the second component in the elasticity term, and considers σ to be the elasticity of demand it faces (Helpman and Krugman 1985).

Up to this point we followed Krugman (1980). Now assume that each variety can have one of the two attributes (*Truth* or *Beauty*). Consumers have preferences over the two attributes that imply the two are perfect substitutes[28]. In particular, we might view quantities of the variety in "quality-adjusted units", so that

$$dj = d_j^T + \lambda^C d_j^B \tag{3.8}$$

d_j^Q is the quantity of variety j that possesses quality Q, for $Q = T, B$ and λ^C ($C =$ *Home, Foreign*) is a "discount" parameter that marks down the physical quantity if the variety consumed has an attribute different from the preferred one. Each country puts a different weight on different quality: Home prefers to consume *Truth*, so $\lambda^H \in (0,1)$. Foreign prefers *Beauty* goods relatively more than do Home consumers, so $\lambda^F > 1$.

[27] In the Helpman and Krugman (1985) terminology actual varieties produced form a set of available varieties with finite price – varieties not available are considered to have an infinite price.

[28] The presence of the linear subutility embedded in the love of variety CES function separates this case from the iceberg transportation cost. In the later home and foreign varieties are consumption variables with an elasticity of substitution of δ in the CES subutility.

The linear lower tier sub-utility function where differing qualities of any variety are substitutes with infinite elasticity of substitution between them ensures only one quality of each variety will be consumed. The knife-edge case where both qualities are consumed is not equilibrium. Think of consumers constructing their own consumption of variety j by purchasing the two different components and putting them together. Using this interpretation, the price of a unit of variety j is the minimum cost of creating the variety from the two component parts. Let p_j^T and p_j^B represent the prices of the two components, then price of the bundle is $p_j = \min\left(p_j^T, p_j^B / \lambda^C\right)$. This follows from the fact that it requires $1/\lambda^C$ units of the good with quality of *Beauty* to provide the same utility as one unit of the good with the quality of *Truth*. If $p_j^T < p_j^B / \lambda^C$, then consumers only demand the quality of *Truth* for variety j. If the inequality is reversed, they demand only the quality of *Beauty* for variety j, and if the two are equal, consumers are indifferent. Since the process of the constituent components can, in principle, vary by variety, it is possible some varieties will be constructed of only *Truth*, others of only *Beauty*.

Increasing returns are internal to firms – an initial outlay of labor ("fixed cost") is needed to start up production, resulting in decreasing average cost; marginal costs are constant within a variety – quality combination. Firms are symmetric. The presence of scale economies ensures that in equilibrium only a finite number of varieties are produced, each firm produces a different variety, and each variety will be produced in one standard (*Truth* or *Beauty*) only. Each firm producing up to a certain specification faces the same cost function regardless of its location. The number of varieties produced

within the economy is determined by the number of firms[29]. Firms enter freely into the industry. The usual profit maximization and zero-profit entry conditions apply regardless of the standard produced, which along with consumer demands determine price and production levels. The equilibrium in production is described by the number of firms and the price level. Since only labor is used in the production, following Krugman (1980) we specify the cost functions:

$$c_i(y_i, Q) = w l_i^Q(y_i) = w\left(F^Q + y_i M^Q\right) \tag{3.9}$$

where $l_i^Q(y_i)$ is the labor requirement to produce y_i units of variety i with attribute Q; F^Q is the fixed labor component for producing any variety with attribute Q, and M^Q is the marginal labor component for producing any variety with attribute Q[30]. Again, letting the wage equal one, we set marginal revenue equal marginal cost to find the profit-maximizing price charged for a variety with quality Q:

$$p_j^Q = \frac{\sigma}{\sigma - 1} M^Q \tag{3.10}$$

As all varieties with a given quality face the same marginal cost, the price of all varieties with the given quality is the same. By free entry, profits are driven to zero, so that price equals average cost. The ratio of prices equals the ratio of marginal labor requirements:

$$\frac{p^T}{p^B} = \frac{M^T}{M^B} \tag{3.11}$$

[29] We choose to ignore integer issues when discussing number of firms in the economy.
[30] Since wage in the model is normalized to one, labor requirements and costs are identical, and will be used interchangeably in the text.

After solving the model, this implies that each firm will hire $F^Q\sigma$ workers (details are provided in Table B.1 in Appendix B). If the amount of labor available is L, and all firms produce the same quality, the total number of varieties that embody attribute Q will be:

$$n^Q = \frac{L}{F^Q\sigma} \tag{3.12}$$

If mixture of *Truth* and *Beauty* made varieties is produced (technically possible when consumers are indifferent between *Truth* and *Beauty*), then:

$$n^B F^B + n^T F^T = \frac{L}{\sigma} \tag{3.13}$$

From Equations 3.10 and 12, it is evident marginal labor requirements influence the price of the varieties with different standards, while fixed costs affect the number of varieties produces in the economy.

The discussion of the within-variety production possibility frontier (PPF) is possible only for the case of identical number of varieties across standards. Otherwise the economy-wide PPF would have to account for the trade-off between attributes caused by different number of varieties across standards. From Equation 3.12, if fixed costs are identical across varieties, number of varieties if the entire stock of labor is directed into a single quality is the same. Figure 3.1 graphs the PPF for any variety j.

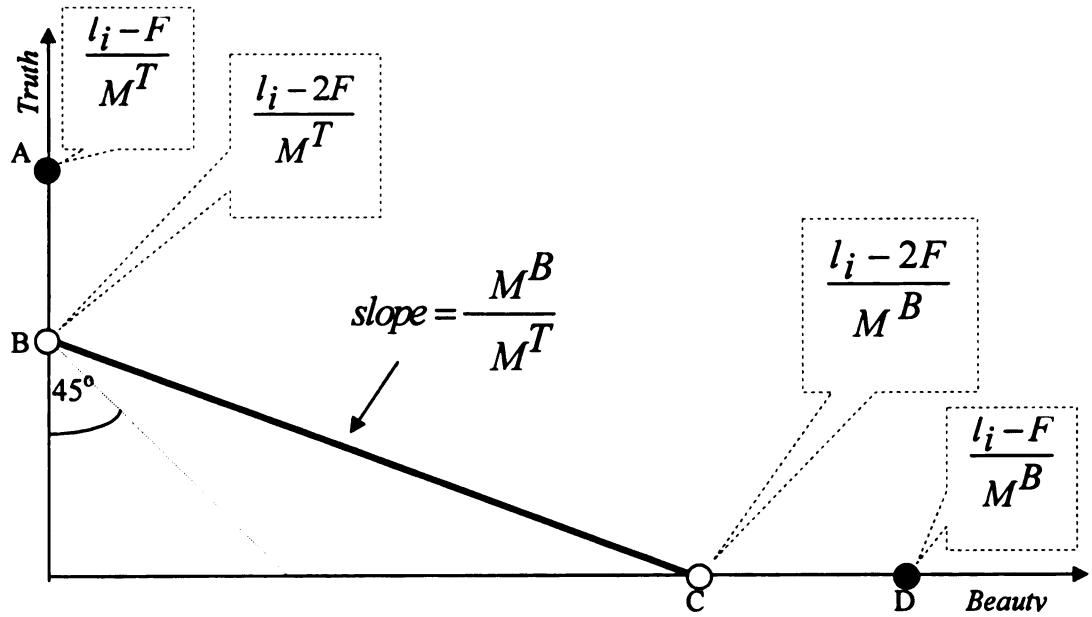


Figure 3.1: PPF in the Standard-variant Marginal, Constant Fixed Labor Requirement Case

$1/n$ units of labor are used to produce each variety ($l_i = F\sigma$). The PPF (curve *ABCD*) is discontinuous at zero units: if any variety is produced in one specification only, it uses up the labor that would have been used otherwise to cover fixed costs of producing the "rival" quality. Due to symmetry the same holds for all varieties. If the number of varieties in the economy is the same regardless of the standard, the prevailing standard is chosen based on within-variety MRS (λ) and the slope of the price line (Figure 3.2).

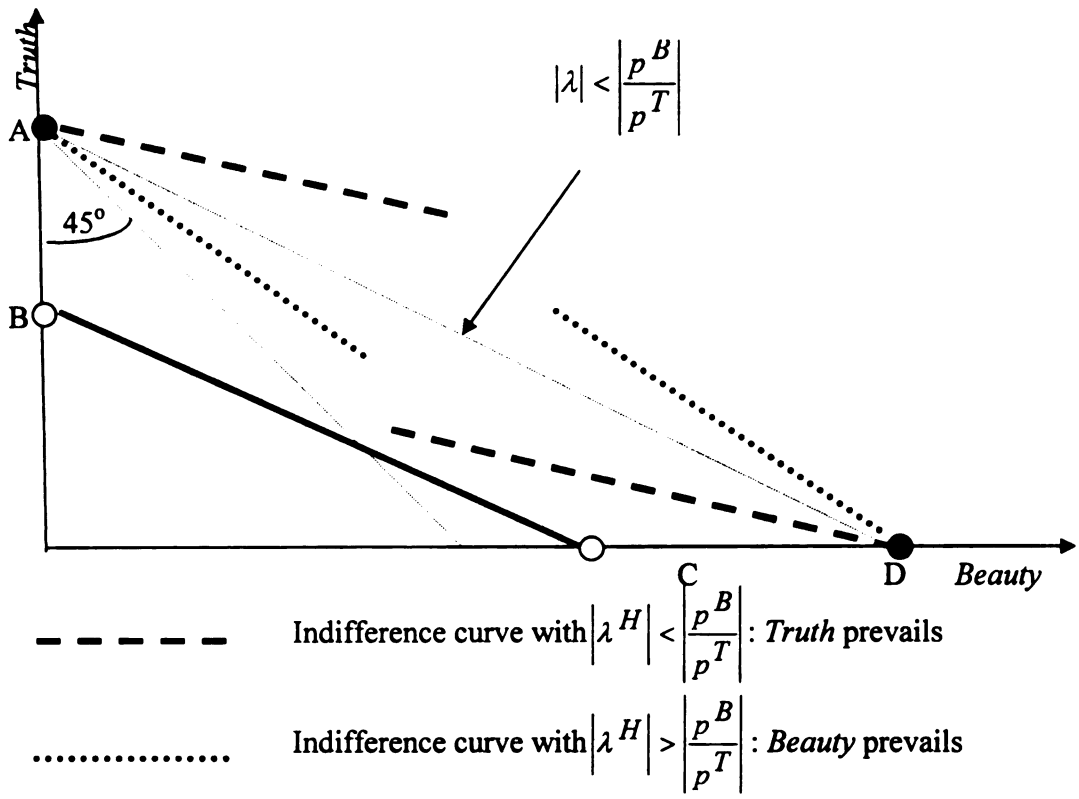


Figure 3.2: Welfare-maximizing Choice of Standard in Standard-variant MC Case

On Figures 3.1 and 2, the slope of the *AD* line (connecting points on the PPF where all labor is devoted to one standard and fixed costs are not duplicated) coincides with the slope of the price line. Because of the fixed cost and perfect substitutability of qualities of the same variety in the consumption, only one quality specification will prevail for each variety. Assume this would not be the case, and some varieties would be produced in both specifications, resulting in an allocation on the continuous part of the PPF (line *BC*). Due to fixed costs the PPF is discontinuous, and choosing one standard increases the utility available from any single variety. The opportunity cost of producing two different versions of one variety is production of not-yet-produced varieties. Utility maximizing standard in any variety consequently prevails for all varieties. Again, assume

this would not be the case, and a representative consumer consumes a mixture of *Truth*- and *Beauty*-made varieties. Then the utility gained from the consumption of some varieties is not maximized, and will be higher if the linear subutility-maximizing standard prevails in all varieties.

Figure 3.2 graphically shows possible cases between within-variety MRS and the price line theoretically discussed earlier. If the absolute value of the within-variety MRS is less than the absolute value of the slope of the price line, *Truth* prevails as a standard of choice. If the MRS is less than the slope of the price line (by definition $\lambda^H < 1$), *Beauty* prevails. The solution is indeterminate if the MRS equals to the slope of the price line and, consequently, some varieties could be made in *Truth* while others in *Beauty*. Thus, the decision on quality is a corner solution determined by a relationship between λ and a function of the cost differentials. In autarky countries produce a single quality standard as in Krugman (1980).

If fixed and marginal labor requirements differ across standards, a tradeoff between number of varieties and price occurs. In this case the consumer compares indirect utility functions (giving maximum utility as a function of prices, income, and number of varieties) attainable with different consumption bundles (Appendix B.2)

"Opening trade" in a one-factor model coincides with Krugman (1980), and translates into a larger resource pool, as well as larger product market to supply. Constant elasticity of demand assures the price levels (outcomes of the profit maximizing conditions) do not change, the entire increase in the stock of labor in the integrated economy is directed into production of varieties not existing in autarky, and the amount of labor directed to existing varieties does not change. The growth in the size of the

market measured as an increase in the labor force does not influence the individual firm's output, but divides it among larger number of consumers, resulting in lower per capita consumption of any variety. Intuitively the basic Krugman model claims that trade is good as it (at least) increases the number of available varieties, as it is the case in this model, and consumers in the integrated economy benefit from a larger number of varieties available to them at the price identical with the autarky price. Therefore, having more varieties available in an open trade than in autarky is a sufficient reason to trade and integrate (Krugman 1980). Size – and potential increases – in the labor force enter consumer's utility through number of varieties available. With a large number of possible varieties, assume each country is producing different set of varieties.

Disregard problems related to conformity assessment procedures, i.e., each country recognizes each others' procedures, and does not require double testing and/or certification (e.g., even when the standards are the same). Assume *Truth* at Home and *Beauty* in Foreign are scientifically justified on the WTO grounds, and not imposed only as a technical barrier to protect domestic producers. In case harmonization is conducted, it is costless.

3.2. Imposed Harmonization Potentially Causing Loss of Welfare

Common standards across countries are often treated as trade and welfare boosting panacea prohibiting application of country-variant standards as trade policy tools advantaging domestic producers, and consequently eliminating trade disputes. While part of the argument – that countries with similar standards often lose (one of the)

grounds for a trade dispute – holds, such quick fix solutions might ignore country-variant characteristics such as preferences or cultural differences. The section builds on two widespread concepts: (1) welfare improving trade; and (2) superiority of common standards to country-variant standards. We show when a common standard is imposed on countries ("we will not trade with you unless there is a common – meaning *our* – standard"), the joint standard might reduce welfare for one nation, autarky will be preferred to "harmonized" free trade, and forced harmonization might impede trade.

3.2.1. Autarky

We demonstrate welfare worsening harmonization on the most simplified version of the model. Assume marginal and fixed costs are the same across qualities: this assumption will allow us to focus on standards and harmonization without being distracted by price and numbers of varieties considerations.[31] From Equation 3.10, if marginal costs are the same across quality – variety combination, then prices are the same:

$$p^T = p^B = p \tag{3.14}$$

From 3.12, if fixed costs are identical across standards, and the entire stock of labor is directed into one quality only, number of all *Truth* and *Beauty*-made varieties is the same:

$$n^T = n^B = n \tag{3.15}$$

For a single [autarkic] economy with identical consumers, only *Truth* is produced if $\lambda < 1$ (by definition this would happen in the Home country). Only *Beauty* is produced

[31] Main points from a generalized case of standard-variant fixed and marginal costs are summarized in the Appendix B.1.

if $\lambda > 1$ (case of the Foreign country). Consequently, the indirect utility function if only *Truth* is produced is:

$$V^T = \frac{1}{p} n^{\frac{1-\theta}{\theta}} \tag{3.16}$$

If only *Beauty* is produced, the indirect utility becomes:

$$V^B = \frac{\lambda}{p} n^{\frac{1-\theta}{\theta}} \tag{3.17}$$

the superscript serves merely notational purposes, *T* indicates only *Truth* is produced and consumed, *B* indicates only *Beauty* is produced. For the autarky purposes we dropped the superscript on λ.

Define $W(\lambda)$ to be a social welfare as a function of λ. Producers earn zero profits, and social welfare consists of the consumer's indirect utility function (Equations 3.16 or 17). On Figure 3.3 we graph social welfare attainable with autarky number of varieties (n), applicable for both Home and Foreign countries.

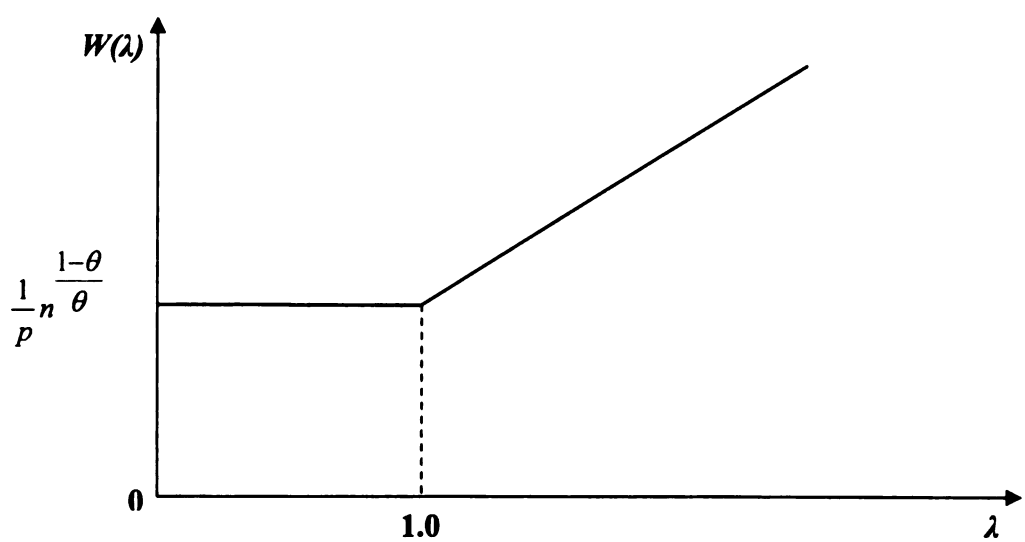


Figure 3.3: Social Welfare as a Function of λ: Autarky.

The shape of the social welfare on Figure 3.3 is determined by the choice of quality standard: if λ (the weight put on the consumption of the *Beauty* good, MRS between *Truth* and *Beauty*) is from the *(0, 1)* interval – that is country values the consumption of *Truth* more that it values the consumption of *Beauty*, country chooses *Truth* as a prevailing standard. In that case the social welfare corresponds to Equation 3.16, and it is graphed as a horizontal line, intersecting the ordinate at $\frac{1}{p} n^{\frac{1-\theta}{\theta}}$. If $\lambda > 1$, country chooses *Beauty* as a prevailing standard, and consumes all varieties in *Beauty*-make. Social welfare, represented by Equation 3.17, is graphed as a line with a slope of $\frac{1}{p} n^{\frac{1-\theta}{\theta}}$. Thus, the graph of a social welfare as a function of within-variety MRS is a line kinked at $\lambda = 1$ (the indifference point).

3.2.2. Unilateral Harmonization

Open the economies for trade, and allow for unilateral harmonization. "Unilateral harmonization" occurs when autarky welfare maximizing standards differ across countries and one country harmonizes its standard with the other country without a reciprocity clause if such a harmonization yields higher utility than autarky. In the exposition we assume no side payments or other benefits (i.e., political and/or economic externalities) from the country which standard is considered for harmonization by the harmonizing country are present in the model. If the harmonizing party finds unilateral harmonization beneficial based on comparisons of autarky and integrated social welfare, it adopts the standard. Otherwise it vetoes the harmonization.

Allow countries to vary by size. From Equation 3.12, labor endowments impact the number of varieties available in the economy. Define n to be number of varieties produced at Home, and n^* to be number of varieties produced in the Foreign country. It is possible $n \neq n^*$ due to differing endowments across countries, not different technologies across countries. Due to the assumptions imposed (constant elasticity combined with standard-invariant fixed costs), total number of varieties available in the integrated economy is the summation of number of varieties previously available in autarky.

Assume countries trade only if a common standard is in place. The indirect utility function if all goods are standardized to *Truth* is:

$$V^T = \frac{1}{p}(n+n^*)^{\frac{1-\theta}{\theta}} \tag{3.18}$$

Likewise, if trade is permitted and all good are standardized to *Beauty*, the indirect utility function becomes:

$$V^B = \frac{\lambda}{p}(n+n^*)^{\frac{1-\theta}{\theta}} \tag{3.19}$$

On Figure 3.4, looking at the trade from the Home country's perspective, we add graphs of social welfare of harmonized trade to the autarky baseline. The autarky line is identical with autarky line from Figure 3.3. When the countries are identical in terms of their endowments, Home autarky social welfare function coincides with the Foreign. Equation 3.18 – social welfare when all goods are standardized to *Truth* – corresponds to a horizontal line intersecting the ordinate at $\frac{1}{p}(n+n^*)^{\frac{1-\theta}{\theta}}$.

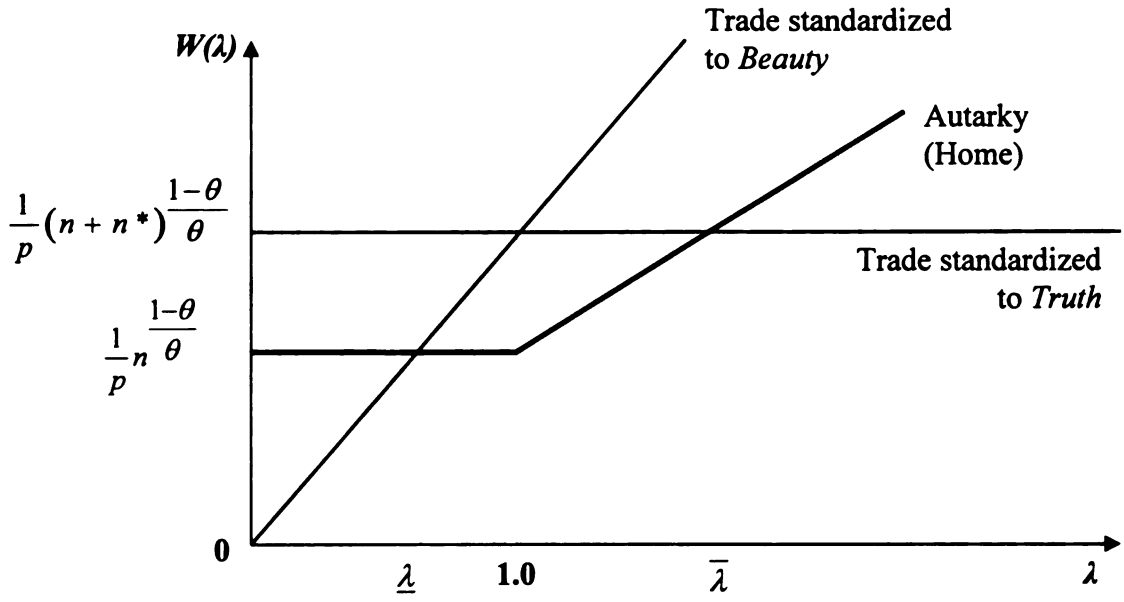


Figure 3.4: Social Welfare as a Function of λ: Autarky, Standardization to *Truth* and *Beauty*, from the Home Country Perspective

Equation 3.19 – social welfare when all goods are standardized to *Beauty* – corresponds to a line originating at zero (when all the goods are standardized to *Beauty*, and the weight assigned to consumption of *Beauty* made varieties is zero, total social welfare is zero) with a slope of $\frac{1}{p}(n+n^*)^{\frac{1-\theta}{\theta}}$. The autarky social welfare function intersects each "all-standardized" welfare function once, and effectively divides the abscissa into four intervals:

1. $(0,\underline{\lambda})$ - autarky dominates trade standardized to *Beauty*;

2. $(\underline{\lambda},1)$ - standardized trade to *Truth* dominates standardized trade to *Beauty* which in turn dominates autarky;

3. $\left(1,\overline{\lambda}\right)$- standardized trade to *Beauty* dominates standardized trade to *Truth* which dominates autarky; and

4. $\left(\overline{\lambda},\infty\right)$- autarky dominates trade standardized to *Truth.*

Thus, if $\lambda < \underline{\lambda}$, trade standardized to *Beauty* is worse than autarky; if $\lambda > \overline{\lambda}$, trade standardized to *Truth* is worse than autarky. $\underline{\lambda}$, the intersection of autarky and trade standardized to *Beauty* social welfare functions, is solution to:

$$\frac{\lambda}{p}\left(n+n^*\right)^{\frac{1-\theta}{\theta}} = \frac{1}{p}n^{\frac{1-\theta}{\theta}} \Rightarrow \underline{\lambda} = \left(\frac{n}{n+n^*}\right)^{\frac{1-\theta}{\theta}} \tag{3.20}$$

$\overline{\lambda}$, the intersection of autarky and trade standardized to *Truth* social welfare, solves:

$$\frac{1}{p}\left(n+n^*\right)^{\frac{1-\theta}{\theta}} = \frac{\lambda}{p}n^{\frac{1-\theta}{\theta}} \Rightarrow \overline{\lambda} = \left(\frac{n}{n+n^*}\right)^{\frac{\theta-1}{\theta}} \tag{3.21}$$

To simplify notation, we follow the usual convention, and leave all Home country parameters "plain", and label all Foreign country parameters with a star (*): thus, $\lambda^H = \lambda$ and $\lambda^F = \lambda^*$. Figure 3.5 shows the unilateral harmonization case from the perspective of the Foreign country. Based on the Foreign parameters, we derive the unilateral harmonization cutoff points, $\underline{\lambda}^*, \overline{\lambda}^*$ (similar to Equations 3.20 and 21).

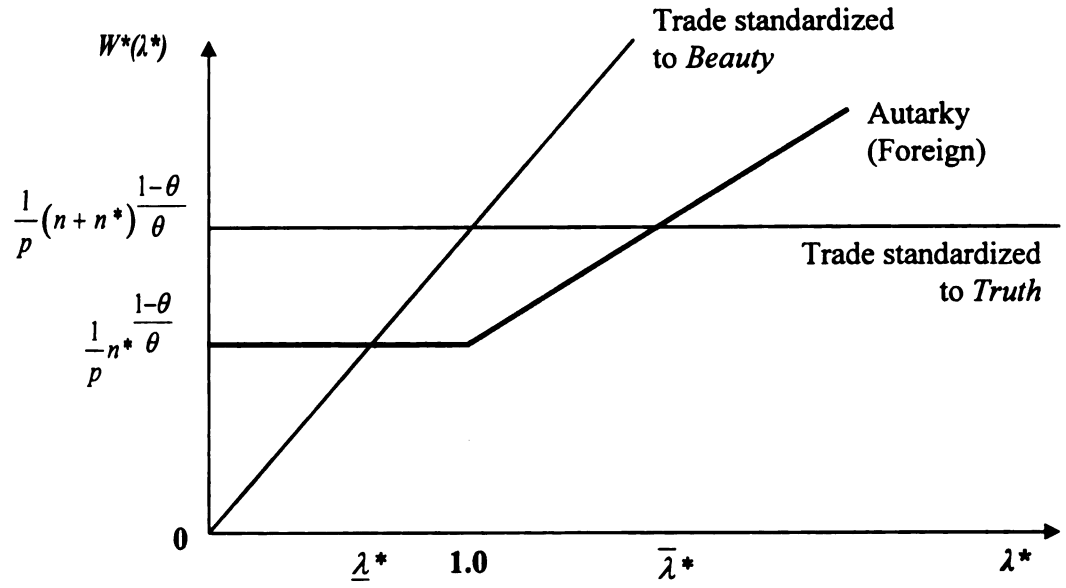


Figure 3.5: Social Welfare as a Function of λ: Autarky, Standardization to *Truth* and *Beauty*, from the Foreign Country Perspective

If both countries have values "close" to the indifference point of one, i.e. if $\{\underline{\lambda} \wedge \underline{\lambda}^*\} < \{\lambda \wedge \lambda^*\} < \{\overline{\lambda} \wedge \overline{\lambda}^*\}$, then standardized trade is welfare improving compared to autarky for each country. The actual location of cutoff points in both countries depends on the elasticity of substitution between varieties[32], and the compensation provided by consumption of larger than autarky number of varieties.

While we consider the case of small vs. large country in detail momentarily in Section 3.2.2.1., we note that increases in the number of varieties available between autarky and free harmonized trade determine the interval over which a country is willing to harmonize: if the increase in the number of varieties from the Home country perspective is large ($n^* > n$), the Home country will find harmonization beneficial on a

[32] **Elasticity of substitution** between varieties is the same between the varieties of the same quality, as well as **"opposing" qualities.**

larger interval by shifting the cutoff points $\left(\underline{\lambda}, \overline{\lambda}\right)$ out. At the same time, the Foreign country finds harmonization to any standard beneficial on a small interval, as $\underline{\lambda}^*, \overline{\lambda}^*$ get closer together.

Bypassing the assumption made earlier on Home preferring *Truth* and Foreign preferring *Beauty*, we now analyze possible outcomes of the harmonization policy.[33] In each country the respective cutoff points divide the continuum of preference parameters into four intervals. For an improved graphical exposition, Figure 3.6 illustrates the welfare rankings Home and Foreign countries face on each interval (autarky, trade harmonized to *Beauty*, trade harmonized to *Truth*), and plot them into a four by four grid. The Home country's intervals are plotted on the ordinate, while the Foreign country's intervals are plotted on the abscissa. In the grid *A* stands for autarky, *T* for trade between countries harmonized to *Truth,* and *B* for trade standardized to *Beauty*. As earlier, "starred" parameters denote the Foreign country. For example, the sequence $T > A > B$ means that in the Home country trade harmonized to *Truth* is preferred in terms to welfare to autarky, which in turn is preferred to trade harmonized to *Beauty*. Owing to the production assumptions of equal fixed and marginal costs across standards, any $\lambda < 1$ implies *Truth* prevails in autarky, and $\lambda > 1$ implies *Beauty* prevails in autarky, as graphed on Figure 3.6.

[33] On the following graphs we show the case when both countries choose the same autarky standards is trivial – it results in usual Krugman-like outcome.

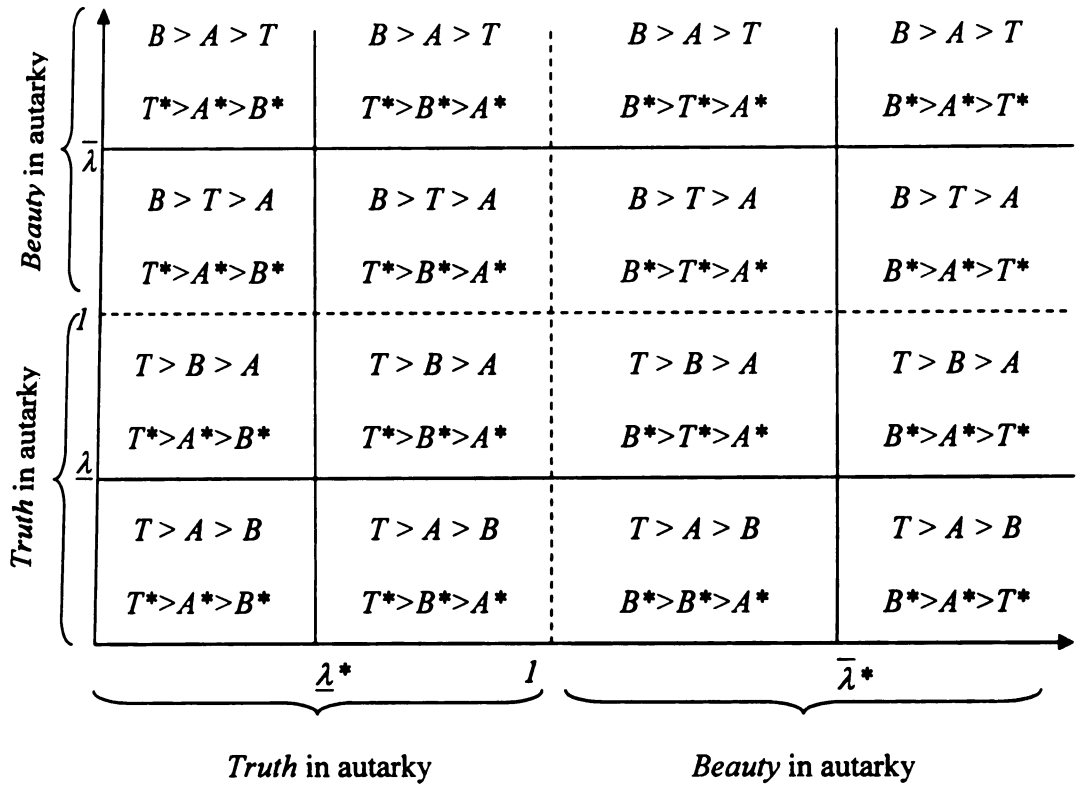
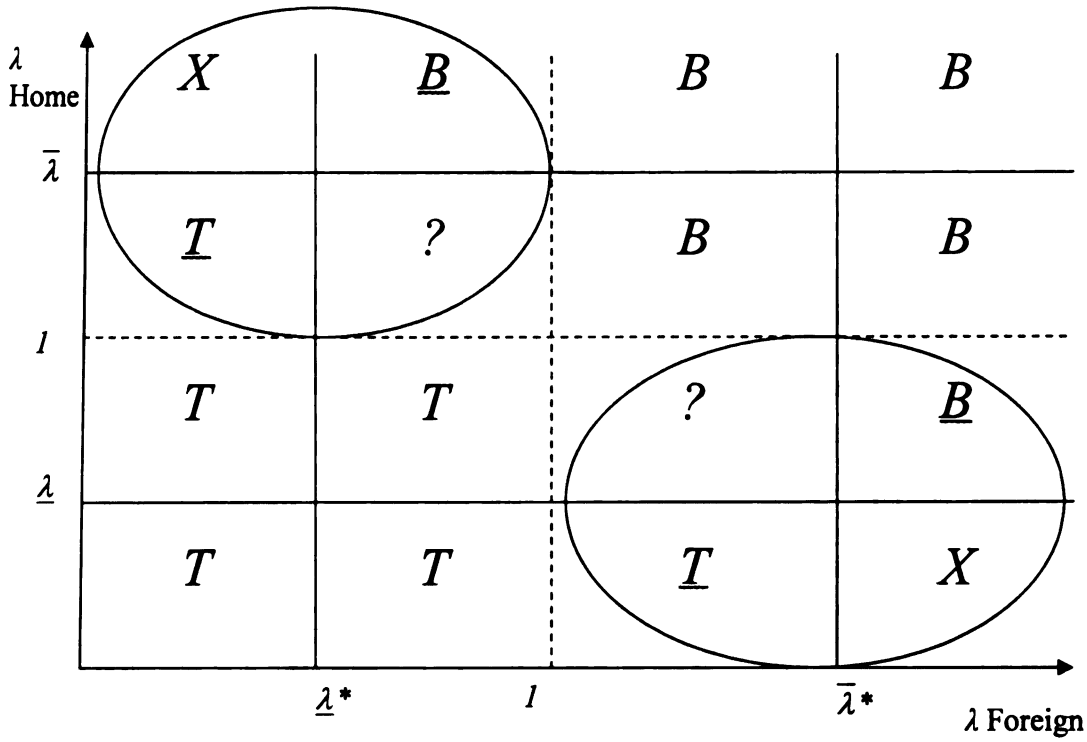


Figure 3.6: Welfare Ranking of Alternatives.

Based on the welfare rankings of the alternatives in the Home and Foreign countries in Figure 3.6, we simplify the potential outcomes (Figure 3.7). For example, when $T > A > B$ and $T^* > A^* > B^*$, both countries rank trade harmonized to *Truth* higher than autarky and trade harmonized to *Beauty*, and *Truth* will prevail. Agreement on the standard is straightforward in the lower left hand and upper right hand corner of the grid: when both Home and Foreign country prefer the same standard (either *Truth* or *Beauty*), and the usual Krugman open trade result prevails.



Legend:

X – No agreement
B, *T* – Harmonized trade, one of the countries gets second choice in the agreement
B – Harmonized trade, both countries rank *Beauty* first
T – Harmonized trade, both countries tank *Truth* first
? – Uncertain outcome without further structure of the model

Figure 3.7: Agreements and Prevailing Standards, Case of Identical Endowments.

The case is more interesting when preferences across countries differ, and each country prefers a different standard (upper left hand and lower right hand corner of the grid, in ovals). *X* marks the case where no agreement is possible: each country prefers a different harmonized standard, while harmonization to a standard different from the preferred standard leads to a lower welfare then autarky. In this case the differences between countries' standards are too large to be bridged by trade, even at the opportunity to consume larger number of varieties.

A question mark indicates a case when the outcome is uncertain unless we specify further model structure. In either case presented both countries rank autarky on the lowest pedestal. However, countries differ in their rankings of free trade: while they would certainly benefit from harmonized free trade more then they would benefit from autarky, they rank harmonization to their autarky preferred standard most. The model as presented does not have the capacity to specify which country would execute unilateral harmonization.

Lastly, there are cases when trade is beneficial – each country ranks some harmonized trade over autarky; however, one of the countries gets second choice in the agreement: for example, Home country ranks trade harmonized to *Truth* over autarky, but finds trade harmonized to *Beauty* welfare worsening. At the same time in the Foreign country autarky is inferior relative to both trade harmonized to *Truth* or *Beauty*, with *Beauty* topping its welfare choices. In this case world trade harmonized to *Truth* prevails: the Home country vetoes trade harmonized to *Beauty*, as it would leave it worse off than autarky. The Foreign country is still better off than it would be in autarky, but worse off than it would be if the trade was harmonized to *Beauty*. Referring to Figure 3.6, instances when one of the countries "gets its second best" are double underlined in Figure 3.7.

3.2.2.1. Large vs. Small Country Harmonization

Now consider the case of two countries of different sizes, and assume n (number of *Truth* varieties in the Home country) is small compared to n^* (number of *Beauty* varieties in the Foreign country). We depict their respective autarky and harmonized open trade social welfare relying on Equations 3.18 and 19 on Figure 3.8. Assume in the small

country MRS between different qualities of the same variety is less than one, and therefore in autarky it prefers *Truth*. Large country prefers *Beauty*.

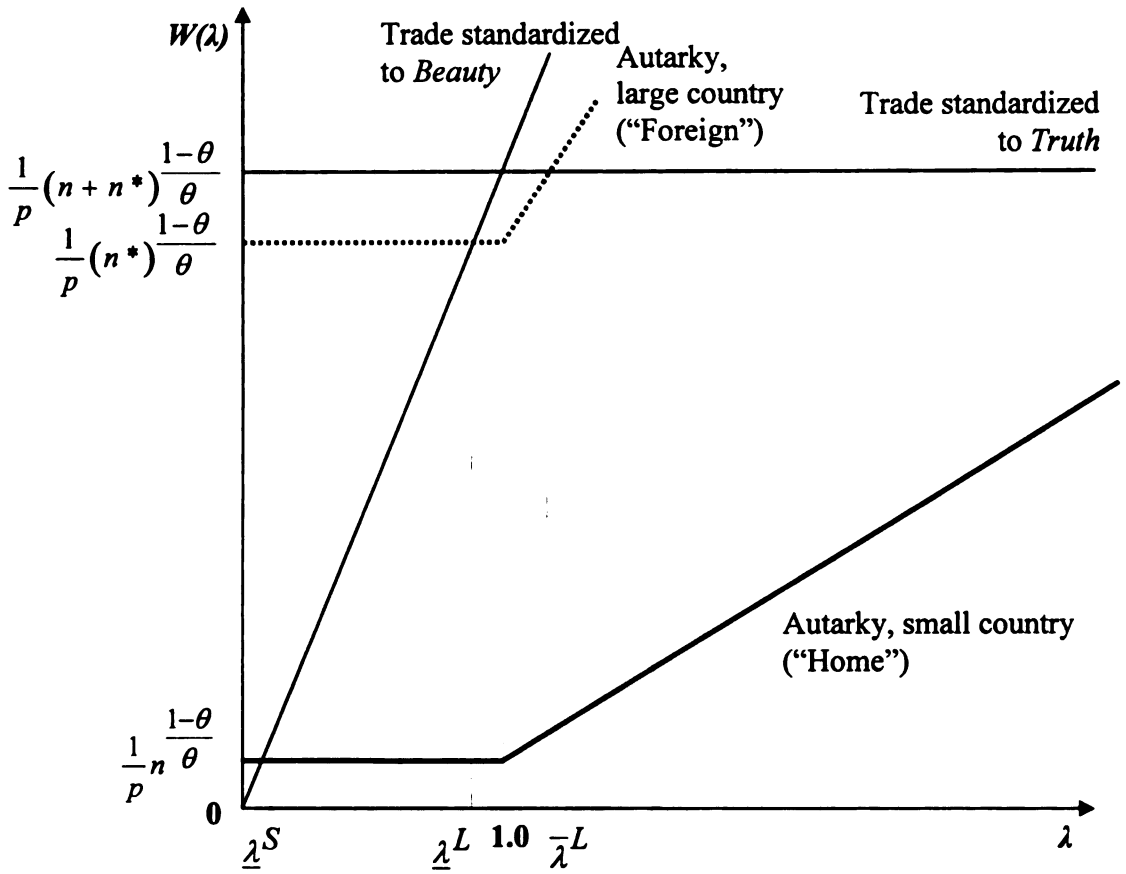
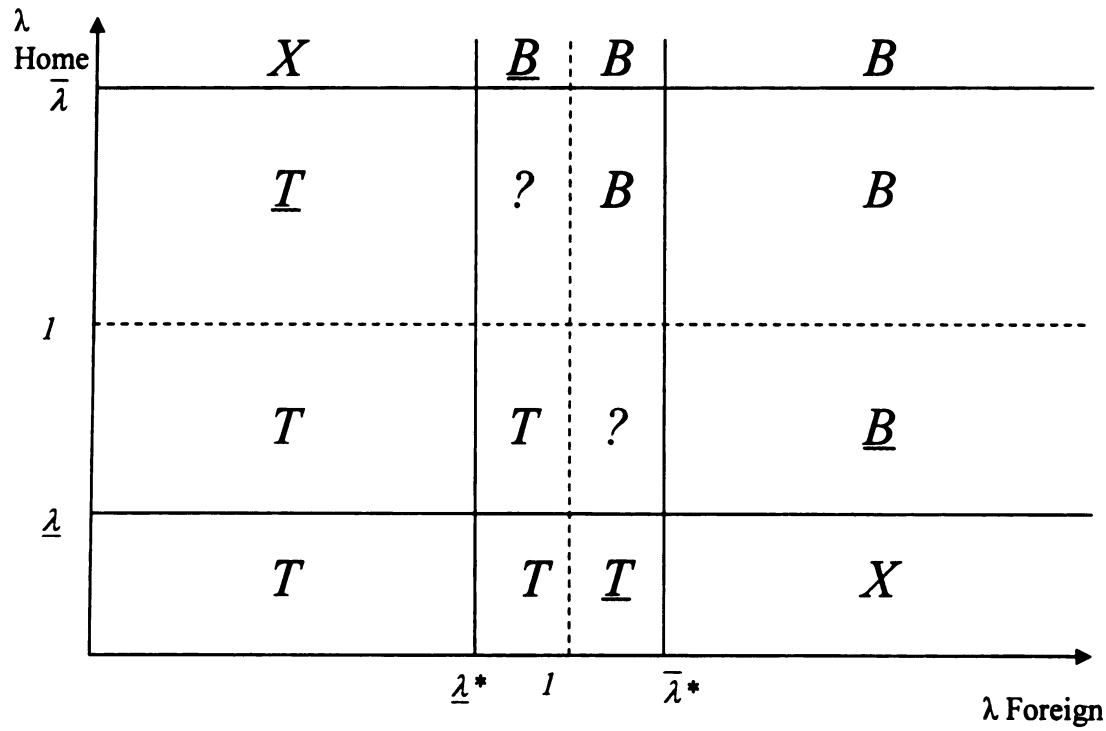


Figure 3.8: Social Welfare as a Function of λ: Autarky, Standardization to *Truth* and *Beauty*. Differently Sized Countries, Home Modeled as Small (not drawn to scale)

Notice that the length of the interval over which the small country finds the unilateral harmonization beneficial is large, while the interval over which it is favorable for the large country to harmonize is narrow. In addition, if the large – *Beauty* preferring –country decides to harmonize to *Truth*, the gain in social welfare from consuming open trade number of varieties is small compared to welfare gains the small country would

experience if it decided to unilaterally harmonize to *Beauty*. Therefore, the small country adopts *Beauty*.

Figure 3.9 transposes attainable welfares in Home and Foreign countries into a matrix of welfare rankings over harmonization intervals. Compared to Figure 3.7, when both countries exercised the same negotiation power (measured by the size of economy, and consequently in terms of varieties a country brings to the market), the lengths of the intervals over which countries find harmonized trade beneficial to autarky change.



Legend:

X – No agreement
B, *T* – Harmonized trade, one of the countries gets second choice in the agreement
B – Harmonized trade, both countries rank *Beauty* first
T – Harmonized trade, both countries tank *Truth* first
? – Uncertain outcome without further structure of the model

Figure 3.9: Prevailing Standard: Home Modeled as Small, Foreign as Large Country.

3.2.3. Non-harmonized Trade

Suppose now non-harmonized trade is allowed, for example facilitated via a mutual recognition of standards and procedures agreement. The Foreign country produces (and trades) only *Beauty* (regardless what Home does). Each consumer consumes number of varieties available in autarky, as well as varieties produced in the other country. The Home indirect utility function from consuming both *Truth* and *Beauty* made varieties is:

$$V^{TB} = \frac{1}{p}\left(n + n^* \lambda^{\frac{\theta}{1-\theta}}\right)^{\frac{1-\theta}{\theta}} \tag{3.22}$$

where n is a number of varieties produced at Home, and n^* is the number of varieties produced in the Foreign country. The shape of the social welfare function in Equation 3.22 depends on the value of θ. If $\theta > 0.5$, the "non-standardized" trade social welfare is convex for any $\lambda \in \langle 0,1 \rangle$ (Figure 3.10). If $\theta < 0.5$, the "non-standardized" trade social welfare is concave for $\lambda \in \langle 0,1 \rangle$ (Figure 3.11).

In either case (Figures 3.10 and 11) non-standardized trade is welfare improving to autarky. If λ is zero, consumption of imported varieties does not add anything to the consumption of the autarky number of varieties, but the autarky welfare – unlike in the harmonized case (Figure 3.4) – remains protected.

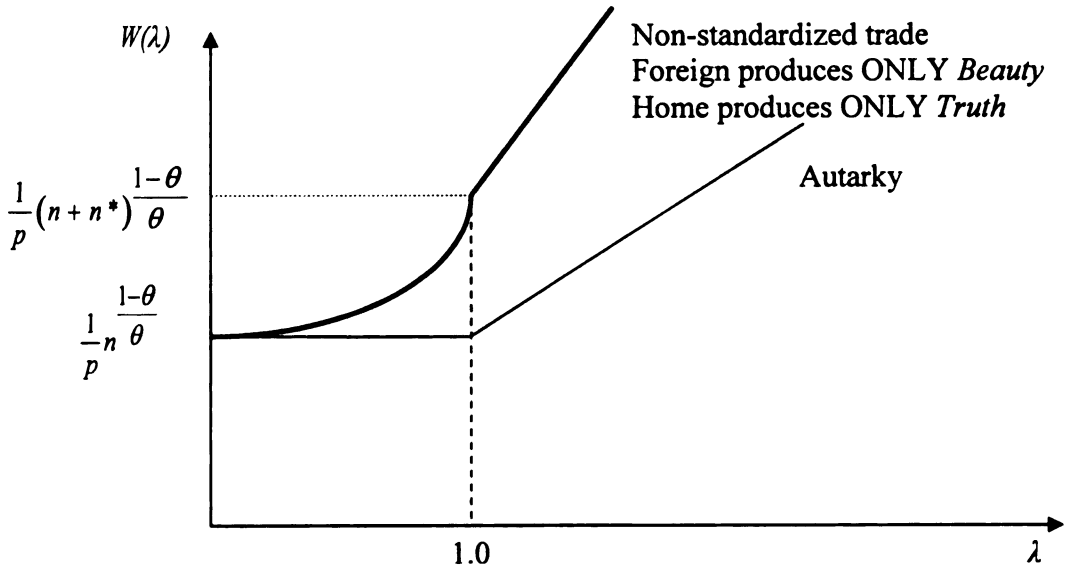


Figure 3.10: Social Welfare as a Function of λ: Autarky, Non-standardized Trade, $\theta > 0.5$.

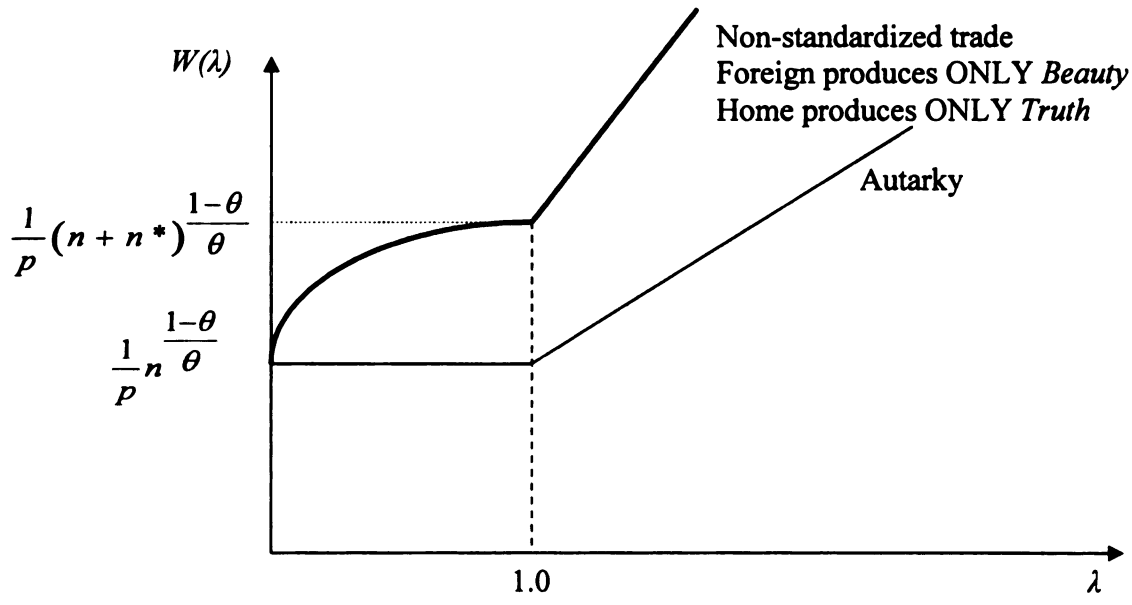


Figure 3.11: Social Welfare as a Function of λ: Autarky, Non-standardized Trade, $\theta < 0.5$.

If the assumptions regarding the size of marginal costs across varieties were released, different prices would result across varieties. Differences in country size or cross-country differences in fixed costs will change n and n^*. Effectively they would change the "critical value" (that is, $\underline{\lambda}$ and $\overline{\lambda}$: where consumers are indifferent between *Truth* or *Beauty*), and shift curves. Nevertheless, the general conclusions would remain the same.

3.3. Large Number of Countries

In the two-country world we have shown unilateral harmonization can be welfare worsening depending on the within-variety MRS, while non-standardized trade is always beneficial. We now extend the analyses to a larger number of countries. Assume there are $(t+b)$ countries in the world: t countries prefer *Truth* standard to *Beauty* ($\lambda < 1$), b countries prefer *Beauty* attribute to *Truth* ($\lambda > 1$). We allow for $t \neq b$. Countries of each type are assumed to be of the same size: each of the t countries produces n varieties, each of the b countries produces n^* varieties. Therefore, the number of varieties (ignoring the quality aspect) consumed in autarky by any single "t" country is n (or n^* in any "b" country if their endowments of labor differ), the number of varieties consumed if all countries with the same preferences for a certain attribute would form an agreement is tn (or bn^*), and finally the total number of varieties produced in the world is $(tn+bn^*)$. The generalized notation is introduced to explore potential market power.

We define a club as a set of countries with similar preferences clustered in a trade agreement. Formation of agreements is costless. The autarkic standard prevails in each

bloc, and essentially becomes a club good. By recognizing the same standards within a club disputes are likely to be prevented. Non-members (or members of a different agreement) do not use the excludable standard of the club, and do not trade with the club members. Therefore, groupings of countries become de facto clubs in a Buchanan sense (Buchanan 1965), where standards have the characteristics of club goods, and non-members are excluded from consuming the benefits – that is unrestrained trade within club.

Assume countries in the model form a *Truth* club and a *Beauty* club based on their preferences. In the *Truth* club – formed by countries with $\lambda < 1$, and thus preferring *Truth* to *Beauty* – each member has access to and consumes tn varieties. The indirect utility function of a representative consumer of a *Truth* club (*TC*) is:

$$V^{TC} = \frac{1}{p}(tn)^{\frac{1-\theta}{\theta}} \tag{3.23}$$

Similarly, each member of a club formed by *Beauty* preferring countries ($\lambda > 1$) has access to bn^* number of varieties. The indirect utility function of a representative consumer in a *Beauty* club (*BC*) is:

$$V^{BC} = \frac{\lambda}{p}(bn^*)^{\frac{1-\theta}{\theta}} \tag{3.24}$$

As earlier, we graph the attainable social welfare within a club as a function of marginal rate of substitution (λ), and compare it with autarky social welfare (Figure 3.12). Social welfare attainable within a club exceeds the autarky social welfare over the entire interval: clubs allow consumption of larger-than-autarky number of varieties at autarky preferred standard.

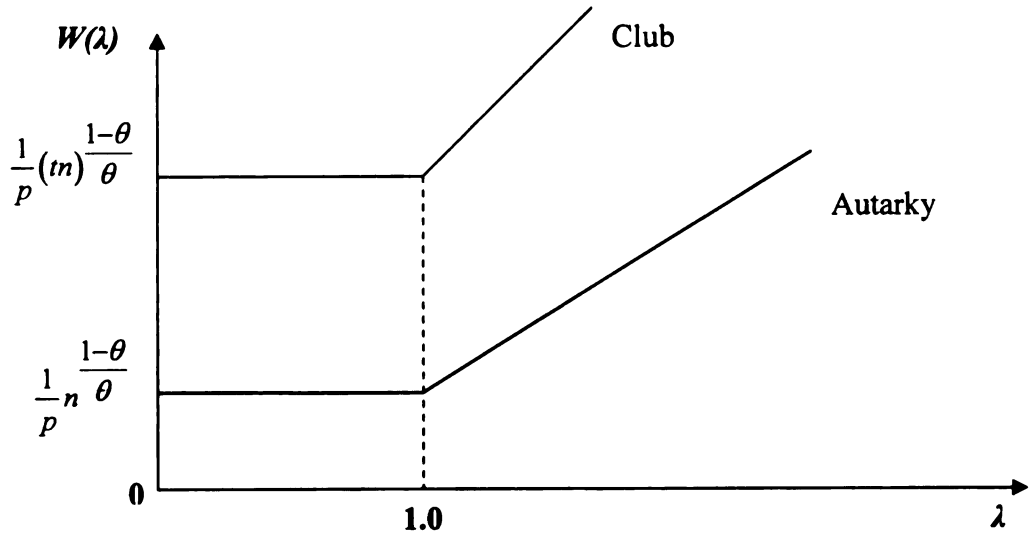


Figure 3.12: Social Welfare as a Function of λ: Autarky, Club.

3.3.1. Non-standardized Trade between Clubs

If non-standardized trade between clubs was allowed, each country would have access to *(tn+bn*)* number of varieties. The total social welfare attainable would be:

$$V = \frac{1}{p}\left(tn + bn^{*}\lambda^{\frac{\theta}{1-\theta}} \right)^{\frac{1-\theta}{\theta}} \tag{3.25}$$

We compare non-standardized free trade with club and autarky welfares. Graphically the scenario is illustrated on Figure 3.13 (for $\theta > 0.5$) and 3.14 (for $\theta < 0.5$). As in the two-country case (Figures 3.10 and 11), non-standardized trade is welfare improving compared to autarky, as well as club trading. However, in the presence of clubs formed by multiple countries with the same preferences, the lowest attainable social welfare when consumers completely discount the consumption of the other good coincides with "club autarky", rather that autarky per se.

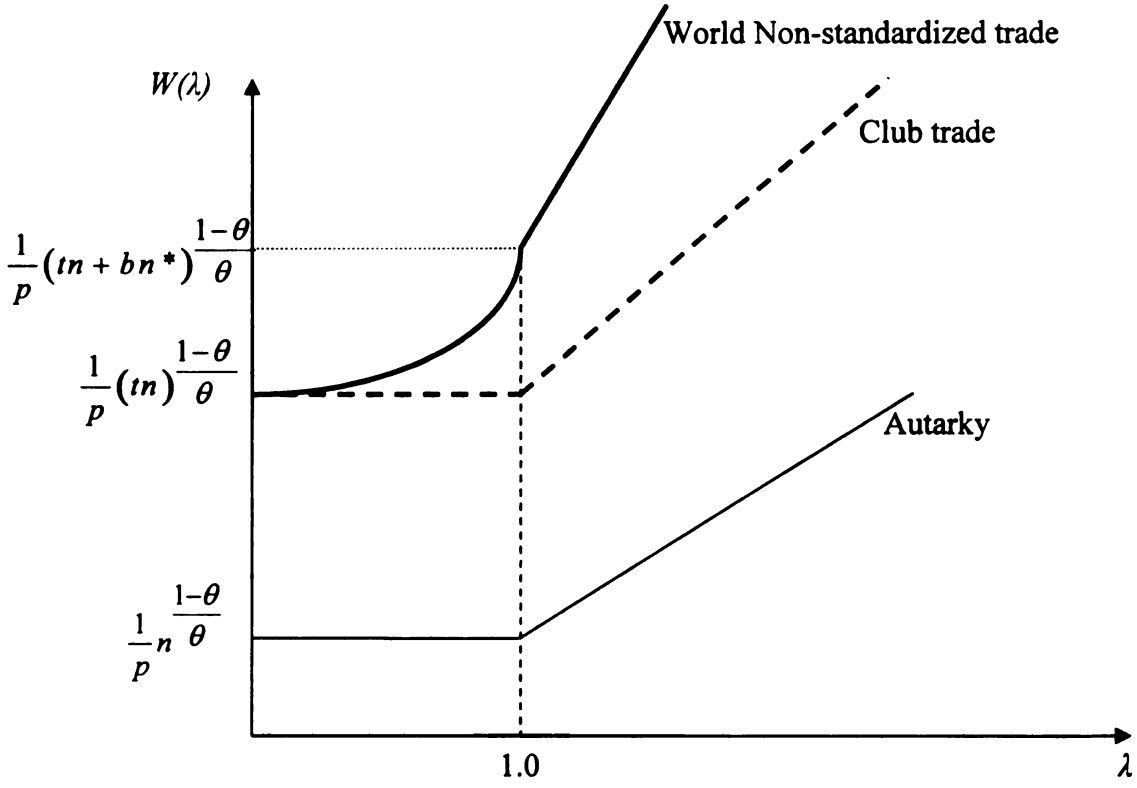


Figure 3.13: Social Welfare as a Function of λ: $(t+b)$ Countries, Autarky, Non-standardized Trade, $\theta > 0.5$ (not drawn to scale).

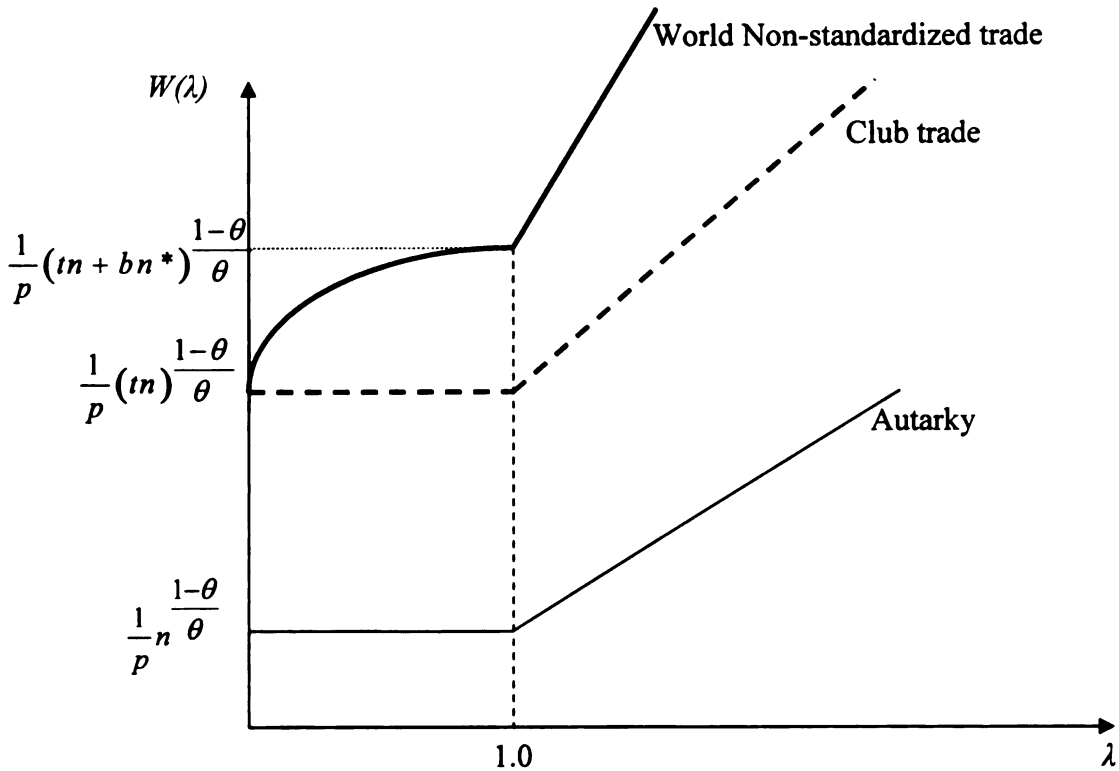


Figure 3.14: Social Welfare as a Function of λ: (t+b) Countries, Autarky, Non-standardized Trade, $\theta < 0.5$ (not drawn to scale).

3.3.2. World Standardized Trade between Clubs

Now assume non-standardized trade is not allowed, and instead countries seek to pursue the harmonization route. Club member are homogenous in all aspects (assumption of identical MRS between attributes might not suffice), and none of the members exhibits any selfish behavior (i.e., they negotiate as a club, see the EU example). The indirect utility function if all goods are standardized to *Truth* is:

$$V^T = \frac{1}{p}(tn + bn^*)^{\frac{1-\theta}{\theta}} \tag{3.26}$$

Likewise, if all goods are standardized to *Beauty*, the indirect utility function becomes:

(3.27) $$V^B = \frac{\lambda}{p}(tn + bn^*)^{\frac{1-\theta}{\theta}}$$

Figure 3.15 graphs social welfare attainable with $(tn+bn^*)$ number of varieties – but harmonized to one standard – together with club and autarky welfares.

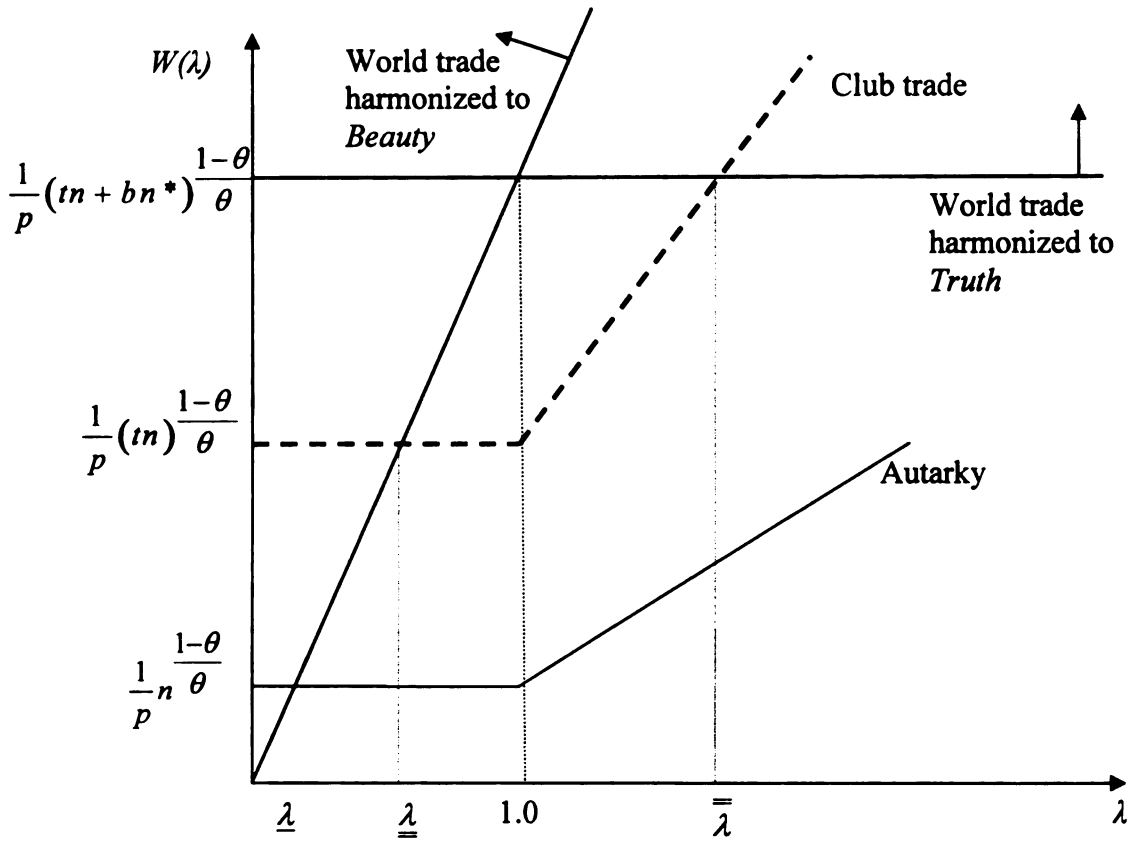


Figure 3.15: Social Welfare as a Function of λ: $(t+b)$ Countries, Autarky, Standardized Trade (not drawn to scale).

Figure 3.15 represents the comparison of autarky, club and harmonized world trade social welfares. In the absence of club trading (i.e., if it was prohibited or otherwise prevented), any individual country would be willing to harmonize (with the exception of very low values of marginal rate of substitution) to either *Truth* or *Beauty*. Presence of club trading narrows the length of the interval over which harmonization to a common

world standard is beneficial $\left(\underline{\underline{\lambda}}, \overline{\overline{\lambda}}\right)$: while on this interval either of the harmonized social welfare functions dominates club welfare, in case an agreement on common standard is not reached, countries are still better of in clubs compared to autarky.

As in the earlier case, size of the clubs – measured by the number of varieties they cumulatively provide – in comparison to the total number in the world determines the club's willingness to harmonize its standards with the other club. If the club is small compared to the rest of the world – i.e., it is formed by a smaller number of countries, countries are smaller in terms of endowments – by adhering to a certain club standard consumers would be restricting their welfare. On Figure 3.15 size of the club is represented by the position of the "club" social welfare compared to harmonized trade social welfare functions: if the club is relatively small compared to the rest of the world, the world trade social welfare function when all trade is harmonized to *Truth* shift up, while the world trade social welfare function when all trade is harmonized to *Beauty* pivots to the left around zero, as outlined by the arrows. Resulting is a large interval $\left(\underline{\underline{\lambda}}, \overline{\overline{\lambda}}\right)$ over which a club is willing to accept other club's standard to experience larger welfare. Again, for extreme values of MRS – i.e., is a country puts small weight on the consumption of the other standard, a club autarky yields higher welfare than harmonized world trade.

3.4. Core Analysis

We now turn to investigate whether or not the outcomes of the models presented are in the core. For the purposes of this chapter, we define the core as a set of allocations that no subset of countries would find separation from the other countries and trade among the subset beneficial. The same applies for the two country case: the core is a set of allocations when no country would find deviation from the agreement and consequent autarky beneficial.

Non-harmonized trade, if allowed, is in the core on the entire continuum of λ: no set of countries can be made better off by segregating and trading among themselves regardless what relative weight they put on the consumption of *Truth* and *Beauty* made varieties.

The outcome of the harmonized trade case depends on the position in the matrix of choices in Figure 3.7 (or fitted to the multiple country case). By definition, the allocation when both countries prefer harmonized trade to the same standard (both countries prefer *Truth* in the lower left hand corner, and both countries prefer *Beauty* in the upper right hand corner) – there is no allocation that yields a higher welfare, and no country can be made better off by a different allocation.

When countries in autarky choose different standards we focus on the upper left hand corner where Home prefers *Truth*, and Foreign *Beauty*. The lower right hand corners mirrors the analysis. When the Home country values consumption of *Beauty* very little and the Foreign values consumption of *Truth* very little, no agreement is possible (marked *X* on Figure 3.7). The multiple country equivalent translates into formation of two sub-agreements, each trading at its preferred standard. As there exists no other

allocation that would allow a subset of countries further to segregate and trade, the trading arrangement consisting of two clubs is in the core. A global club arrangement, if formed, would not be in the core: as given the countries' preferences, harmonized trade is welfare worsening, and each subset of countries will be made better off by trading among themselves.

When the differences between countries' valuation of standards exists, but those differences do not prevent them from forming an agreement, such an allocation is in the core, even though one country (or one set of countries in the multi-country case) gets its second choice of standard in the agreement (marked by double underlining in Figure 3.7). Separation from the (global) agreement and within club trading would not yield higher welfare. The same applies for the cell labeled with a question mark when both (sets of) countries prefer some harmonized trade to autarky: assuming they would reach an agreement on the prevailing standard, a deviation from the agreement does not result in an improved distribution.

3.5. Applying Lessons from the Club Theory

Using the vocabulary of public economics, the country providing the public good of the standard (or unilaterally harmonizing) finances its provision via discounted utility it obtains from the consumption of more varieties. The country to whose standard unilateral harmonization took place de facto "free rides" on the other country – it benefits from a larger number of varieties it originally preferred without changing its behavior. If the weight put on the consumption of a less preferred standard is too small to justify

unilateral harmonization or both countries would benefit from unilateral harmonization but are adopting a waiting strategy (cell marked by question mark in Figure 3.7, fitted to the multi country case), a global agreement is not feasible. The only way to take advantage of (at least some) gains from trade in form of larger number available varieties is for the countries to resort to sub-global agreements among countries with similar preferences. The number of varieties consumed in a sub-global agreement exceeds the number of autarky-consumed varieties, but is less than the number of varieties consumed if a global agreement was formed. Countries stay in a "within-club" autarky: trading varieties only with countries with the same preferences, showing optimal harmonization (or any other policy coordination) domain can be sub-global. The current stage of the WTO negotiation is a likely fit: despite the advantages of a global domain achievable via unilateral concessions ("financing" the provision of a public good of standards, and consequently, free movement of goods), countries adopt a waiting strategy and form sub-global agreements. The emergence of sub-global agreements clustered based on countries' preferences towards certain attributes is supported by consistent with social choice (Olson, 1968) and club theories (Buchanan, 1965).

If standards are common across all countries, or any country is willing to "finance a provision of public good" via unilateral harmonization, a global club is formed. Thus, as described above, countries sharing similar members' characteristics (i.e., choosing the same standards) voluntarily cluster themselves into clubs: "*Truths*" will form a club, as will the "*Beauties*", resembling a separating equilibrium. Otherwise, in sub-global clubs, countries consume more varieties at their original quality standard than in autarky, without any standards adjustment. Each firm within any club produces one variety for all

consumers in the club, everyone specializes, and everyone trades, but only with the members of its own club, including global. WTO-compatible clubs[34] in this paper are not necessarily strictly the clubs in Buchanan's sense that provide or facilitate the provision of public goods per se. Nevertheless, in a broader sense, clubs facilitate movement of goods within a group of countries by having only one standard prevailing within a club. The club standard does not necessarily have to be institutionalized to facilitate trade, or to provide a club good of free movement of goods (and services) among a certain subset of countries. A dominant standard within a club thus serves as a sort of exclusion mechanism keeping countries with different preferences external to the club. Non-members are – and also want to be – excluded from the trade with members.

Theoretically speaking, the global domain – encompassing all countries – might not be workable to reach: "unless the number of individuals in a group is quite small, or unless there is a coercion or some other special device to make individuals act in their common interest, [the] rational, self-interested individual will not act to achieve their common or group interest" (Olson 1965, pg. 2). Countries homogeneous to a certain degree form a smaller group of fewer players able to bargain more effectively and efficiently and provide a club good (for example, grades, standards and labeling harmonization) where provision of public goods has failed (or is likely to fail). Homogeneity is defined in terms of similar consumers' attitudes, industry structure, interest groups, income, tolerance levels, perceptions of risk etc. Requiring outsiders to produce their product up to a certain standard (or label or impose any other NTB) can act as a tax or technical barrier to trade, and probably leads to prohibition of goods from

[34] Preferential agreements presented in this paper do not violate the WTO rules since they do not make trade with non-members more difficult than before an agreement was in place.

outside the club. Similarly, leaders are more likely to emerge in a smaller, more homogeneous setting (i.e. Kindleberger 1981 or Fratianni and Pattison 2001). A real world example of agricultural biotechnology clustering countries into clubs based on similar positions is discussed in Chapter 5.

While we only discussed a simple case of discrete standards resulting in two clubs being formed, with a more complicated setup multiple clubs would occur, thus lowering chances of survival of a global organization already in place – if any. Therefore, the number of clubs is predetermined by the existing number of standards, assuming standards are not clustered and the marginal entrant into any club can be clearly determined. Nevertheless, as supported by Olson, members are more likely to reach a conclusion in a smaller grouping of more homogenous members compared to a heterogeneous global organization.

3.6. Chapter Conclusions

The chapter built a Krugman-like model of endogenous standards setting and consequent trade. Consumers in each country loved variety, but had different marginal rates of substitution between different standards of the same variety. Due to the constant elasticity of substitution, gains from trade are limited to a greater number of varieties available. We studied a discrete version of a quality standard: that is, a variety either contained a certain trait ("*Truth*") or it did not ("*Beauty*"). The model abstracted from price effects due to the assumption of constant elasticity. We considered two different equilibrium candidates: open trade without harmonization (and free of any technical

barriers to trade), and open trade with harmonization. In the first case by assumption Home and Foreign produced different sets of varieties and traded. We showed that trade without any harmonization (equivalent to consuming mix and match of varieties, but never any variety in both specifications) was always welfare increasing as compared to autarky. However, when one of the countries required every variety on its domestic market to be produced up to a certain quality standard, trade at an imposed uniform standard could be welfare worsening as opposed to autarky depending on actual ratio of marginal labor requirements to produce each quality, the increase in the number of varieties available, the elasticity of substitution and the parameter "discounting" the utility gained from a consumption of varieties produced at a different standard. Nevertheless, we have shown autarky can dominate free trade if there is a distortion involved. Transposing the result into the policy arena, we conclude that in some cases the negative "harmonization effect" – or the effect of a standard different from the one originally preferred – exceeded the increased variety effect, and a country would veto the harmonization and trade.

Once trade opened countries with the same autarky-prevailing standards "formed agreements": if the same standard prevailed across the world, a global agreement is formed. A global agreement could be also formed when any party decides to harmonize unilaterally, bringing in issues of public goods provision, such as financing and free riding. Otherwise countries formed smaller agreements with their allies. Nevertheless, in either type of agreement, each country benefited from having access to a larger number of varieties than in strict autarky, even though the number of varieties available in the sub-global club is smaller than it would be in a global club. The model also supports

some stylized facts of international trade: "regional" trade agreements being formed among geographically distant partners based on their preferences, and "large countries free-riding on smaller ones" due to their willingness to execute unilateral harmonization owing to the relative larger gains that small countries obtain from trade. While the actual process of negotiating a free trade agreement might not necessarily follow the process outlined in this paper, it clarifies why countries choose negotiation partners with similar preferences or willingness to pursue unilateral harmonization to secure success. Global negotiation when countries have different preferences could be problematic. In addition, agreements discussed in this paper do not necessarily have to be explicitly institutionalized; rather, they can take form of an informal club.

Another stylized fact is that the small trade agreements act as a stumbling bloc in the world trade negotiations. The model confirms that it is indeed true that non-harmonized trade can be desired. However, when harmonized trade is desired, sub-global agreements can be welfare improving when global trade is welfare worsening (that is, on certain intervals).

The discussion in the paper was limited only to two types of countries with two discount parameters (λs). However, in reality the world consists of countries with more heterogeneous preferences, and consequently the number of sub-global agreements is likely to exceed two. This extension is a topic for future research.

CHAPTER 4

ECONOMIES OF SCALE: AUTARKY, HARMONIZATION AND COMPROMISE

Chapter 3 explored standards selection decisions in autarky and consequent agreement formation based on the "love of variety" in the usual Krugman (1980) setting of non-sunk fixed costs, constant marginal costs, and constant elasticity of substitution between varieties; Chapter 3 enhanced this analysis by including a discrete attribute (standard) to the model. Owing to production assumptions, a within-variety production possibilities frontier was "discontinuous" with a linear continuous section (Figure 3.1). Constant elasticity of demand kept the prices unaffected by the increases in the labor force, and allowed exploring changes in the number of varieties available, but prevented employing a traditional economies-of-scale argument originating in decreasing costs over larger output. Finally, strict discreteness of standards (the product either did or did not possess a certain attribute) did not permit analyses of a compromise or allowed countries to make small changes in reaching a common tolerance level.

Chapter 4 follows up on the problem introduced earlier: it addresses the differences in national standards for *like* products and their potential harmonization, either unilaterally or by defining a common tolerance level. Relying on graphical illustrations, it releases assumptions regarding fixed and marginal labor requirements, elasticity, and the discreteness of a standard. Standards are associated with tolerance levels towards certain attributes, such as occurrence of genetically modified (GM) organisms and foodstuffs (GMOs) or pesticide residues in the food system: *Beauty* (complete acceptance, or full tolerance) and *Truth* (complete rejection, or zero tolerance)

being extreme cases, with the possibility of some intermediate level (i.e., products containing more/less than a certain amount of the attribute are labeled – either mandatory or voluntary). The assumption of the horizontal separation between standards on a global level, and vertical differentiation from the standpoint of consumers in individual countries remains honored. Once again we emphasize the connotation of individual standards: while Home considers *Truth*-made goods superior to *Beauty*-made, Foreign has the exact opposite inclination. Nevertheless, from the WTO perspective, *Truth* and *Beauty* are equal in terms of performance, and as such are classified as *like* products.

This chapter emphasizes modifications of consumption and production under a "traditional" economies-of-scale argument with decreasing marginal costs. While different standards are not directly comparable in terms of their performance, their respective labor requirements are directly comparable. Assume marginal labor requirements are distributed along a continuum; for any level of output produced the marginal requirement of producing *Truth* ("lower tolerance level" or a stricter standard) exceeds the one of producing the same amount of *Beauty* ("higher tolerance level," more lenient standard). Sunk (fixed) labor requirements ensure the PPF is continuous (details discussed in Section 4.2). The number of varieties available depends on the country size (defined in terms of workers).

We start with a model description and graphical solutions to the general example of autarky standard selection (not related to any specific sector), followed by harmonization, and compromise between two countries with different preferences. We analyze the two country case (one each of the two different types), later releasing the

equal size assumption. As in the previous chapter, total welfare considerations are limited to maximizing a representative consumer's utility, as firms' profits are confined to zero.

4.1. Consumption

Assume the world consists of two representative countries: Home and Foreign, with identical endowments of labor (this assumption will be relaxed later) and access to the same production technologies, but with different within-variety marginal rates of substitution depending on an attribute (e.g. percentage of the GM ingredients). Standards are defined on the bases of attributes present as tolerance levels; and in border cases *Truth* stands for zero tolerance, and *Beauty* for full acceptance.

The model is based on the love-of-variety in differentiated goods. There are many differentiated goods available. The differentiated goods may be produced with different levels of a specified attribute; one or both country(ies) may choose to subject the level of this attribute to a standard(s). Assume there are L identical consumers in each country, each consumer is endowed with one unit of labor earning a wage of w. Each consumer's preferences are defined as[35]:

$$U^C = \sum_{j=1}^{N} v\left(d_j\right) \tag{4.1}$$

where d_j represent consumption of any individual variety, superscript C takes the values H (for Home) or F (for Foreign). Due to the symmetry imposed by assigning same qualities of different varieties of the differentiated good equal weights, the share available

[35] Unlike earlier, here we refrain from specific functional forms for the upper tier utility function, but define the lower (within-variety substitutes) tier.

for the "quality variant" goods is spent evenly on each variety. In addition, $v' > 0$ and $v'' < 0$, ensuring v is increasing and concave. Assume that the number of varieties in the differentiated sector (N) is sufficiently large so that the budget share of each of them is small, and the impact of a change in one price on the marginal utility of income can be ignored. For any variety j the elasticity of substitution – and elasticity of demand facing an individual producer is defined as:

$$\varepsilon_j = -\frac{dc_j}{dp_j}\frac{p}{d_j} = -\left(\frac{v'}{d_j v''}\right) > 0 \tag{4.2}$$

Also assume

$$\frac{\partial \varepsilon_j}{\partial d_j} < 0 \tag{4.3}$$

Presenting a generalized case of love of variety utility function without placing any limits on the elasticity of substitution (other than decreasing in consumption, Equation 4.3) does not exclude trade for reasons of accessing a wider variety of goods, while at the same time it allows for the traditional economies of scale argument – as will be clarified momentarily. As in Chapter 3, assume consumers in each country are composing their consumption from two available qualities (*Truth* and *Beauty*) such that:

$$d_j = d_j^T + \lambda^C d_j^B \tag{4.4}$$

where T is for *Truth* and B for *Beauty*, C in the superscript stands for country (Home or Foreign). To account for differing preferences with respect to qualities across countries, assume that:

$$0 < \lambda^H < 1 \qquad \text{(preference parameter in the Home country)} \tag{4.5}$$

(4.6) $\lambda^F > 1$ (preference parameter in the Foreign country)

Equations 3.4 – 6 define different quality versions of any differentiated good as substitutes in consumption, as represented by a linear subutility function, with different weights put on the consumption of different standard across countries. Since the total utility is increasing in each subutility obtained from a differentiated good, for the total utility to be maximized, each linear subutility has to be maximized. Thus, the consumer is maximizing based on the within-variety marginal rate of substitution (λ^C) in each country. Mixing and matching of *Truth* and *Beauty* varieties is prevented: if, for example, consumption of *Truth*-made version is chosen as welfare maximizing as opposed to *Beauty*-made version, then *Truth* standard prevails for all available varieties. In this case mixing in some *Beauty*-made varieties would decrease the utility. The number of varieties available under *Truth* or *Beauty* is assumed to be identical regardless of the prevailing standard, allowing us to concentrate solely on the within-variety quality tradeoff and ignore choices between qualities and number of varieties consumers would have to choose from otherwise. Due to the symmetry imposed in the model, considerations given only to a representative differentiated variety are appropriate.

Assume standards – if present – are introduced and imposed by respective country governments at no cost based on consumer preferences to facilitate consumer's decision. Countries are not necessarily obligated to recognize each other standards, as it will be shown in the last section of the chapter on the case of transgenetic crops and GMOs.

4.2. Production

L available units of labor (one unit per consumer) are divided between n produced varieties of differentiated good. In the production of the differentiated good we assume a hybrid production structure providing differentiated varieties in the presence of increasing returns to scale and sunk cost[36]. Each variety of the differentiated sector requires an unrecoverable sunk cost investment, defined by Tirole (1988) as "those investment costs that produce a stream of benefits over a long horizon but can never be recouped." Consider the sunk costs being the cost of research and development, learning by doing incurred regardless whether the good finally enters the market, licensing fee, or any one-time entry fee. Sunk costs of *Truth* exceed sunk costs of *Beauty*. Consumer's love for variety in the differentiated product prevents the usual increasing returns to scale monopoly outcome, and allows for a monopolistic competition model. The sunk cost ensures that a certain (finite) number of varieties is produced, and markets are not contestable. Once firms invest in sunk costs, they have an incentive to stay in business, and do not surrender themselves to other firms or give the other firms an opportunity to grow large. The differentiated sector exhibits increasing returns to scale with decreasing marginal costs. In general,

$$Q = f(L) \tag{4.7}$$

$$\vartheta^{\psi} Q = f(\vartheta L), \psi > 1, \vartheta > 0 \tag{4.8}$$

Labor is more productive in the *Beauty*-made versions: for any *Truth* made version:

[36] Usual outcome on the in the presence of increasing returns to scale and sunk cost is a monopoly. Detailed production structure would not improve the intuition gained from the model. Sunk costs, compared to usual fixed costs, are to maintain continuous PPF and influence number of varieties.

(4.9) $$y_i^T = l_i^{\alpha^T}$$

For any Beauty made version:

(4.10) $$y_i^B = l_i^{\alpha^B}$$, where

(4.11) $$\alpha^B > \alpha^T > 1$$

In the previous L represents total supply of labor available in the economy, while l corresponds to the stock of labor used to produce any individual variety. The same production structure and standards choice apply to every differentiated variety produced in the economy, and are the same for both countries. α^T and α^B are linked to the standards themselves – higher α represents higher productivity labor can achieve in that particular standard, and are assumed to be distributed along a continuum with *Truth* (α^T) and *Beauty* (α^B) representing border cases.

The number of varieties produced (n) is an increasing function of country's labor force only:

(4.12) $$n = n\,(L)$$

In addition, assume that number of varieties in each country is determined exogenously in some previous period by the unrecoverable sunk cost interpreted as research and development expenditure. Thus, the number of varieties produced is independent from the prevailing standard[37].

When mapped into a within-variety production possibilities frontier (PPF) space, the PPF is non-symmetric (due to different productivity of labor in *Truth* and *Beauty*

[37] Simplifying assumptions regarding, for example, the research and development costs, number of varieties, etc., allow us to concentrate on the impact of harmonization and compromise in standards across countries, as well as set the stage for the last chapter. Indisputably, a detailed exposition of the model would add rigor, but not necessarily the intuition we seek.

versions of the same variety) and convex to the origin (due to decreasing marginal costs resulting from increasing returns to scale in both varieties). Economies of scale observed in the model are internal to firms, not correlated with the size of the industry, and are apparent in any quality-variety specification.

4.3. Competitive Equilibrium vs. Social Optimum

This section discusses reasons for employing a benevolent social planner as a decision maker rather than relying on competitive markets. The Pareto efficiency of a Walrasian equilibrium in competitive markets depends on preferences and technologies being monotone and convex. However, the production function described in the previous section was non-convex with increasing returns to scale, and a sunk fixed cost was observed by every entrant. In this case the competitive equilibrium is inefficient resulting in a market failure due to non-convexities present while the social optimum accounting for non-convexities and using values for social benefits and costs is Pareto optimal. In an economy with increasing returns, the first best efficiency may be impossible to attain through an equilibrium concept based on market prices (Dall'Olio and Vohra, 1999). Nevertheless, the presence of increasing returns to scale does not rule out production efficiency in the sense of producing on the PPF. Symmetry simplifies the problem to a benevolent social planner maximizing social welfare – or utility obtained from any differentiated good based on the relationship between the within-variety marginal rate of substitution between *Truth* and *Beauty* made versions and the production possibilities frontier, and avoids problems associated with average cost pricing in a decreasing

marginal cost environment. If the utility gained from any differentiated good is maximized, then the total welfare is maximized as well (assuming labor force is equal size), since producers' profits are assumed to be constrained to zero. Nevertheless, the main goal of the paper is in demonstrating the benefits of standard's adjustments using the traditional economies of scale case, rather than arguing over the Walrasian equilibrium and social optimum in the presence of the Second Welfare theorem.

4.4. Autarky Decision

In the socially optimal equilibrium, social planners in each country allocate goods and factors such that the consumers' utility is maximized; firms earn zero profits; labor and goods markets clear.[38] Recall that each economy consists of L consumers, each owning one unit of labor. Analyses are carried out on the aggregate level assuming egalitarian distribution of welfare. Each variety requires sunken set-up costs, and can be produced in either standard. Increasing returns to scale and substitutability in consumption (Equation 3.4) ensure in the optimum only one standard of each differentiable good will be produced.

The relationship between the two countries' standards in an autarky setting can be depicted on an indifference curve map (Figure 4.1). The PPF for variety i is depicted by the curve $A_T A_B$. This curve is convex to the origin due to the assumption of increasing returns to scale. The points A_T and A_B represent the maximum possible production of *Truth* and *Beauty* version, respectively. Since production of *Beauty* is cheaper (or less factor intensive), $A_B > A_T$. Each country has access to the same production technologies,

[38] Planner could equally well maximize profits subject to minimum utility constraint.

so that the PPF is identical for each. Due to symmetry imposed in the production, the same holds for all products. From 4.4 the home country consumer must consume x/λ^H units of the *Beauty* version "like" product *i* to generate the same utility as generated by *x* units of *Truth*, so that his indifference curve is a line with slope $-\lambda^H$. His utility is maximized at the corner solution A_T; i.e., where all production of variety *i* is in *Truth* standard. Similarly, the foreign consumer must consume $\lambda^F x$ units of the *Truth* version to generate the same utility as generated by *x* units of *Beauty*, with $\lambda^F > 1$. This means that the foreign country consumer's indifference curves are also linear, with slope $-\lambda^F$. Her utility is also maximized at a corner solution, but at the corner A_B, indicating that at the optimum the foreign country will produce only *Beauty* version of variety *i*.

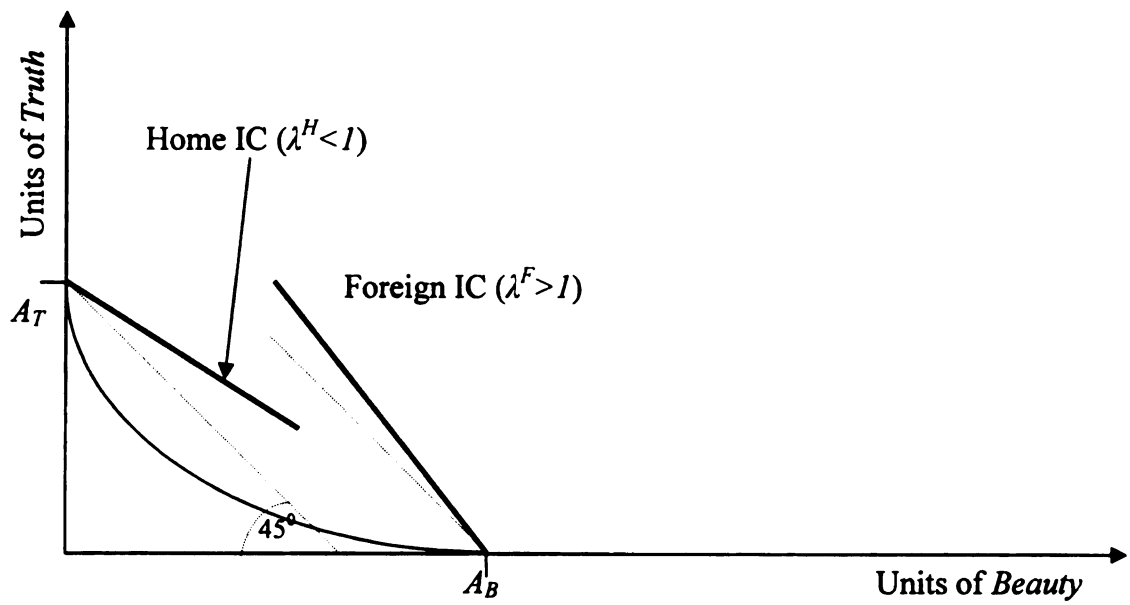


Figure 4.1: Autarky Decision in General Equilibrium

Since the two types of good *i* (i.e., food) are indistinguishable to the consumer at the time of purchase, maintaining these optima requires regulatory standards. Assume

costless enforcement of standards. The autarky equilibrium is a corner solution, in which Home produces and consumes at A_T, while Foreign consumes and produces at A_B. That is, the Home country chooses the *Truth* standard, while the Foreign country chooses the *Beauty*, and all production exactly meets the respective standard.

4.5. Open Trade

Opening trade translates into a larger pool of labor available to produce differentiated goods (and a larger number of varieties), as well as a larger product market to supply with finished goods – assuming the existence of different attributes is not sufficient to prevent trade. For now assume countries are of equal size. Labor is not mobile internationally, and disregard any problems related to conformity assessment procedures and legitimacy of different standards across countries under the WTO rules.

With love of variety bestowed on consumers, trade between countries is driven by both increased variety and economies of scale originating in increasing returns and larger amount of output at a lower price. Recall that the number of varieties produced in an economy is a function of labor available and predetermined in the earlier period by research and development expenditures: as integrated market labor supply exceeds the autarky labor supply, open trade number of varieties exceeds autarky number of varieties. Also, the amount of labor available for each variety in the integrated economy increases, resulting in a greater output and PPF shifted to the right (covered in detail in 4.5.1). We label the increase in output γ ($\gamma > 1$).

For a graphical exposition of increased number of varieties we refer to Figure 4.2. In autarky each country produces and consumes own set of varieties. There exists a subset of varieties in which countries have the potential to realize economies of scale, assuming they settle on a common standard (to be elaborated momentarily). If they reach a common ground regarding a standard, the labor savings can be used to produce varieties (at a common standard) previously not available in the autarky. Thus both countries realize the economies of scale effect of producing at the same standard, as well as potential variety effect. We focus on the economies of scale effects from harmonization to a common standard on a single representative variety from the overlapping intersection of varieties (Figure 4.2).

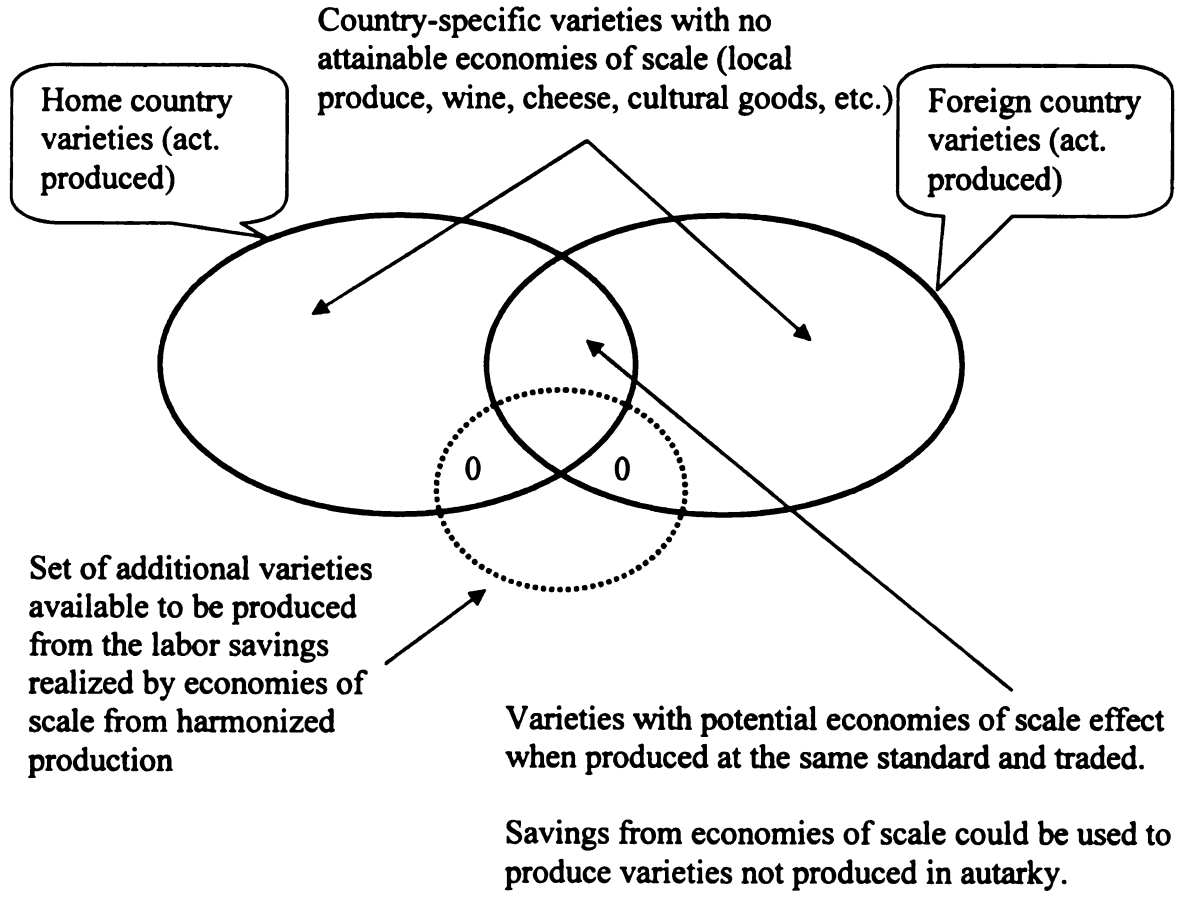


Figure 4.2: Number of Varieties

Open trade is thus a static decision whether or not to open the trade this period, and at what standard. Assume costless and instantaneous adjustment to a new standard if needed – regard it as a costless technology calibration after the sunk cost was already made.[39] By utilizing increasing returns to scale and supplying larger market, average costs of production are reduced leading to a greater efficiency. Potential equilibrium candidates, besides autarky are:

1. Unilateral harmonization;
2. Mutual compromise on standard (finding a common tolerance level); and
3. "No trade" - the standards are too far apart, economies of scale are not sufficient to justify change in standards, and there are no gains from trade to be had. Consequently countries do not engage in any trade even if it is legally and technically possible (i.e. we do not assume autarky).

4.5.1. Unilateral Harmonization

In the starting position foreign standards – from the home's point of view – are more lenient: Foreign country in autarky adopted a full acceptance policy (*Beauty*), while Home maintains a more labor intensive zero tolerance (*Truth*). *Beauty* consumers are willing to consume the *Truth* version of the good (and vice versa) if compensated somehow, and conversely with trade, production costs fall due to economies of scale. There is a possibility that the reduced production costs are sufficient to induce one of the parties to change their standard. This situation is depicted in Figure 4.3.

[39] If change of standard was not costless, the new world PPF (graphed in Figure III.2) would like to the left of the graphed PPF, as part of the available resources would be used up in the adjustment.

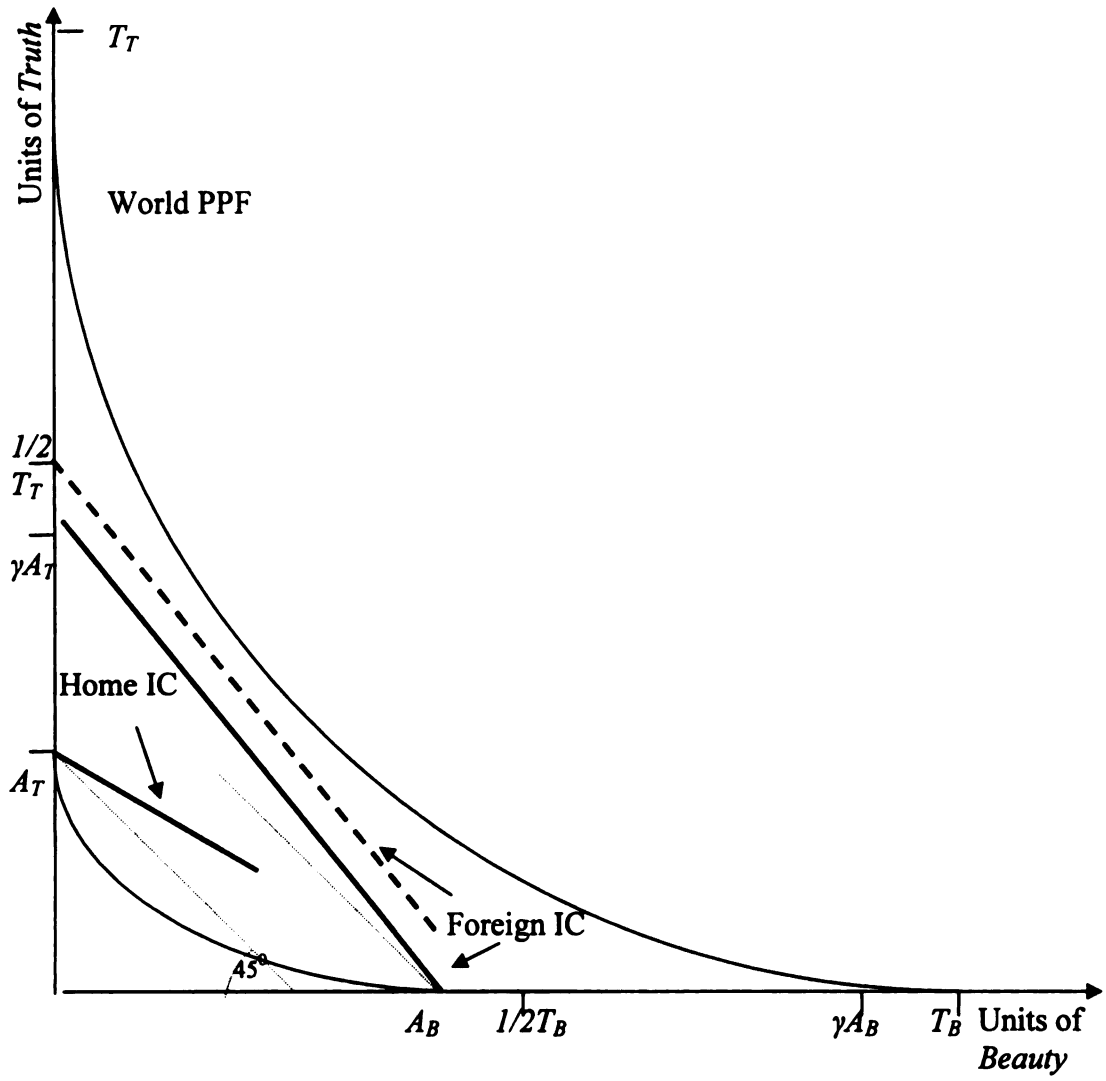


Figure 4.3: Decision to Harmonize

The PPF $A_B A_T$ and the foreign indifference curve through A_B start the foreign situation in autarky. With the opening of trade all production of a certain variety takes place in one country, the labor allocation in this variety increases; The increased labor supply results in increased production levels γA_T and γA_B. Additionally, a single firm could produce all of the world's demand for this variety and thereby capture economies of scale. Thus the trade ("world") PPF has endpoints $T_T > \gamma A_T$ and $T_B > \gamma A_B$. Moreover,

because the higher costs of meeting the *Truth* standard are captured in the (sunk) fixed cost term, the economies of scale are greater in the production of the *Truth*-made good. This means that the proportionate increase in the endpoint on the ordinate (*Truth* axis) is greater than the proportionate increase in the endpoint in the abscissa (*Beauty* axis): $T_H/A_H > T_L/A_L$.

By definition the foreign (i.e., country starting with the full acceptance standard) has half of the labor force, allowing it to be either at $1/2T_T$ (when producing on the *Truth* standard), or A_B (when it produces on the *Beauty* standard). Thus, the choice for the foreign country is between $1/2T_T$ and A_B. However, $1/2T_T$ guarantees higher obtained utility from variety *i*, and thus the foreign country decides to accept the *Truth* standard, preferring more of *Truth* quality good in trade to less of the *Beauty* quality good in autarky production. The same holds for each variety consumed, and when summed across varieties, the utility of the foreign country increases. Due to symmetry of the domestic and foreign indifference curves, the foreign indifference curve intersects the ordinate below $1/2T_T$, but the domestic indifference curve intersects the abscissa to the left of $1/2T_B$. That is, the economies of scale are sufficient to compensate the foreign country to harmonize standards at *Truth*, but insufficient to compensate the domestic country for harmonization of standards at *Beauty*. Consequently we assume that standards are harmonized at *Truth* (the case of intermediate standard is dealt with momentarily).

Thus, the *Truth* standard prevails and firms are realizing economies of scale from access to a bigger market. Consumers in both countries enjoy a larger number of varieties. Due to balanced trade, each country is trading the same number of varieties. In

the *Truth*-loving country the utility increases due to the larger number of varieties supplied at the desired level of standard.

4.5.2. Mutual Compromise

By compromising on a standard in terms of finding a common tolerance level the countries increase the possibility of mutually beneficial trade. Assume the *Truth*-loving country lowers its standard from T to T' (for example, it moves from the zero tolerance policy to ten percent tolerance level). For simplicity assume there is no change in the *Beauty*-loving country. Since the cost of producing goods of quality T' is less than the costs of producing goods of quality T, the new autarky PPF becomes $A_T'A_B$. As illustrated in Figure 4.4, with open trade the world PPF becomes $T_T'T_B$. The foreign-country indifference curve passing through A_B also rotates, as the change in quality from T to T' also changes the consumers' marginal utility of the *Truth*-quality good relative to the *Beauty*-quality good. Because the standard T' is closer to the foreign standard that is T, it takes fewer units of T'-quality goods to equal in utility one *Beauty*-quality good (in the foreign utility function); consequently the indifference curve rotates counter-clockwise.

The two effects of the compromise on the *Truth* standard are thus to expand outward the PPF on the *Truth*-standard axis, and to pull inward the indifference curve on that same axes. These two effects are reinforcing in the sense each increases the possibility and extent of gains from trade from the perspective of the foreign country.

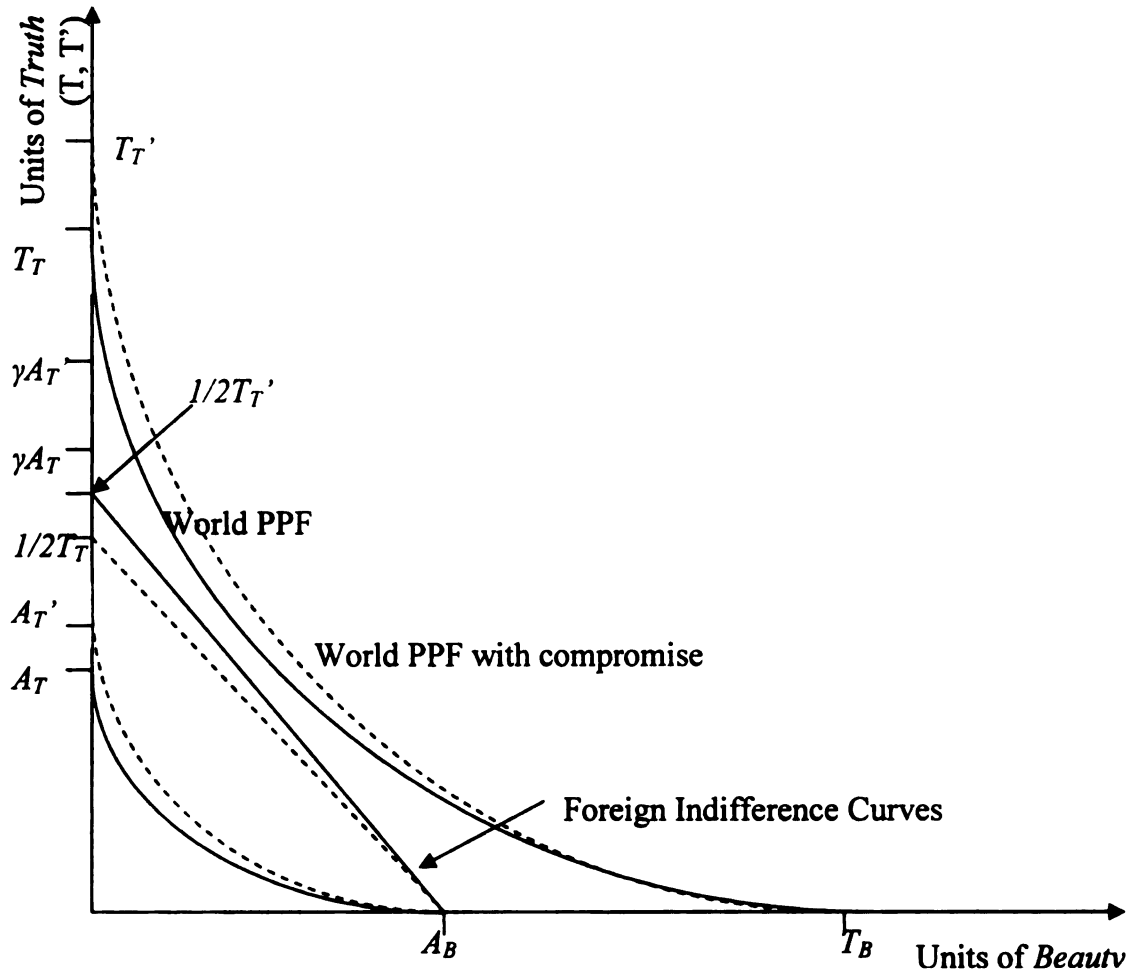


Figure 4.4: Decision to Compromise: The Foreign Perspective

The case described above represents a unilateral compromise, however, a case when the *Truth*-standard country lowers the standard by providing for greater flexibility in allowing exceptions is not uncommon[40]. In this case both *Truth*- and *Beauty*-standard countries are willing to adjust their standards. A small adjustment downwards from the upper limit of a standard would leave the *Truth*-standard country at least as well off or better off due to terms of trade effects, increased variety, and realized economies of scale. Similar adjustment holds for the *Beauty*-standard country as well, leaving both countries

[40] Consider examples of trade with countries with different labor or environmental standards.

better off. Nevertheless, even if a potential Pareto improvement is possible, the political difficulty in negotiating the access to the Pareto improving point is well known.

4.5.3. No Trade Occurring due to Large Differences in Standards

In this case standards are too far apart and there are no gains from trade to be had – that is, there is no trade even if it is legally and technically possible (i.e. we do not assume autarky). Countries endogenously choose not to purchase other goods, as there are no benefits. Similarly, if economies of scale are not sufficient to justify harmonization or compromise, no trade occurs. Graphically on Figure 4.3, this would occur when a foreign indifference curve passing through A_B on the horizontal axes would intersect the vertical axes above $1/2T_T$, leaving foreign country better off by staying isolated rather than trading and adjusting standards.

4.6. Two Countries Case with Equal Size Assumption Released

Now we allow the countries to differ in the number of workers available in the economy keeping their per capita endowments the same. The Home country consists of L^H number of workers, Foreign of L^F, where $L^H << L^F$. In this case economies of scale anticipated by differently sized partners influence the decision to harmonize. In addition, the number of varieties is an increasing function of labor available: the large country's number of varieties exceeds the number of varieties produced by the small country. For any single variety the comparison is graphed in Figure 4.5.

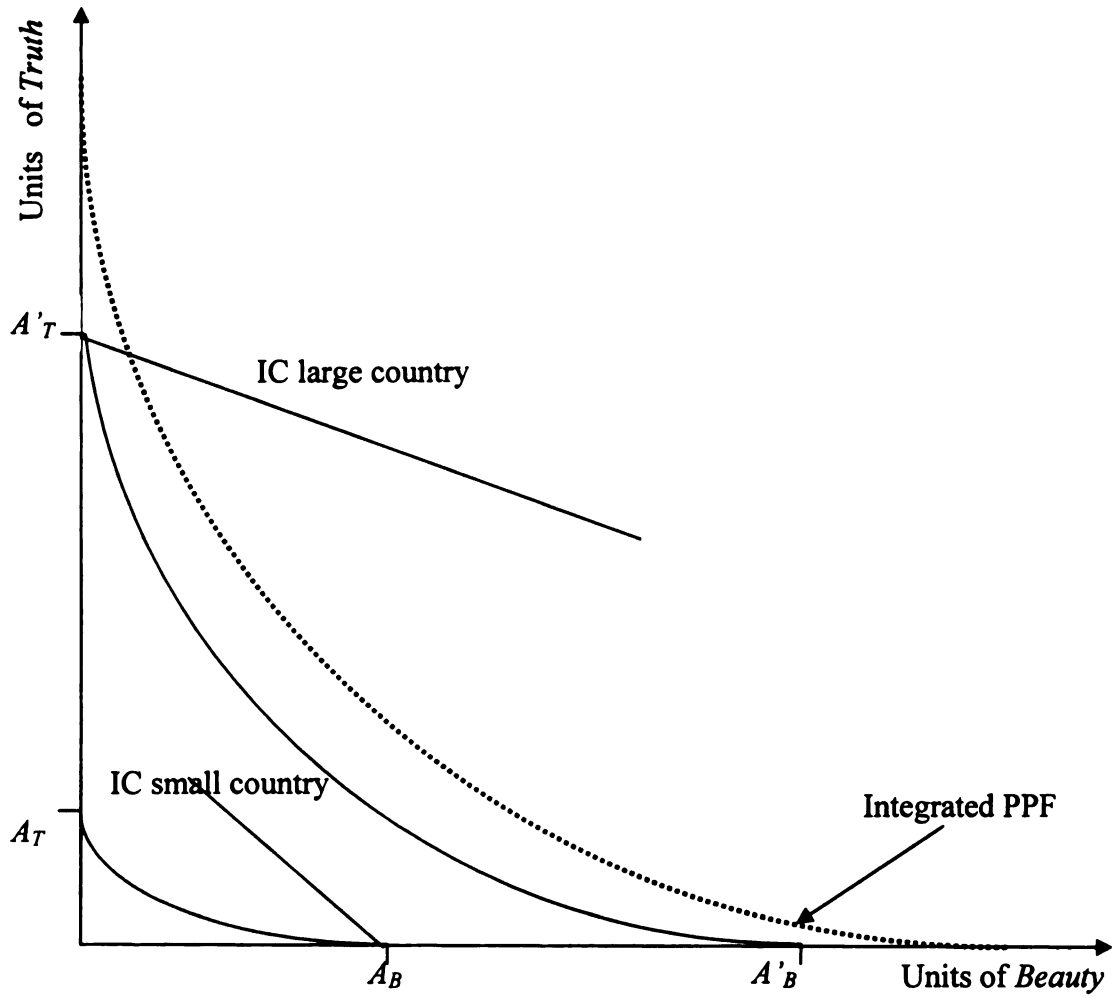


Figure 4.5: Small vs. Large Country

The small country's autarky PPF (A_TA_B) lies below the large country PPF ($A'_TA'_B$). In autarky *Beauty* prevails in the small country, while *Truth* prevails in the large country. Combined open trade PPF is represented by a dotted line. Due to the differences in size, the foreign country gains a small amount from trade with the domestic country. The integrated PPF lies only slightly to the right of the large country PPF. Thus, the potential gains for the foreign country are small, and the foreign country will be

unwilling to compromise on standards for these small gains. In contrast, access to trade with a large foreign country can yield large gains from trade for the domestic economy.

4.7. Chapter Conclusions

We have developed a theoretical model of standard formation. In autarky, national standards reflect the preferences of domestic consumers. The possibility of gains from trade encourages countries to modify their standards to facilitate trade with other countries having similar standards. If the gains from trade are sufficient, countries will compromise or harmonize of standards to achieve these gains. In the case of countries of similar size (bargaining power), compromise may be feasible. In the case of countries of different size, harmonization of the smaller country's standard to that of the larger country may be more likely.

CHAPTER 5

CONCLUSIONS AND BIOTECHNOLOGY APPLICATION[41]

The theory essays presented in the earlier chapters provide a well-suited basis for analyzing one of the most challenging issues currently troubling trade relations between the European Union and the United States: biotechnology and related trade in transgenic crops and genetically engineered (GE) foods. In the context of countries' preferences discussed in this dissertation, the EU position lies close to the *Truth* boundary, while the North American position lies close to the *Beauty* boundary.

The chapter abstracts from any legal analyses of the formal GE dispute filed in the WTO by the US in August 2003, as well as any policy consequences such as labeling requirements in the EU. Instead, it aims to apply the conclusions from the theory to a pressing problem of divergent regulatory approaches, and discuss its implications. First, this chapter presents a non-technical list of conclusions in a general form from the theory chapters[42] and a backgrounder on GE clarifying the differences between the EU and US. Next, we apply the model to the GE case, and finally discuss its implications.

5.1. Conclusions from the Theory Essays

In autarky, national standards reflected the preferences of domestic consumers regardless of the model considered. Chapter 2 utilized a model of endowed economies

[41] Earlier draft published as Tothova, M. and J.F. Oehmke (2004) "Genetically Modified Food Standards as Trade Barriers: Harmonization, Compromise, and Sub-Global Agreements", *Journal of Agricultural and Food Industrial Organization*: Vol. 2: No. 2, Art. 5 http://www.bepress.com/jafio/vol2/iss2/art5

[42] The discussion of the social planner's problem with different endowments (Appendix A2) is omitted.

forced to trade by the structure of the utility function: autarky utility was zero, showing standards have the potential to be used for strategic reasons and influence the terms of trade. Standards were modeled on a continuum of choices, allowing for a compromise. Conclusions derived include, but are not limited to:

1. A Pareto optimizing decision by the social planner choosing standards simultaneously for both countries, accounting for the externality imposed on the other country because of the difference between standards, and accounting for the difference between relative endowments between countries. When countries were of equal size and:
    a. The difference between countries' standards was small, social welfare was maximized by allowing countries to "keep" their preference standards. That is, two different standards were present in the global economy.
    b. The difference between countries' standards was large, social welfare was maximized by introduction of a single standard in the middle of the respective countries' preference standards.
2. When countries forsake the terms of trade effect and considered domestic consumers only, each country chose its choice parameter to be identical with its exogenous preference parameters regardless countries' sizes and differences in endowments.
3. When countries considered the gains in welfare introduced by terms of trade effects (technically they played a Nash game), the outcome depended on the relative endowments of the countries. Unlike in the social planner problem, the difference between standards did not play any role.

a. When the endowments across countries were identical, countries chose their standards in the same Euclidian distance from their preference parameters.
b. When the endowments across countries differed, the country with abundant endowments exercised more power in standard selection, and placed its standard closer to its preference parameter relative to the location of the country with scarce endowments.

Chapter 3 considered a monopolistic competition with increasing internal returns to scale, constant marginal costs, and love of variety bestowed on the consumers. Trade in the model was induced by love of variety – however, trade was an option to achieve higher welfare, rather than a requirement to achieve positive utility. Standards were modeled as a choice between two discrete standards, with harmonization being a unilateral decision. Model conclusions included, but were not limited to:

1. Trade without any harmonization (equivalent to consuming mix and match of varieties, but never any variety in both specifications) was never welfare decreasing, and almost always welfare increasing as compared to autarky.
2. Harmonization to a common standard had a potential to be welfare worsening – when the "harmonization effect," or the effect of a standard different from the one preferred in autarky – exceeded the increased variety effect, and a country would have vetoed the harmonization and trade.
3. When harmonization was found to be welfare improving, it necessarily brought larger benefits the country whose standard was unilaterally adopted by the other, harmonizing country. While both countries benefited from the larger number of

varieties available, the harmonizing country discounted the consumption in the standard that suboptimally matched its preferences.

4. Extending to a larger number of countries, when countries found harmonization to a common standard welfare worsening, they may have vetoed the formation of a global agreement. Instead, they clustered in two (same as number of standards considered) sub-global agreements composed of like members to avoid problems with global harmonization, although the gains from trade could have been smaller in the sub-global harmonization than in a global agreement.

Chapter 4 kept some, while released other, assumptions from Chapter 3. As in Chapter 3, trade was not a requirement, but an option. Trade was mostly driven by economies of scale achieved by producing on a common standard, and to a lesser impact by introduction of additional varieties. As in Chapter 2, standards were modeled as a continuum of choices, and compromise was allowed. Thus,

1. Harmonization (understood as one country altering its behavior) to a common standard occurred only when the economies of scale were sufficient enough to yield higher utility, including compensation for the consumption of a less preferred standard.
2. Compromise (understood as both countries altering their behavior and agreeing to a common standard different from their respective autarky standards) only occurred when the economies of scale were sufficient to justify the change, and both countries were compensated by higher utility from consuming larger amount of goods and/or more varieties at a less-preferred standard.

3. If standards were too far apart and / or economies of scale were not sufficient to justify a change in standards, gains from trade were insufficient to justify harmonizing or compromising standards.
4. Due to larger benefits, smaller country as more likely to adjust its standard to the larger country standard.
5. When harmonization or compromise were not feasible options (economies of scale not sufficient for compensation), remarks on sub-global agreements from Chapter 3 apply.

5.2. Backgrounder on Genetic Modification

Genetic modification (also "gene splicing", "recombinant DNA technology" or "genetic engineering (GE)") is defined as the manipulation of a living organism's genetic make-up by eliminating, modifying or adding copies of specific genes, often from other organisms [and from other species] through modern molecular biology techniques.[43] Biotechnology is the application of GE to living organisms to develop new products and processes.[44] Two applications of genetic engineering exist: transgenic and non-transgenic. Transgenic modification adds new material from different biological organisms, and hence, could be considered a new product characteristic under the WTO. Non-transgenic modifications simply select genetic material from the same species (Phillips and Kerr, 2000).

[43] http://www.jic.bbsrc.ac.uk/exhibitions/bio-future/glossary.htm, viewed June 20, 2004
[44] Id. For a more scientific treatise of GM and biotechnology refer to Bernauer (2003), brief overview in Runge and Jackson (2000).

Some of the often repeated terms accompanying GE crops and foods are identity preservation, segregation, and traceability. Identity preservation is a system of crop or raw material management which preserves the identity of the source or nature of materials. Segregation implies setting up and monitoring separate production and marketing channels for GE and non-GE products. Traceability measures covering feed, food and their ingredients includes the obligation for businesses to ensure that adequate procedures are in place to withdraw feed and food from the market where a risk to the health of the consumer is discovered.[45] Lacking mechanisms for identity preservation, segregation and traceability are likely to cause the entire production of a certain crop of which some is GE, to be considered "contaminated" with the GE kind.

5.2.1. Economic Importance

The first GE products were approved for commercialization in the United States in the early 1990s. According to the ISAAA (2004), in 2003 among the major biotech growers (all crops) are the United States (accounting for 63 percent of global total), Argentina (21 percent), Canada (six percent), Brazil (four percent), China (four percent), and South Africa (one percent). Small areas were planted in Australia, India, Uruguay, Romania, Spain, Germany (limited area), Bulgaria, Philippines, Indonesia, Columbia, Honduras, and Mexico (ISAAA, 2004). The most widespread crops are corn, soybeans, canola, and cotton (ISAAA, 2004). Among other crops are carnation, chicory, flax, melon, papaya, potato, rice, squash, sugar beet, sunflower, tobacco, tomato, and wheat[46].

[45] Definitions of identity preservation, segregation, and traceability are from http://europa.eu.int/comm/agriculture/publi/gmo/glossary.htm, viewed on June 20, 2004.
[46] http://www.agbios.com, accessed on June 23, 2004.

About 99 percent of the crops involved two key input traits – herbicide tolerance and insect resistance – while less than 1 percent of the crops had other input or output traits (e.g. improved nutrition) (Phillips and Kerr, 2000). In 2003, herbicide tolerance, deployed in soybean, maize, canola and cotton occupied 73% or 49.7 million hectares of the global GE 67.7 million hectares, with 12.2 million hectares (18%) planted to Bt crops. Stacked genes for herbicide tolerance and insect resistance deployed in both cotton and maize continued to grow and occupied 8% or 5.8 million hectares (James, 2003).

In 2003, the global market value of GE crops was estimated to be $4.50 to $4.75 billion, having increased from $4.0 billion in 2002 when it represented 15% of the $31 billion global crop protection market and 13% of the $30 billion global commercial seed market. The market value of the global transgenic crop market is based on the sale price of transgenic seed plus any technology fees that apply. The global value of the GE crop market is projected at $5 billion or more, for 2005 (James, 2003).

5.2.2. Reasons for Controversy and Technology Regulation

The controversy over GE food has spread from initial concerns about consumer health to include concerns over environmental risks, world food security, corporate dominance of the food supply, ethical issues, farm-level economics, and regulatory problems (Bernauer, 2003). Sheldon (2003) divides concerns concerning GE ingredients in food products into a series of *ethical* concerns over the science of biotechnology (not accepting genetic engineering as an extension of traditional breeding), concerns relating to *food safety* (i.e., introduction of new allergens by using a protein from nuts, resistance to antibiotics), and the impact of GE crops on the *environment* (pollen drift, modified

resistance of naturally occurring counterparts) (italics in the original). Attitudes towards "white" biotechnology (medical and environmental) are very positive across the globe, while attitudes toward "green" biotechnology (field crops)[47] differ (e.g. Sheldon (2003), Bernauer (2003), etc.). The public may be unaware of auxiliary substances used in processed food, like GE enzymes used in cheese and beer production.

In principle the nature of the GE is similar to the problem of processes: as of now the WTO does not recognize a production process as a product's attribute if the product made using process *A* is indistinguishable from product made using process *B*. Mandatory standards may be applied domestically that, for example, limit the use of energy in production process, but an imported product cannot be discriminated against only because the process was energy-intensive; equivalently, imported products that are physically the same as domestically produced ones are considered to be "like" domestic products irrespective of how they were produced (Sampson, 2000). In the same manner one cannot legally differentiate GE corn from its natural (wild) or conventional (traditional breeding) counterparts.

Any advanced technology –including biotechnology – characterized by a large information gap between the producers of the innovation and the intended consumers brings up new regulatory issues (Isaac and Kerr, 2003)[48], and different perceptions of "risk". Risk is defined as a scientific determination of the relationship between cause and effects in situations where adverse effects can occur (Samson, 2002). Risk assessment is defined as the evaluation of the potential for adverse effects on human or animal health

[47] Some sources categorize biotechnology into red (medical), green (agricultural), and white (industrial – i.e., making advanced enzymes, biological manufacture of plastics and fuel) (survey of biotechnology in Economist, March 27, 2003)

[48] Please see Isaac and Kerr (2003) for a discussion on technology regulation in the Risk Analyses Framework.

arising from the presence of additives, contaminants, toxins or disease-causing organisms in food, beverages or feedstuffs (Pauwelyn, 1999). Risk management is a determination of the acceptable level of risk and the selection of [SPS] measure or other necessary standards to permit risk to be managed appropriately to meet that level (e.g., Pauwelyn (1999); Samson (2002)).

The precautionary principle is based on the notion that regulation should prevent damage occurring from a particular action rather than letting it arise and then dealing with the consequences (Perdikis, 2000). It states that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent the eventual outcome of risk, covering the gap between banning a product or procedure until science has proved it is harmless and not banning it until science has proved that there is a real risk (Sampson, 2000). McNelis (2000) describes it as a cautious approach to managing potential threats to the environment, human, animal, or plant health.

Substantial equivalence is often cited as an antonym of the "precautionary principle," and as a synonym of "scientific approach." A concise definition of substantial equivalence is hard to achieve: one of the few identifies it as a concept that embodies the idea that existing organisms used as foods, or as a source of food, can be used as the basis for comparison when assessing the safety of human consumption of a food or food component that has been modified or is new (OECD, 1993 in Millstone et al, 1999).

5.3. Controversy: EU vs. US

Because the US and EU are major trading partners, unresolved regulatory issues have negative effect on mutual trade relations. For example, after the introduction of GE corn to the US, corn exports to the EU fell by 95% due to refusal of the EU to accept shipment which contained a small amount of GE corn.

The first GE product was exported by the US to EU in 1996 – tomato puree from California was voluntarily labeled as genetically engineered and, due to its price advantage compared to its conventional counterpart, it became highly popular with the consumers (i.e., Carter and Cruere, 2003). However, imports of GE soybeans to Britain later that year draw an opposition from environmental groups such as Greenpeace[49] (Carter and Cruere, 2003; Bernauer, 2003). Later, the countries adopted different approaches to GE regulations[50] (US endorses the substantial equivalence, the EU precautionary principle), resulting in the current biotech/GE puzzle of differing regulations impeding trade resting on the divergence in societal choice, science, principles and standards among countries.

Consumers' attitudes with respect to GE are often categorized with the US being pro-biotech, and the EU being against. Runge et al (2001) provides an overview of the historical and cultural factors that have contributed to divergent U.S. and European views on GMOs, and to resulting different national regulatory approaches for these products, specifically labeling policy. Sheldon (2003) offers a comprehensive discussion of the EU

[49] Greenpeace consists of Greenpeace International (a Council based in Amsterdam), and offices around the world. Greenpeace International, among others, monitors organizational development of local offices, coordinates global campaigns, monitors compliance with core policies, etc. As of 2004, "Say No to Genetic Engineering" is one it its global campaigns (http://www.greenpeace.org, accessed June 28, 2004).
[50] For a book-length review on regulation polarization please refer to Bernauer (2003).

legislation related to GMOs. The key pieces of EU legislation include two directives adopted in 1990 concerning the management of GMO research and development and the deliberate release of GMOs), the Novel Food Regulation (NFR) adopted in 1997 (establishing an approval procedure for novel foods and novel foods ingredients defined either as foods or food ingredients containing or consisting of GMOs, or foods and food ingredients produced from but not containing GMOs), and the formalized moratorium on GMO approval in form of an amendment to a directive from in 1999 (lifted in April 2004). The last directive also updated the labeling rules: all food containing ingredients that have been derived from GE crops has to be labeled, irrespective of whether the relevant rDNA or proteins are still detectable, although accidental traces up to 0.9 percent of authorized GE material is exempt from labeling (Sheldon, 2003). The main tensions are caused by the (former) moratorium and the labeling requirement. The EU regulatory approach focuses on "process" as well as "product" in an effort to handle consumer concerns and demands for certainty of the safety of the new biotechnologically modified products. Risk-averse regulators have tended to pursue certainty, with the result that product approval has generally been withheld until all risks have been eliminated (Buckingham and Phillips, 2001).

In the US, biotechnology is regulated through three existing agencies: USDA's Animal and Plant Health Inspection Service (APHIS) – regulating permits for or providing notification of the introduction of a GMO into the US, the Environmental Protection Agency (EPA) – responsible for regulating plants that are GM to express pesticides, and finally the US Food and Drug Administration (FDA) – dealing with the pre-market approval of GMOs and foods containing GM ingredients, and also providing

guidelines on the labeling of GM foods (Sheldon, 2003). The US, unlike the EU, advocates the policy of substantial equivalence, recognizing genetic engineering as an extension of traditional breeding, and requiring labeling of GE if and only if the GE product is substantially different from its conventional counterpart (i.e., presence of allergens, advanced nutrition, etc.). In all other cases, a GE product is considered as safe as its conventional counterpart. The regulatory approach taken by the US is consistent with recommendations for assuring the safety of GMOs made by the OECD and Codex (Sheldon, 2003). The North American model used by Canada and the United States focuses on products rather than processes and allows for the use of existing agencies and risk assessment methodologies (Buckingham and Phillips, 2001).

The case can be made that the EU standards – resulting from its regulatory approach – act as a barrier to trade, but a barrier that in a relatively unchanged form will withstand challenges made *via* the WTO. The barrier does not arise because of border measures but because of differences in domestic regulatory approaches (Isaac and Kerr, 2003). The conflict of underlying principles behind polarization of regulatory frameworks has fundamental consequences for the WTO, multilateral environmental agreements (MEAs), and the relationship between trade and environment.

5.4. Model Application

For practical purposes this chapter assumes the EU and US are equally endowed countries. While causality is open to discussion, we argue that different regulatory approaches in fact reveal country's preferences for transgenetic crops and GE foods. In

the context of the models, we arbitrarily select that the EU, applying precautionary principle, reveals preference for *Truth* (zero tolerance), the US, endorsing substantial equivalence, discloses preference for *Beauty* (full acceptance). In autarky, the EU and US standards reflected the preferences of domestic consumers.

Chapter 2 worked with a model where trade was a necessity: countries' utility was zero unless trade took place. The social planner's decision was dependent on the distance between the standards. Since it is impossible to quantify the difference between the "precautionary principle" and "substantial equivalence," we consider both cases. If indeed the difference between the EU and US was "small," it is socially optimal to let the countries trade at their respective preference parameters: the EU applying precautionary principle, the US applying substantial equivalence. However, as the EU is not willing to accept GE products, it is more probable that the difference between the "precautionary principle" and "substantial equivalence" is large. In that case the social planner would "split the difference." Anecdotal evidence on the EU imports of soybeans seemingly supports the argument: as most of the soybeans produced in the US are GE, the EU imports soybeans from Brazil. Brazil law does not allow production of GE; another anecdote claims cross-trade in GM between Brazil and Argentina, and lack of intellectual property protection. The EU might not have the necessary regulation to get "half way," however; imports from Brazil could practically be positioned in the middle of the interval to account for the terms of trade externality. Returning to the EU – US case, if the EU and US forsake the terms of trade effect and considered domestic consumers only, each country would choose its choice parameter to be identical with its exogenous preference parameters (zero tolerance and full acceptance). Conclusions of Chapter 2 demonstrated

that under certain circumstances the social welfare maximizing outcome is emergence of two different standards: which, translated into the GE case, implies the social welfare is maximized by applying the precautionary principle in the EU, and substantial equivalence in the US.

Chapter 3 showed that non-harmonized trade between the US and EU (and, consequently, around the world) would be always welfare improving - assuming absence of any trade restricting policies. The EU and US policies regarding GE impose a certain standard (or perhaps lack of it in the US), and thus have a potential to be welfare worsening. The EU valuation of the GE products is very low, positioning it to the very left (possibly zero) on Figure 3.4. The US valuation is very high, positioning it to the very left. Any gains in the number of varieties if harmonization took place would be offset by the consumption on a different standard. Both countries would likely veto harmonization and trade. Adding other trading partners to the picture (to be discussed momentarily on the evidence from developing countries) results in formation of sub-global agreements, each using a different regulatory approach.

Chapter 4 explored harmonization and compromise in the traditional economies of scale argument. It is arguable whether there are economies of scale in agriculture, and it was already stated the differences in standards between the EU and US are high. Thus, the economies of scale are not sufficient to justify harmonization or compromise of standards. Consequently, earlier remarks on the emergence of sub-global agreements apply. Conclusions from Chapter 3 and 4 on formations of sub-global agreements in case harmonization of standards is required are confirmed in the GE case.

5.5. Anecdotal Evidence from Third Countries: Small vs. Large

The transatlantic GE "conflict" does not remain confined to only two countries. Rather, third countries wishing to conduct business with either of the leaders (EU and US) ought to observe their protocols, and are often caught in between, potentially with insufficient resources to conduct scientific assessments, and possibly with safety of GE not given priority on their agenda. In these cases the decision is often based on trying to secure potential markets for their agricultural exports. The dominant strategy might be to not adopt GE varieties (albeit their adoption might produce higher and less labor intensive yields) and thus potentially have access to both types of markets.

The transatlantic regulation polarization influencing the rest of the world can be seen on the example of China. China appears to be primarily concerned with producing food and fiber for internal needs. It leads the world in public biotech crop research (Huang et al, 2002 in Carter and Gruere, 2003), it is conducting transgenic research on over 130 species, and in 2002 transgenic crop area exceeded 2 million hectares (Gao, 2003). GE cotton accounts for about 30% of China's cotton acreage. In the field trial stage are GE rice, wheat, soybeans, potatoes, cabbage, and tobacco. While China has yet to announce a firm position on GE labeling, it has recently proposed restrictions on GE crop imports. Outside China, this is viewed as a trade barrier that limits soybean imports from the United States. Despite its labeling requirements, it has recently approved five transgenic US varieties (one corn, two soybean and two cotton) for import (ISAAA, 2004). China's position towards biotechnology in agriculture appears to be heavily influenced by EU policy (Carter and Gruere, 2003); while at the same time it has widely adopted GE research and crop production. India appears to be following suit in adopting

biotechnology production, albeit at a slower pace. These are populous countries and even though they may be low-cost producers on a per unit basis, the large populations mean that these countries face high costs of feeding their populations. At a national level the aggregate cost reductions from GM production may be very significant (Tothova and Oehmke, 2004).

In contrast, some African countries have apparently given higher priority to potential export markets than to existing domestic food needs. Malawi, Zambia and Zimbabwe all faced severe food shortages due to drought in 2002. The U.S. offered food aid to these countries, much of which was in the form of GE corn. Even though each of these countries has been a net importer of corn/maize over the past several years, they all balked at receiving GE food aid. Eventually Malawi and Zimbabwe accepted the GE corn if it was previously milled or milled immediately upon entry to the country (to prevent gene escape with possible damage to trade); Zambia never did accept the aid.

Namibia has an EU import quota that allows it to export 13,000 tons of beef to the EU (Republic of Namibia). In order to feed the cattle, Namibia was set to import maize from South Africa. However, South Africa allows the use of GE maize, which is widely adopted by farmers. Because Namibia (nor South Africa) could guarantee that the imported maize would have been GE free, the EU said it would refuse to accept Namibian beef that had been fed South African maize. Namibia found alternative sources for GE-free cattle feed (Fox, 2003).

Egypt actively developed a GE local (brown) potato variety (Spunta) with locally valuable pest resistance characteristics (tuber moth resistance). Egypt sought US collaboration in the genetic modification, and established regulatory infrastructure,

intellectual property protection and biosafety protocols (Madkour et al, 2000). However, fear of gene escape to export (white) potato varieties and consequent loss of European export markets was sufficient to quash commercialization of the GE variety.

Interestingly, some countries have *de facto* accepted GE agriculture even though they don't quite have the necessary infrastructure in place. For example, Argentina has the second largest area planted to GE crops, even though there is anecdotal evidence that local companies are selling herbicide tolerant varieties without appropriate royalty payments (increasing herbicide sales could explain some of the patent owner insouciance toward this situation) (i.e., Qaim and de Janvry, 2003). In Brazil, there is increasing evidence that herbicide tolerant soybeans are being adopted, despite an official stance disallowing GE crops.[51]

5.6. Deeper Conflict: Countries vs. Multilateral Agreements

The three sets of multilateral treaties most relevant (to standards) for GMOs and foodstuffs are the Cartagena Protocol on Biosafety (CPB), in principle an environmental treaty; the Trade-Related Aspects of International Property Rights (TRIPS), negotiated as part of the Uruguay round of the General Agreement on Tariffs and Trade (GATT); and the Codex Alimentarius Commission (Codex) allied directly with the Agreement on the

[51] "Illegal GMO soybeans give Brazil 'unfair advantage'", Delta Farm Press, Sept. 19, 2003. Available at http://www.findarticles.com/p/articles/mi_m0HEE/is_37_60/ai_108087663, last viewed on June 23, 2004.

Application of Sanitary and Phytosanitary Measures (SPS) and in some way indirectly with the Agreement on Technical Barriers to Trade (TBT)[52].

The CPB ensures that the transfer, handling, and use of *living* modified organisms[53] (LMO) (italics added) does not have an adverse effect on biological diversity and impose risk on human health (Sheldon, 2003). Its key element is the Advanced Informed Procedure, i.e., a prior notification and consent procedure for the export and import of LMOs (Eggers and Mackenzie, 2000). The CPB does not establish any standards or labeling requirements regarding processed GE foods (pharmaceuticals are excluded completely). It establishes some minimum rules regulating the exportation of transgenetic seeds for field trials or commercial cultivation. The regulation of GE foods and feedstuffs, which make up 90 percent of international trade in GE products, is largely left to the parties. Similarly, detailed identification requirements only apply to LMOs that are to be introduced into the environment, while shipments of LMOs intended for feed or food or processing have to be labeled as "may contain LMOs."[54] The CPB does not directly address the contentious issue of domestic labeling, and it does not determine how to deal with the scientific uncertainties arising from GMOs or give any clear directives when a Party should prohibit or restrict the import of a particular LMO (Eggers and Mackenzie, 2000). The EU and the US disagree on the precautionary principle that is endorsed by the CPB (the U.S. is not a signatory to CPB) (Kerr, 1999; Caswell, 2000; Eggers and Mackenzie, 2000; Phillips and Kerr, 2000, Maredia et al., 2001).

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[52] Also applicable is the work of the International Office of Epizootics for animal and International Plant Protection Convention for plant health (Buckingham and Phillips, 2001). Standard developed by these organizations are not binding and serve as reference points.

[53] The definition of LMOs was part of the negotiation: the Miami Group (comprising the US, Canada, Australia, Argentina, Chile and Uruguay) argued that lengthy approval procedures are not justified for commodities which are not intended to be released into the environment, and hence would not impact the conservation and sustainable use of biological diversity (Eggers and Mackenzie, 2000).

[54] Full text of the CPB is available at http://www.biodiv.org/biosafety/protocol.asp, accessed June 23, 2004.

North America and the EU are basically in accord on intellectual property rights, and the TRIPS agreement is not a major source of friction between the two (Tothova and Oehmke, 2003).

The Codex Alimentarius was created in 1963 by the Food and Agriculture Organization and the World Health Organization to protect health of the consumers, ensure fair trade practices in the food trade, and promote coordination of all food standards work undertaken by international governmental and non-governmental organization (Codex Alimentarius, 2003). Although the Codex was not originally given direct powers to set binding standards, it is explicitly recognized under the WTO SPS Agreement as setting food safety standards, guidelines and recommendations. Codex is currently developing principles for the human health risk analysis of GM foods with non-binding effects on national legislations. Codex standards for GM foods presumably will not be forthcoming until after the risk assessments are completed.

The SPS and TBT Agreements were discussed in Chapter 1. The SPS Agreement itself dictates that measures to be taken to ensure food safety and animal and plant health should be based in the analysis and assessment of objective and accurate scientific data (Sampson, 2000), but it also explicitly recognizes members' sovereign right to adopt higher standards that may restrict international trade, assuming the country provides scientific justification of such a measure (WTO, 2004).

Different regulatory policies, presented as consequences of underlying regulatory approaches applied in the US and EU – and at the same time, foundations of a trade conflict – are indicative of multilateral international treaties: Codex, for example,

endorses the scientific evidence approach, while CPB gives its backing to the precautionary principle.

The WTO has the ability to address issues raised under the umbrella of GATT Article I (non-discrimination), III (national treatment), and XX (country's right to address policies protecting human, animal and plant health), as well as SPS and TBT agreements relying on the concept of *like goods*, and it provides a natural outlet to channel trade related disputes (Isaac and Kerr, 2003). In the GE dispute the WTO is challenged to determine an issue of domestic regulatory competence, namely which regulatory approach – scientific rationality and substantial equivalence or social rationality and the precautionary principle – is consistent with trade rules and when these regulations are appropriate from a trade perspective (Isaac and Kerr, 2003).

The WTO does not appear to be properly equipped to entertain disputes interrogating the precautionary principle, and thus indirectly questioning the legitimacy of the CPB (i.e., Isaac and Kerr, 2003). Whether or not the EU "embargo" is in fact a trade barrier depends on what paradigm – substantial equivalence or the precautionary principle – would be adopted by the panel. If the US position of substantial equivalence was adopted, then the EU position would imply a discriminatory, less favorable treatment, and thus would be considered a trade barrier. However, the panel is not in the position to condemn domestic regulatory policies, especially when in compliance with the CPB. Nevertheless, the presence of the CPB brings up yet another issue. The CPB is in fact an environmental treaty, existing independently of the WTO and its signatories.[55] As a matter of fact, the US has not became a signatory to the Protocol – leaving it in a

[55] Detailed discussion on the relationship between the Cartagena Protocol and WTO is in Eggers and Mackenzie (2000).

position to be completely aside, and not bonded by its clauses, and putting potential WTO panel wishing to consider the Protocol in a unwelcoming position of reconciling (subglobal) CPB (or other environmental agreements) with a (global) GATT, SPS and TBT Agreements (e.g. Sheldon, 2003; Eggers and Mackenzie, 2000)

The CPB may be reasonably well designed to deal with issues related to trade in GMOs that will enter agronomic or aquaculture production, but it seems poorly designed for regulating trade in GE products (Phillips and Kerr, 2000). As such, the CPB, lacking clear linkages with the WTO, is not an amicable settlement between the US and EC on their trade conflicts regarding the GMOs (Eggers and Mackenzie, 2000). The position of the WTO, eager to maintain the divide between domestic and trade policies though the rigid application of four principles (focus on products and not PPMs, national treatment, most favored nation, and common exemption of environmental and natural resource issues under GATT 1994), is likely to be challenged by agricultural biotechnology centered around PPMs (Phillips and Kerr, 2000). The CPB, although aimed to coexist with the WTO, re-opened the doors to the trade and environment discussions by allowing considering process rather than final product characteristics. Isaac and Kerr (2003) claim the CPB is the only one stirring such an attention from a large pool of multilateral environmental agreements and challenging the WTO, mostly because other agreements (such as Basel Convention, Montreal Protocol, etc), are (1) very specific, pertaining only to the transboundary movement of very select products and not to broad arrays of products with quite disparate end uses such as GMO, and (2) in agreement across Atlantic, meaning they are represented by similar regulatory approaches, and there are no

significant differences in the systemic principles and frameworks that provide the foundation for regulation.

5.7. Implications for the World Trading System

Bernauer (2003) concludes that prevailing public and private sector policies in the US and EU do not add up to an effective strategy for mitigating or overcoming regulatory polarization.[56] Since trade policies originate in domestic regulatory frameworks, without the harmonization of the domestic regulatory frameworks the harmonization of the trade policies is unlikely.[57]

If the EU wins the GM dispute and that the panel endorses the EU regulatory approach by making a decision against the science-based, rules-based trading principles at the heart of the WTO, and legitimizes the use of discretionary, protectionist measures (Isaac and Kerr, 2003). In this case the WTO essentially endorses different domestic regulatory frameworks and trade will not occur. On the other hand, if North America wins, a WTO decision will be portrayed as both a positive decision for biotechnology and a negative decision against human, animal and environmental health and safety regulations in the EU as well as a decision against the CPB and the protection of biodiversity (Isaac and Kerr, 2003). The criticism of environmentalists that trade liberalization is only achieved at the expense of environment is inevitable.

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[56] Isaac and Kerr (2003) use term "transatlantic regulatory regionalism".

[57] Not to blame the US and EU for not being willing to cooperate: according to Buckingham and Phillips (2001) agreed to the Trans-Atlantic Economic Partnership, established under the New Trans-Atlantic Agenda in 1995 to "tackle regulatory barriers and to improve regulatory and scientific cooperation in the fields of consumer and plant health, biotechnology, and environment'. Similar partnership is in place between the EU and Canada. Also in May 2000 the US and Europe announced they would create a bilateral high-level discussion group, which would look at the risks and benefits of GM crops and foods (Buckingham and Phillips, 2001). The GM issue also regularly shows up in the G-8 meetings.

As a result of a current lack of consensus between the EU and US as world leaders, a global consent on the GM issue (allowing for non-harmonized trade via mutual recognition, or endorsing a common approach) is likely to be a matter for the distant future. At the moment the polarization in regulatory approaches applied by the trade leaders is being transposed into the polarization of the trading partners in accordance to the regulatory principle they choose – and their implementation.

Consequent to the polarization of regulatory approaches would be a split of the trading partners into two parallel "alliances" – the "*precautionary principle* alliance," and the "*substantial equivalence* alliance". The former is likely to be slow to approve new GM varieties (especially green biotechnology), and would tend to require mandatory labeling regardless of whether the product in question would be regarded as safe. The latter alliance, in contrast, would be more liberal in approving GM varieties and would require (mandatory) labeling if and only if the products would be different from their conventional counterparts nutritionally or otherwise. The alliances – smaller, more homogeneous groupings of countries – would be facilitated by their respective leaders: the EU in the "*GM-free/precautionary principle* alliance" and the US in the "*GM/substantial equivalence* alliance." The CPB allows parties to proceed according to their own domestic regulatory framework, adopt simplified procedures, or enter into bilateral or regional agreements as long as these are consistent with the objective of the Protocol (Eggers and Mackenzie, 2000).

This notion is consistent with the findings of the theory essays, and the evidence on increasing numbers of small trade agreements of all types (not necessarily related to biotechnology), and fully supported by social choice and club theory (i.e., Buchanan,

1965; Olson and Zeckhauser, 1966; Olson, 1968; Cornes and Sandler, 1996). "Alliances" or "clubs" are formed by a relatively homogeneous set of countries where homogeneity can be defined in terms of similar consumers' attitudes, industry structure, interest groups, income, tolerance levels, similar perceptions of risk, etc. Groupings of countries with similar regulatory approaches in the biotech case become *de facto* clubs in a Buchanan sense, where standardized goods (or non-standardized goods, depending whether precautionary principle or scientific equivalence was adopted) have the characteristics of club goods, and non-members are excluded from consuming the benefits – that is, unrestrained trade is conducted among members of the club. Rege (2002) claims that harmonization of policy goals is more feasible on a "regional" basis (quotation marks added), particularly in the case of economic groupings that have made considerable progress in economic integration, than on a multilateral basis particularly. A club, for example, can develop common standards,[58] agree on certain procedures identifying previously negotiated requirements, or require traders to label their product (if applicable). Such steps could be perceived as a tax or a technical barrier to trade by non-members.

Unavoidably, the polarized "club" outcome is accompanied by a number of dilemmas. Although the argument of securing welfare maximizing gains from trade is a valid one, it comes at the expense of a separating equilibrium – and lower welfare than non-harmonized trade. The choice of a club is also determined by the positive externalities for smaller countries of belonging to a certain club, such as economic

[58] For example, Australia and New Zealand cooperate in developing GM standards, as are the Canadian Food Inspection Agency and the USDA Animal and Plan Health Inspection Service "which seeks to study, compare and harmonize where possible the molecular genetic characterization components of the regulatory review process for transgenetic plants" (Buckingham and Phillips, 2001).

networks, political allies, etc. For a small country that has less to offer a large country (or club) in terms of gains from trade, there is a greater incentive to harmonize its domestic standards with the large-country standards, even if these standards are not what the country would have chosen without the trade considerations (e.g., the Zambia food aid case). In addition, the separation might reflect neither consumer preferences in respective countries nor the chosen regulatory approach to transgenic crops and GM foods. Rather, it might be representative of trade and the "political" affiliation of countries. This hypothesis remains to be empirically tested – assuming a data set allowing such analysis would be available. As of now, *GE* and *GE-free* transgenic crops are treated as like products, and their major producers (US, Argentina, Brazil) do not have separate distributions channels to market their crops (with the exception of the organic channel and a few contract farming situations). Therefore, unless proven *GE-free*, all products are considered to be *GE*.

Isaac and Kerr (2003) see similar fragmentation of international markets as an obstacle in recouping research and development costs sunk into product development – countries would be forced to choose between a North American/WTO-style approach or an EU/CPB-style approach to regulating GMOs, depending upon which side of the Atlantic is deemed the more important market. Countries wishing to export their own products to the EU will welcome neither GMO products nor GMO technologies, and thus reducing the scale benefits arising from international market access.

The legal status of sub-global alliances is also questionable. The "clubs" might not be institutionalized and the WTO notified in the spirit of the GATT, and in principle function as a *de jure* agreement. As almost all countries belong to the WTO, disputes

similar to the current GM dispute are likely to arise again since the underlying regulatory preferences will *de facto* be perceived as a trade barrier – as it is now. "Clubs" might also choose to notify the WTO and function as formal trade agreements[59]. However, in that case, the WTO places three relevant restrictions on trade agreements: the agreements should not help nations in the agreement to the disadvantage of those not in the agreement; domestic products and imports should be treated alike; and standards may be set only on products, not on the production processes (WTO, 2004). In addition, with a web of overlapping trade agreements already in existence, the effect of formalized trade agreements based on a common regulatory approach remains to be seen. Alliance of the countries based on their regulatory preferences is likely to reopen the issue of trade and environment, resulting in sub-global environmental clubs.

Still, some countries might not fit the profile (precautionary principle, labeling vs. substantial equivalence, no labeling) suggested here. For example, Australia and New Zealand each employ the substantial equivalence approach, while requiring mandatory labeling justified by consumers' right to know in order to make an informed decision. It is likely the "hybrid" countries would find it easier to penetrate into the "precautionary principle club" market, since having a mandatory labeling experience would be considered an advantage.

[59] Chapter 1 demonstrated how countries are allowed to formed sub-global agreements in the WTO framework.

5.8. Chapter Conclusions

While both the EU and US would benefit from harmonization or a compromise on standards in the biotechnology arena, the latter case study shows that a position uniting the EU and US is unlikely due to the systemic principles underlying the regulation of GMOs. In addition, the EU's socially rational approach is consistent with the CPB and its focus on PPMs, the scientifically rational North American regulatory approach is consistent with the WTO and its focus on end-use products (Isaac and Kerr, 2003) – with the US arguing that the EU's precautionary principle acts as a barrier to trade.

Consequent to the polarization of regulatory approaches we notice polarization to trade partners. Currently, two "trading" blocs are forming. The first consists of those countries with restrictive standards regarding the commercialization and sale of GE crops and foods. This group consists largely of the EU and their smaller trading partners, although Japan and some other countries have similar standards. The second group consists of those countries that have found GE crops to be essentially the same as or "substantially equivalent" in US regulatory language – their non-GE counterparts. Each of these trade blocs can make legitimate arguments that their stance is in the best interest of their citizens.

The losers in this bifurcation of countries appear to be the developing countries, most of whom are agriculturally based. These countries face a tension between lower production costs by adopting GE crops and the maintenance of export markets in conventionally grown varieties. In some food-insecure cases, the tension is severe enough to force a tradeoff between export markets and food availability. While the US, EU, and other affluent countries were framing their regulatory policies based on domestic

situation and preferences, some of the smaller agricultural export-oriented countries, might find themselves choosing biotech regulatory frameworks to fit their trading partners.[60]

Based on Isaac and Kerr (2003), the transatlantic GE crisis sends out at least two signals (if North America win the current dispute). First, the EU as a pillar of international trading regime is willing to ignore its WTO obligations. Second, when a member does not agree with a WTO ruling, they can simply revert to a regional (in the language of this chapter, sub-global) approach among like-minded countries aimed at protecting them from the reach of the WTO. Regionalism could emerge as a protectionist stumbling block to multilateralism rather than a constructive stepping-stone.

GE regulations and disputes in fact open the door to other issues, such as labor, environmental, animal welfare regulations and standards on the WTO level, potentially questioning national sovereignty granted in Article XX of the GATT. Indeed, Runge and Jackson (2000) see GMOs as an issue resonating well beyond agriculture, helping to mobilize and align consumer, environmental and health advocates in opposition to further trade liberalization. With GMOs indirectly challenging the CBP, rather than encouraging the coordination and cooperation between trade agreements and MEAs, it would justify MEAs as a countervailing force to the environmentally insensitive WTO (Isaac and Kerr, 2003).

Some blending of regulatory principles is inevitable too: while the US claims to operate on the "sound science" based substantial equivalence principle, it too is

[60] At the meeting in February 2004, developing countries insisted on tighter rules for trade in bioengineered crops, prompting dismay in the US and other exporting nations... http://www.foodtraceabilityreport.com/ejournals/articles/demo_article.asp?id=80592, accessed June 24, 2004

beginning to incorporate traits usually associated with precautionary principle such as traceability and identity preservation, especially in the view of the Starlink episode[61] and as a means of retaining export markets.

Biotechnology has evolved as a complex matrix uniting issues that touch on scientific, political, social, ethical and economic concerns, processes regulation, food safety, environment, human, animal, and plant health, and issues of industry regulation. It is highly unlikely that any international institution has the scope, the resilience, the political support, or the expertise to provide and support a comprehensive framework for the regulation of biotechnology (Buckingham and Phillips, 2001).

If in the absence of other institutions – and in the view that most of the disputes are trade related (market access, SPS measures, technical barriers to trade, etc.) – the WTO may be the best suited multilateral body, it might be necessary to re-evaluate its underlying concepts: end product vs. production method, like products etc. Does a gene inserted for agronomic reasons change the product, although the consumer experiences the product as the same? Heumueller and Josling (cited in Sheldon, 2003) suggest that if the relevant benchmark for deciding a "like good" is the chemical composition of a product, this would likely undermine domestic regulations on GM foods. To account for an appended understanding of like goods differentiated (for example) on the basis of production processes, tariff classifications would have to be substantially appended.

Thus, for the GE foodstuffs case, the EU and US positions suggest potential gains from trade are not sufficient to justify harmonization, and their respective trading partners cluster into "clubs" based on similar preferences and actual or perceived gains from trade.

[61] Starlink is a US corn hybrid approved as a feed. However, in year 2000, Starlink was detected in manufactured foods.

APPENDICES

Appendix A: Standards as Strategic Policy Instruments

All numeric examples and solutions were generated with Mathematica's FindRoot function using different values for countries' preference parameters and endowments. Starting points for numeric evaluations of different endowments and number of iterations might have differ to achieve the prescribed accuracy of the Newton's method. Numbers might be rounded due to computer precision.

A.1. Social Planner Problem with Identical Endowments

Table A.1: Social Planner: Numeric Solutions, Stationary Points, Identical Endowments.

Foreign Preference (F)	Home Preference (H)	Foreign Endwmnt (Y)	Home Endwmnt (X)	Foreign Choice (f)	Home Choice (h)	Soc (f)	Soc (h)
0.5	1.5	2	2	1	1	+	+
				287.732	287.732	-	-
0.5	1.5	4	4	1	1	+	+
				287.732	287.732	-	-
1	3	2	2	2	2	+	+
				247.603	247.603	-	-
1	3	6	6	2	2	+	+
				329.742	329.742	-	-
1	5	2	2	3	3	+	+
				226.159	226.159	-	-
1	5	10	10	3	3	+	+
1	7	10	10	4	4	-	-
				2.3984	2.3984	+	+
				5.6016	5.6016	+	+
1	9	2	2	5	5	-	-
				1.7867	1.7867	+	+
				8.2133	8.2133	+	+
1	9	10	10	5	5	-	-
				1.7867	1.7867	+	+
				8.2133	8.2133	+	+

Note: F, H, X and Y are exogenous.

More than one stationary point possible, each stationary point is evaluated separately.

Analytically:

Home: the second derivative of the social welfare function with respect to Home choice parameter (h) evaluated at the critical point ($h^* = (F+H)/2$) reduces to:

$$\left.\frac{\partial^2 W}{\partial h^2}\right|_{h=h^*} = \frac{-64Y\left[(\ln 8-2)(F-H)^2-\ln 16\right]}{\left(4+(F-H)^2\right)^3} \quad \text{(A.1)}$$

For a critical point to be a local maximum, the second order condition evaluated at the critical point is negative. For the Equation A.1 to satisfy the second order condition to maximization, it has to be true that

$$(\ln 8-2)(F-H)^2-\ln 16 \geq 0 \quad \text{(A.2)}$$

The equation A.2 holds if:

$$(F-H) \geq \sqrt{\frac{\ln 16}{(\ln 8-2)}} \quad \text{(A.3)}$$

The social planer's decision to split the difference between standards when endowments across countries are the same is welfare maximizing only in case of the Euclidian distance between Home and Foreign preference parameters (F and H) being "large": in numeric terms the right hand side of the Equation A.3 is *5.9*. When difference between F and H is smaller than the critical value, the point in the middle of the interval is welfare minimizing. Thus, the social planner chooses countries' preference parameters as prevailing standards. Same line of reasoning applies for the Foreign country. Graphing social welfare in a three-dimensional space as a function of Home and Foreign choice parameters (h and f) yields Figures A.1 and 2.

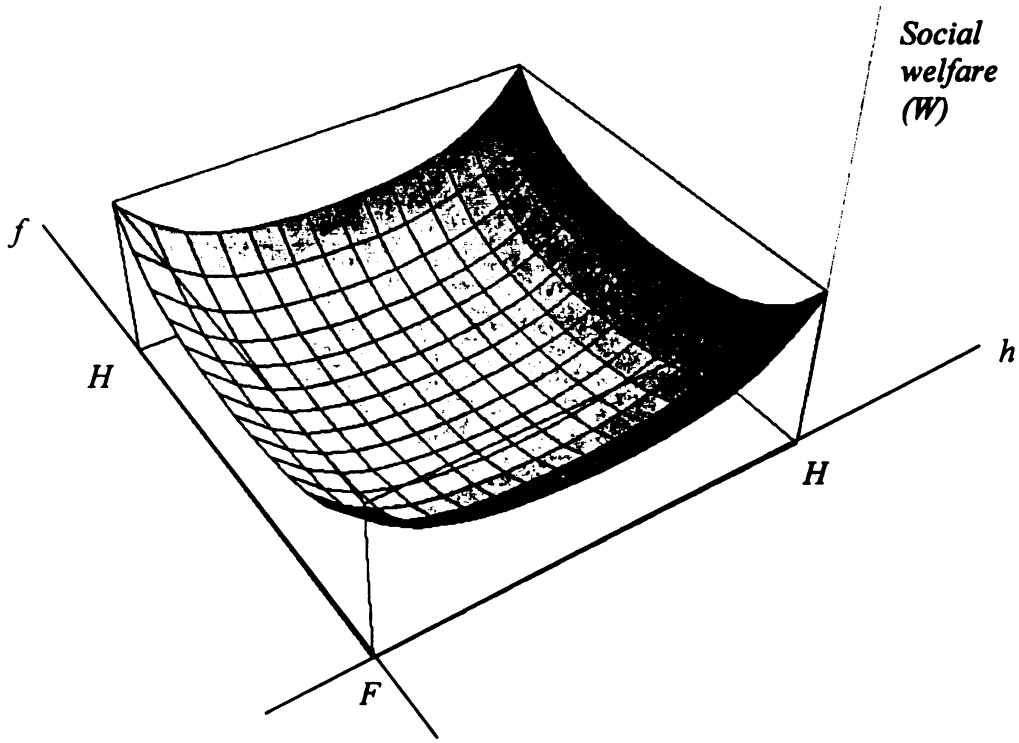

Figure A.1: Social Welfare as a Function of Choice Parameters *h, f*, Identical Endowments, Difference between Preference Parameters (*H, F*) "small".

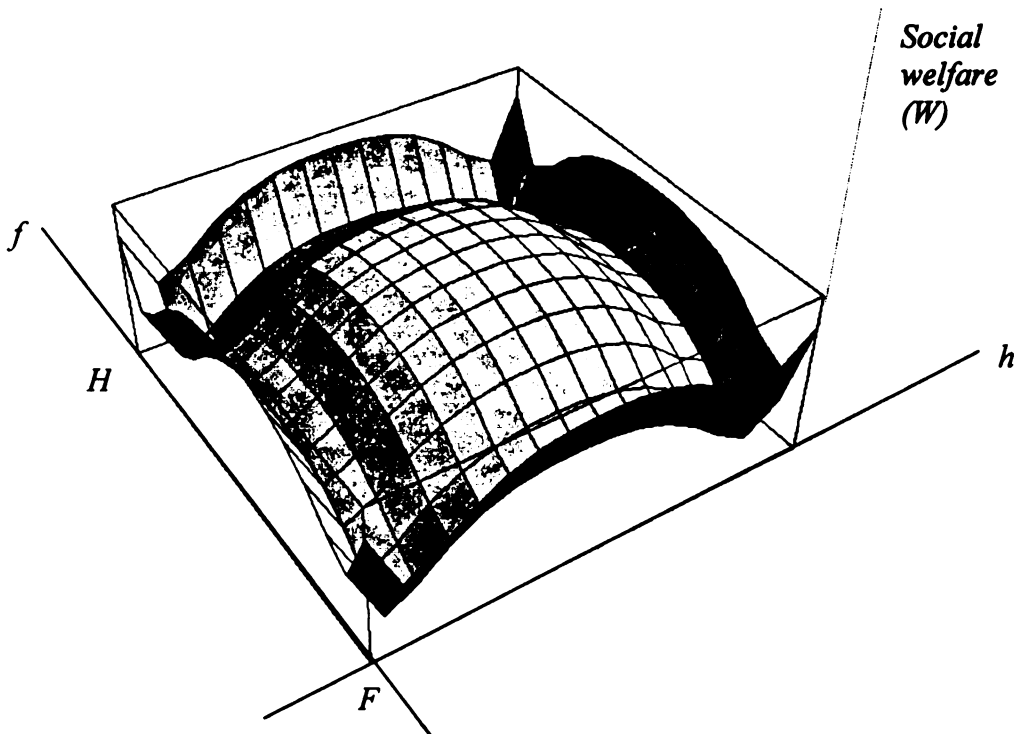

Figure A.2: Social Welfare as a Function of Choice Parameters *h, f*, Identical Endowments, Difference between Preference Parameters "large".

A.2. Social Planner Problem with Different Endowments

Table A.2: Social Planner: Numeric Solutions, Stationary Points, Different Endowments.

Foreign Pref. (F)	Home Pref. (H)	Foreign Endwmn (Y)	Home Endwmn (X)	Critical Points "Foreign Choice" (f)	Critical Points "Home Choice" (h)	Soc (f)	Soc (h)
0.5	1.5	3	2	0.89604	0.84705	+	+
0.5	2.5	3	2	1.25785	0.77769	+	+
0.5	3.5	3	2	1.55367	0.63070	+	+
0.5	4.5	3	2	1.75656	0.57124	+	+
0.5	5.5	3	2	1.8065	0.54318	+	+
0.5	6.5	3	2	1.6295	0.52819	+	+
0.5	7.5	3	2	1.41349	5.8421	+	-
				7.5390	0.51945	-	+
0.5	8.5	3	2	1.27152	6.2998	+	-
				8.52	7.68776	-	+
0.5	9.5	3	2	1.17562	6.87874	+	-
				9.52	8.80565	-	+
					0.51044		+
1	2	3	2	1.39605	1.34705	+	+
1	9	3	2	1.77152	1.014	+	+
				9.02793	6.7999	-	-
					8.18776		+
1	3	4	2	1.16854	1.13779	+	+
1	4	4	2	1.95959	1.0646	+	+
1	6	4	2	1.19581	1.02083	+	+
1	8	4	2	1.8954	1.00922	+	+
				8.02767		-	
1	10	4	2	1.67208	1.00489	+	+
				10.0149	7.73795	-	-
					9.29347		+
1	12	4	2	1.55078	1.00292	+	+
				12.009	9.03703	-	-
					11.4373		+
1	14	4	2	1.47309	1.00189	+	+
				14.0059	10.3865	-	-
					13.5212		+
1	16	4	2	1.418	1.00129	+	+
				16.0041	11.7566	-	-
					15.5788		+
1	18	4	2	1.3764	1.00093	+	+
				18.0029	13.1375	-	-
					17.6216		+

Table A.2: Social planner: numeric solutions, stationary points, different endowments (cont.).

Foreign Preference (F)	Home Preference (H)	Foreign Endwmnt (Y)	Home Endwmnt (X)	"Foreign Choice" (f)	"Home Choice" (h)	Soc (f)	Soc (h)
2	3	3	9	2.86036	2.69769	+	+
2	4	3	9	3.39247	1.67184	+	-
					3.37282		+
2	5	3	9	4.96895	1.85228	+	-
					4.11087		+
2	6	3	9	5.98353	1.91862	+	-
					4.93549		+
2	8	3	9	7.99376	1.967	+	-
					6.97102		+
2	10	3	9	2.93022	1.98325	+	-
				3.44765	9.2425	-	+
				9.99698		+	
2	12	3	9	2.63658	1.99027	+	-
				4.2324	11.3982	-	+
				11.9983		+	
2	20	3	9	2.36186	1.9978	+	-
				6.53109	19.6411	-	+
				19.9996		+	
3	4	2	20	3.96687	3.7572	+	+
3	6	2	20	5.999399	2.87724	+	-
					5.18714		+
3	8	2	20	7.99821	2.95282	+	-
					6.95781		+
3	10	2	20	9.99924	2.97649	+	-
					9.14169		+

Based on Table A.2, we induce that when endowments differ across countries, both the differences in the countries' endowments (measured by their ratio) and the Euclidian difference between Foreign and Home preference parameters influence the social planner's decision:

1. The difference between countries' preference parameters and/or the ratio of countries' sizes is small, social planner's selection of choice parameters coincides

with the countries' preference parameters. The social welfare function is convex on the interval if interest.

2. The difference between countries' preference parameters is small and/or the ratio of countries' sizes approaches a certain critical value, standard of a smaller country prevail. The social welfare function is neither concave nor convex on the interval of interest.
3. The difference between countries' preference parameters and/or the ratio of countries' endowments are sufficiently far away from each other, social planner's choice of standard for the larger country approaches smaller country's preference parameters, while smaller country's choice standard lies between the preference parameters, closer to the smaller country's preference parameter. The social welfare function is concave on the interval of interest.

Analytical hint of a proof:

As described in the Proposition 2.3, the outcome of the social planner's maximization problem depends on the Euclidian distance between the countries' preference parameters and the ratio of their respective endowments influencing – like in the case of equal endowments, the curvature of the objective function. Unlike in the equal case endowments, the different endowments case does not allow for an elegant solution in solving for a critical value of the Euclidian distance between Home and Foreign preference parameters and endowments. However, scrutiny of the numerical solutions together with the first and second order conditions result in useful intuition.

The first order conditions coincide with Equations 2.16A and B. The second order conditions (notationally simplified using Equations 2.2A – 3B) are:

$$\frac{\partial^2 W}{\partial h^2} = 2X\alpha_H^3\left(3(h-H)^2-1\right)\ln\left[\frac{X\alpha_H}{X\alpha_H+Y\alpha_F}\right]+$$

(A.4)
$$2Y\alpha_F^3\left(3(h-F)^2-1\right)\ln\left[\frac{X\alpha_F}{X\alpha_H+Y\alpha_F}\right]+$$

$$\frac{4XY\alpha_H^3\alpha_F^3\left(1+(F-h)(h-H)\right)^2(F-H)^2}{X\alpha_H+Y\alpha_F}$$

$$\frac{\partial^2 W}{\partial f^2} = 2X\beta_H^3\left(3(f-H)^2-1\right)\ln\left[\frac{Y\beta_H}{X\beta_H+Y\beta_F}\right]+$$

(A.5)
$$2Y\beta_F^3\left(3(f-F)^2-1\right)\ln\left[\frac{Y\beta_F}{X\beta_H+Y\beta_F}\right]+$$

$$\frac{4XY\beta_H^3\beta_F^3\left(-1+(f-F)(f-H)\right)^2(F-H)^2}{X\beta_H+Y\beta_F}$$

(A.6)
$$\frac{\partial^2 W}{\partial h\partial f} = \frac{\partial^2 W}{\partial f\partial h} = 0$$

The curvature of the social function depends on the signs of the principal minors of the Hessian matrix. The second order cross-partials (Equation A.6) are zero. Recall by definition the exponents $\alpha_i, \beta_i \in (0,1\rangle$ (i = F, H). Thus the natural logarithm of weighted consumption shares ($\ln\left[\frac{X\alpha_H}{X\alpha_H+Y\alpha_F}\right]$, etc) is always negative. Both non-zero second order conditions (Equations A.4 and 5) are similar in structure, and thus we analyze in detail only one of them. Depending on the position of Home's choice parameters, the key

components with varying signs of the Equation A.4 are $\left(3(h-H)^2-1\right)$ and $\left(3(h-F)^2-1\right)$. While no statements can be made regarding the distance between the choice parameter and exogenous preference parameters, potential signs of the second derivative of the social welfare function with respect to Home's choice parameter are summarized in Table A.3.

Table A.3: Sign of the Second Derivative of the Social Welfare Function.

Sign of $\frac{\partial^2 W}{\partial h^2}$	$3(h-F)^2-1<0$	$3(h-F)^2-1=0$	$3(h-F)^2-1>0$
$3(h-H)^2-1<0$	>0	>0	*depends*
$3(h-H)^2-1=0$	>0	>0	*depends*
$3(h-H)^2-1>0$	*depends*	*depends*	*depends*

In the fields labeled as "*depends*" the sign of the second derivative depends on the distance between the countries' preference parameters as well as the ratio of their endowments: in case of small differences the first principal minor of the Hessian matrix is positive. Similarly we evaluate the second derivative of the social welfare function with respect to the foreign choice parameter (*f*). Thus, the signs of the principal minors of the Hessian matrix cannot be assigned without an ambiguity, and the social welfare function can be convex, not convex and not concave, or concave.

When the social welfare function is convex due to small distance between the countries' preference parameters, the objective function cannot be optimized. In this case

social planner chooses countries' respective preference parameters as choice parameters, as they yield the highest welfare.

When the social welfare function is concave, the local maximum occurs in the midpoint between the preference parameters.

A.3. Myopic equilibrium, Second order conditions

We employ the second order condition (SOC) to evaluate the SOC whether the stationary point is a minimum or maximum. The SOC in the Home country is:

$$\frac{\partial^2 V_H}{\partial h^2} = 2\alpha_H^3 \left\{ 2(h-H)^2(1-\theta_H) + \left(4(h-H)^2 - \frac{1}{\alpha_H} \right) (\ln \theta_H + \ln X) \right\} \tag{A.7}$$

Evaluating the SOC in the stationary points described in the text we get

$$\left. \frac{\partial^2 V_H}{\partial h^2} \right|_{h=H} = -2 \left(\ln \left[\frac{1}{\beta_H + 1} \right] + \ln[X] \right) \tag{A.8}$$

$$\left. \frac{\partial^2 V_H}{\partial h^2} \right|_{h=H-\sqrt{-2-(H-f)^2+X+(H-f)^2 X}} = \frac{4\beta_H^3 \left(-2+(f-H)^2(X-1)+X \right)}{(X-1)^2 X} \tag{A.9}$$

(A.10)

$$\left. \frac{\partial^2 V_H}{\partial h^2} \right|_{h=H+\sqrt{-2-(H-f)^2+X+(H-f)^2 X}} = \frac{4\beta_H^3 \left(-2+(f-H)^2(X-1)+X \right)}{(X-1)^2 X}$$

First we assign sign to the SOC at the stationary point $h = H$. For a stationary point to be a maximum, the SOC evaluated in the stationary point has to be negative. Therefore, it has to be true that:

(A.11) $$\ln\left[\frac{1}{\beta_H + 1}\right] + \ln X > 0$$

which can be rewriten as:

(A.12) $$\ln\left[\frac{1}{\beta_H + 1}\right] > \ln[X]^{-1}$$

Since ln is a monotonically increasing function, it has to be true that:

(A.13) $$\frac{1}{\beta_H + 1} > X^{-1} \text{ or}$$

(A.14) $$\beta_H + 1 < X$$

Recall $\beta_H = \frac{1}{1+(f-H)^2}$ reaches its maximum value of one at $f = H$ (Figure 2.2).

Therefore, if the Home country's endowment exceeds two (the maximum attainable value for the left hand side of Equation (A.13)), $h = H$ is a local maximum. For values of endowment less than two, $h = H$ would be a local minimum. Thus, we assume endowments are greater than two.

The sign of the A.9 and 10 is dependent on $\left(-2+(f-H)^2(X-1)+X\right)$, as the rest of the expression is positive. It can be rewritten as $\left(-1+(X-1)\left((f-H)^2+1\right)\right)$.

Since we assumed X to be greater than two, and $(f-H)^2$ is always non-negative, it follows that $(X-1)\left((f-H)^2+1\right)$ is a product of two numbers greater than one, and therefore itself greater than one. Consequently, the sign of the A.9 and 10 are positive, and minimums are observed in the other two stationary points.

Proof proceeds in the similar fashion for the Foreign country. The SOC in the Foreign are:

$$\text{(A.15)} \qquad \frac{\partial^2 V_F}{\partial f^2} = 2\beta_F^3 \left\{ 2(f-F)^2 \theta_F + \left(-1 + 3(f-F)^2 \right) \left(\ln[1-\theta_F] + \ln Y \right) \right\}$$

Evaluating the SOC (A.15) in the stationary points leads to:

$$\text{(A.16)} \qquad \left. \frac{\partial^2 V_F}{\partial f^2} \right|_{f=F} = -2 \left(\ln \left[\frac{1}{1+\alpha_F} \right] + \ln[Y] \right) < 0$$

$$\text{(A.17)} \qquad \left. \frac{\partial^2 V_F}{\partial f^2} \right|_{f=F-\sqrt{-2-(F-h)^2+Y+(F-h)^2 Y}} = \frac{4\alpha_F^3 \left(-2 + (h-F)^2 (Y-1) + Y \right)}{(Y-1)^2 Y} > 0$$

$$\text{(A.18)} \qquad \left. \frac{\partial^2 V_F}{\partial f^2} \right|_{f=F+\sqrt{-2-(F-h)^2+Y+(F-h)^2 Y}} = \frac{4\alpha_F^3 \left(-2 + (h-F)^2 (Y-1) + Y \right)}{(Y-1)^2 Y} > 0$$

Following the procedure for Home, we find if the endowment of the Foreign good is larger than two, maximum occurs in F, while other two stationary points are local minima.

A.4. Price Behavior

As actual FOCs (rather complex) do not provide any additional intuition, we only list the FOC conditions evaluated at the border points (F and H), without solving for the actual stationary point. Taking and evaluating the FOC in the border points for each country (keeping the other country's choice parameter constant) we find that:

(A.19A) $$\left.\frac{dp}{dh}\right|_{h=F} = \frac{2(H-F)Y}{\left(1+\frac{1}{1+(F-H)^2}\right)^2\left(1+(H-F)^2\right)^2 X} > 0$$

(A.19B) $$\left.\frac{dp}{dh}\right|_{h=H} = \frac{(F-H)Y}{\left(1+(F-H)^2\right)X} < 0$$

(A.20A) $$\left.\frac{dp}{df}\right|_{f=F} = \frac{2\alpha_H(F-H)Y}{\left(2+(F-h)^2\right)X} < 0$$

(A.20B) $$\left.\frac{dp}{df}\right|_{f=H} = -\frac{2(F-H)(1+\alpha_H)Y}{\left(1+(F-H)^2\right)^2\left(\frac{1}{1+(F-H)^2}+\alpha_F\right)^2\left(1+(F-h)^2\right)X} > 0$$

Assigning the FOCs of price evaluated in the border points of the interval relies on the assumption that *(H – F)* is positive, as $H > F$, and *(F – H)* is negative. Therefore, as Home is trying to optimize (maximize) the price, we find the price function is increasing at $h = F$, and decreasing at $h = H$. A stationary point where the first derivative is zero must lay between points F and H. Similarly, as Foreign is trying to minimize the price, the stationary point must lay between F and H: the first derivative evaluated at $f = F$ is decreasing, while increasing at $f = H$.

A.5. Nash Equilibrium

Table A.4: Simulations of Nash Equilibrium with Identical Endowments

F	H	X	Y	h	$\lvert H-h\rvert$	f	$\lvert F-f\rvert$	
.5	1.5	2	2	1	.5	1	.5	$\lvert H-h\rvert=\lvert F-f\rvert$
.5	1.5	3	3	1.30291	.19709	.69709	.19709	$\lvert H-h\rvert=\lvert F-f\rvert$
.5	1.5	4	4	1.35544	.14456	.644564	.144564	$\lvert H-h\rvert=\lvert F-f\rvert$
.5	1.5	5	5	1.37965	.12035	.620349	.120349	$\lvert H-h\rvert=\lvert F-f\rvert$
.5	1.5	6	6	1.394	.106	.605999	.105999	$\lvert H-h\rvert=\lvert F-f\rvert$
.5	1.5	7	7	1.40366	.096343	.596343	.096343	$\lvert H-h\rvert=\lvert F-f\rvert$
.5	1.5	8	8	1.41068	.08932	.58932	.08932	$\lvert H-h\rvert=\lvert F-f\rvert$
.5	1.5	9	9	1.41606	.08394	.583937	.083937	$\lvert H-h\rvert=\lvert F-f\rvert$
.5	1.5	10	10	1.42035	.07965	.57965	.07965	$\lvert H-h\rvert=\lvert F-f\rvert$
1	2	3	3	1.80291	.19706	1.19706	.19706	$\lvert H-h\rvert=\lvert F-f\rvert$
1	3	3	3	2.93372	.06628	1.06628	.06628	$\lvert H-h\rvert=\lvert F-f\rvert$
1	4	3	3	3.97452	.02548	1.02548	.02548	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	3	3	4.98798	.01202	1.01202	.01202	$\lvert H-h\rvert=\lvert F-f\rvert$
1	6	3	3	5.99349	.00651	1.00651	.00651	$\lvert H-h\rvert=\lvert F-f\rvert$
1	7	3	3	6.99611	.00389	1.00389	.00389	$\lvert H-h\rvert=\lvert F-f\rvert$
1	8	3	3	7.9975	.0025	1.0025	.0025	$\lvert H-h\rvert=\lvert F-f\rvert$
1	10	3	3	9.9988	.0012	1.0012	.0012	$\lvert H-h\rvert=\lvert F-f\rvert$
1	12	3	3	11.9993	.00067	1.00067	.00067	$\lvert H-h\rvert=\lvert F-f\rvert$
1	14	3	3	13.996	.00041	1.00041	.00041	$\lvert H-h\rvert=\lvert F-f\rvert$
1	16	3	3	15.9997	.00027	1.00027	.00027	$\lvert H-h\rvert=\lvert F-f\rvert$
1	20	3	3	19.9999	.00013	1.00013	.00013	$\lvert H-h\rvert=\lvert F-f\rvert$
1	50	3	3	49.9999	.00001	1.00001	.00001	$\lvert H-h\rvert=\lvert F-f\rvert$
1	100	3	3	$\rightarrow$ 100	$\rightarrow$0	$\rightarrow$1	$\rightarrow$0	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	2	2	4.98084	.01916	1.01916	.01916	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	4	4	4.9905	.0095	1.0095	.0095	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	10	10	4.9943	.0057	1.0057	.0057	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	20	20	4.99562	.00438	1.00438	.00438	$\lvert H-h\rvert=\lvert F-f\rvert$

Table A.4: Simulations of Nash Equilibrium with Identical Endowments (cont.)

F	H	X	Y	h	$\lvert H-h\rvert$	f	$\lvert F-f\rvert$	
1	5	50	50	4.99665	.00335	1.00335	.00335	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	100	100	4.99716	.00284	1.00284	.00284	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	200	200	4.99753	.00247	1.00247	.00247	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	500	500	4.99789	.00211	1.00211	.00211	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	1000	1000	4.9981	.0019	1.0019	.0019	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	10^6	10^6	4.99905	.00095	1.00095	.00095	$\lvert H-h\rvert=\lvert F-f\rvert$
1	5	10^9	10^9	4.99937	.00063	1.00063	.00063	$\lvert H-h\rvert=\lvert F-f\rvert$

Table A.5: Simulations of Nash Equilibrium with Different Endowments

F	H	X	Y	h	$\lvert H-h\rvert$	f	$\lvert F-f\rvert$	
.5	1.5	2	3	1.13504	.36496	.730675	.230675	$\lvert H-h\rvert>\lvert F-f\rvert$
.5	1.5	2	4	1.16112	.33888	.672632	.172632	$\lvert H-h\rvert>\lvert F-f\rvert$
.5	1.5	2	5	1.17294	.32706	.645095	.145095	$\lvert H-h\rvert>\lvert F-f\rvert$
.5	1.5	2	6	1.17986	.32014	.628541	.128541	$\lvert H-h\rvert>\lvert F-f\rvert$
.5	1.5	2	7	1.18449	.31551	.6173	.1173	$\lvert H-h\rvert>\lvert F-f\rvert$
.5	1.5	2	8	1.18784	.31216	.60907	.10907	$\lvert H-h\rvert>\lvert F-f\rvert$
.5	1.5	2	10	1.19243	.30757	.597668	.097668	$\lvert H-h\rvert>\lvert F-f\rvert$
.5	1.5	2	20	1.20183	.29817	.573836	.073836	$\lvert H-h\rvert>\lvert F-f\rvert$
.5	1.5	4	3	1.34917	.15083	.687949	.187949	$\lvert H-h\rvert<\lvert F-f\rvert$
.5	1.5	5	3	1.37208	.12792	.683481	.183481	$\lvert H-h\rvert<\lvert F-f\rvert$
.5	1.5	6	3	1.38611	.11386	.680767	.180767	$\lvert H-h\rvert<\lvert F-f\rvert$
.5	1.5	7	3	1.39573	.10427	.678916	.178916	$\lvert H-h\rvert<\lvert F-f\rvert$
.5	1.5	10	3	1.41273	.08727	.65567	.17567	$\lvert H-h\rvert<\lvert F-f\rvert$
.5	1.5	20	3	1.43364	.06636	.671717	.171717	$\lvert H-h\rvert<\lvert F-f\rvert$
.5	1.5	50	3	1.44956	.05044	.668741	.168741	$\lvert H-h\rvert<\lvert F-f\rvert$
1	5	2	3	4.9809	.0191	1.01206	.01206	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	4	4.98093	.01907	1.00955	.00955	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	6	4.98095	.01905	1.00739	.00739	$\lvert H-h\rvert>\lvert F-f\rvert$

Table A.5: Simulations of Nash Equilibrium with Different Endowments (cont.)

F	H	X	Y	h	$\lvert H-h\rvert$	f	$\lvert F-f\rvert$	
1	5	2	8	4.98096	.01904	1.00636	.00636	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	10	4.98096	.01904	1.00574	.00574	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	14	4.98097	.01903	1.00501	.00501	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	15	4.98097	.01903	1.00488	.00488	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	20	4.98097	.01903	1.00441	.00441	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	25	4.98098	.01902	1.0041	.0041	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	30	4.98098	.01902	1.00388	.00388	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	40	4.98098	.01902	1.00358	.00358	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	50	4.98098	.01902	1.00338	.00338	$\lvert H-h\rvert>\lvert F-f\rvert$
1	5	2	100	4.98099	.01901	1.00287	.00287	$\lvert H-h\rvert>\lvert F-f\rvert$

A.6. Nash Bargaining Solution

Table A.6: Simulations of Nash Bargaining Solution with Identical Endowments

F	H	X	Y	H	$\lvert H-h\rvert$	F	$\lvert F-f\rvert$	
1	2	2	2	1.26569	.73431	1.73431	.73431	$\lvert H-h\rvert=\lvert F-f\rvert$
		3	3	→2	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
		4	4	→2	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
		6	6	→2	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
		10	10	→2	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
1	3	2	2	2.87302	.12698	1.12698	.12698	$\lvert H-h\rvert=\lvert F-f\rvert$
		4	4	1.9242	1.0758	2.0758	1.0758	$\lvert H-h\rvert=\lvert F-f\rvert$
		6	6	1.77136	2.22864	2.22864	1.22864	$\lvert H-h\rvert=\lvert F-f\rvert$
		10	10	→3	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
		20	20	→3	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
1	4	2	2	→4	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
		3	3	2.60949	1.39051	2.39051	1.39051	$\lvert H-h\rvert=\lvert F-f\rvert$
		4	4	2.50903	1.49097	2.49097	1.49097	$\lvert H-h\rvert=\lvert F-f\rvert$

Table A.6: Simulations of Nash Bargaining Solution with Identical Endowments (cont.)

F	H	X	Y	H	$\|H-h\|$	F	$\|F-f\|$	
1	4	6	6	2.39595	1.60405	2.60405	1.60405	$\|H-h\|=\|F-f\|$
		10	10	2.28184	1.71816	2.71816	1.71816	$\|H-h\|=\|F-f\|$
		15	15	2.20535	1.79465	2.79465	1.79465	$\|H-h\|=\|F-f\|$
		20	20	2.15633	1.84367	2.84367	1.84367	$\|H-h\|=\|F-f\|$
		30	30	2.09267	1.90733	2.90733	1.90733	$\|H-h\|=\|F-f\|$
		50	50	2.01098	1.98092	2.98092	1.98092	$\|H-h\|=\|F-f\|$
		100	100	1.92672	2.07328	3.07328	2.07328	$\|H-h\|=\|F-f\|$
		1000	1000	→4	0	→1	0	$\|H-h\|=\|F-f\|$
1	5	2	2	→5	0	→1	0	$\|H-h\|=\|F-f\|$
		4	4	3.04903	1.95097	2.95097	1.95097	$\|H-h\|=\|F-f\|$
		10	10	2.81293	2.18707	3.18707	2.18707	$\|H-h\|=\|F-f\|$
		20	20	2.68742	2.31258	3.31258	2.31258	$\|H-h\|=\|F-f\|$
		50	50	2.55738	2.44262	3.44262	2.44262	$\|H-h\|=\|F-f\|$
1	5	200	200	2.40509	2.59491	3.59491	2.59491	$\|H-h\|=\|F-f\|$
		500	500	2.32238	2.67762	3.67762	2.67762	$\|H-h\|=\|F-f\|$
		1000	1000	2.2662	2.7338	3.73379	2.73379	$\|H-h\|=\|F-f\|$
		10^6	10^6	1.83719	3.16281	4.16281	3.16281	$\|H-h\|=\|F-f\|$
1	6	2	2	→6	0	→1	0	$\|H-h\|=\|F-f\|$
		3	3	3.69791	2.30209	3.30209	2.30209	$\|H-h\|=\|F-f\|$
		5	5	3.50333	2.49667	3.49667	2.49667	$\|H-h\|=\|F-f\|$
		7	7	3.40542	2.59458	3.59458	2.59458	$\|H-h\|=\|F-f\|$
		10	10	3.31801	2.38199	3.38199	2.38199	$\|H-h\|=\|F-f\|$
		20	20	3.18023	2.81977	3.81977	2.81977	$\|H-h\|=\|F-f\|$
		100	100	2.95226	3.04774	4.04774	3.04774	$\|H-h\|=\|F-f\|$
		200	200	2.87711	3.12289	4.12289	3.12289	$\|H-h\|=\|F-f\|$
		500	500	2.79106	3.20894	4.20894	3.20894	$\|H-h\|=\|F-f\|$
		1000	1000	2.73365	3.26635	4.26635	3.26635	$\|H-h\|=\|F-f\|$
		10^6	10^6	2.3455	3.6545	4.6545	3.6545	$\|H-h\|=\|F-f\|$

Table A.6: Simulations of Nash Bargaining Solution with Identical Endowments (cont.)

F	H	X	Y	H	$\lvert H-h\rvert$	F	$\lvert F-f\rvert$	
1	10	2	2	→10	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
		5	5	5.56267	4.43733	5.43733	4.43733	$\lvert H-h\rvert=\lvert F-f\rvert$
		10	10	5.27748	4.72252	5.72252	4.72252	$\lvert H-h\rvert=\lvert F-f\rvert$
		20	20	5.06701	4.93299	5.93299	4.93299	$\lvert H-h\rvert=\lvert F-f\rvert$
		100	100	4.72342	5.27658	6.27658	5.27658	$\lvert H-h\rvert=\lvert F-f\rvert$
		200	200	4.61188	5.38812	6.38812	5.38812	$\lvert H-h\rvert=\lvert F-f\rvert$
		500	500	4.4855	5.5145	6.5145	5.5145	$\lvert H-h\rvert=\lvert F-f\rvert$
		1000	1000	4.40209	5.59791	6.59791	5.59791	$\lvert H-h\rvert=\lvert F-f\rvert$
		10^6	10^6	3.86506	6.13494	7.13494	6.13494	$\lvert H-h\rvert=\lvert F-f\rvert$
1	7	2	2	→7	0	→1	0	$\lvert H-h\rvert=\lvert F-f\rvert$
		3	3	4.23974	2.76026	3.76026	2.76026	$\lvert H-h\rvert=\lvert F-f\rvert$

Table A.7: Simulations of Nash Bargaining Solution with Different Endowments

F	H	X	Y	H	$\lvert H-h\rvert$	F	$\lvert F-f\rvert$	
1	2	2	3	1.47175*	.52825	1.60417*	.60417*	$\lvert H-h\rvert<\lvert F-f\rvert$
		2	5	1.93639	.06361	1.66813	.66813	$\lvert H-h\rvert<\lvert F-f\rvert$
		2	7	1.8829	.1171	1.65926	.65926	$\lvert H-h\rvert<\lvert F-f\rvert$
		2	10	1.84053	.15947	1.65222	.65222	$\lvert H-h\rvert<\lvert F-f\rvert$
		2	20	1.78192	.21808	1.64265	.64265	$\lvert H-h\rvert<\lvert F-f\rvert$
		2	100	1.70099	.29901	1.63017	.63017	$\lvert H-h\rvert<\lvert F-f\rvert$
		2	500	1.65174	.34826	1.6232	.6232	$\lvert H-h\rvert<\lvert F-f\rvert$
1	4	4	5	2.45794	1.54206	2.5024	1.5024	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	7	2.39562	1.60438	2.51327	1.51327	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	10	2.34256	1.65744	2.52018	1.52018	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	20	2.26313	1.73687	2.52711	1.52711	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	100	2.14067	1.85933	2.53154	1.53154	$\lvert H-h\rvert>\lvert F-f\rvert$

Table A.7: Simulations of Nash Bargaining Solution with Different Endowments (cont.)

F	H	X	Y	H	$\lvert H-h\rvert$	F	$\lvert F-f\rvert$	
1	4	4	500	2.05908	1.94092	2.53141	1.53141	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	1000	2.03075	1.96925	2.53093	1.53093	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	10^6	1.84203	2.15797	2.52391	1.52391	$\lvert H-h\rvert>\lvert F-f\rvert$
1	10	4	5	5.60371	4.39629	5.35647	4.35647	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	7	5.50724	4.49276	5.39571	4.39571	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	10	5.424	4.576	5.4233	4.4233	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	20	5.29568	4.70432	5.45821	4.45821	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	100	5.09787	4.90213	5.49442	4.49442	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	500	4.96902	5.03098	5.50957	4.50957	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	1000	4.92548	5.07452	5.51348	4.51348	$\lvert H-h\rvert>\lvert F-f\rvert$
		4	10^6	4.66714	5.33286	5.52691	4.52691	$\lvert H-h\rvert>\lvert F-f\rvert$

* Newton's method failed to converge to the prescribed accuracy after 2,000,000 iterations.

Second order conditions in Nash equilibrium and Nash bargaining solution are satisfied.

Appendix B: Differing Standards, Welfare, and Sub-global Agreements

Table B.1: Production – Entire Stock of Labor Directed into a Single Quality

"Standard"	"Beauty" = δ^B	"Truth" = δ^T
Fixed cost	$F^B = F(\delta^B)$	$F^T = F(\delta^T)$
Marginal cost	$M^B = M(\delta^B)$	$M^T = M(\delta^T)$
Production (Labor allocation)	$l_i^B = F^B + y_i^B M^B$	$l_i^T = F^T + y_i^T M^T$
Total cost ($w = 1$).	$wl_i^B = wF^B + wy_i^B M^B$	$wl_i^T = wF^T + wy_i^T M^T$
Zero profit condition (P_i=AC_i)	$p_i^B = \frac{wF^B}{y_i^B} + wM^B$	$p_i^T = \frac{wF^T}{y_i^T} + wM^T$
	$\frac{p_i^B}{w} = \frac{F^B}{y_i^B} + M^B$	$\frac{p_i^T}{w} = \frac{F^T}{y_i^T} + M^T$
Profit maximization condition (MR_i=MC_i)	$p_i^B(1-\frac{1}{\sigma}) = wM^B$	$p_i^T(1-\frac{1}{\sigma}) = wM^T$
	$\frac{p_i^B}{w} = \frac{M^B}{\left(1-\frac{1}{\sigma}\right)}$	$\frac{p_i^T}{w} = \frac{M^T}{\left(1-\frac{1}{\sigma}\right)}$
Goods mkt clearing	$y_i^B = Lc_i^B$	$y_i^T = Lc_i^T$
Due to symmetry $\forall i$	$p_i^B = p^B$	$p_i^T = p^T$
	$y_i^B = y^B$	$y_i^T = y^T$
	$c_i^B = c^B$	$c_i^T = c^T$
Equilibrium output	$y_i^B = \frac{F^B(\sigma-1)}{M^B}$	$y_i^T = \frac{F^T(\sigma-1)}{M^T}$
Labor market clearing	$\sum_{i=1}^{n^B} l_i^B = L$	$\sum_{i=1}^{n^T} l_i^T = L$
Equilibrium number of firms	$n^B = \frac{L}{F^B\sigma}$	$n^T = \frac{L}{F^T\sigma}$

B.1. Tradeoff between Number of Varieties and Price: "Quantity and Quality"

To allow for general discussion of a tradeoff between the price and number of varieties available under each attribute (if the entire stock of labor is directed into one standard only), assume that the marginal labor component of *Truth* is more than the marginal labor component of *Beauty* ($M^T > M^B$), and the fixed labor component of *Truth* is less than the fixed labor component of *Beauty* ($F^T < F^B$). The quality associated with the lower marginal cost (*Beauty*) will have the lower price, and lower fixed costs (*Truth*) lead to more varieties. Combining both fixed and marginal costs, per firm output of a variety made in *Beauty* specification exceeds per firm output of *Truth* specification.

Accurate selection of the standard depends on the relationship between the individual country's discount parameter and a function of cost differential – defined by underlying technology. Consumers compare indirect utilities[62] obtainable from bundles consisting of different number of varieties depending on quality. Possible bundles include *Truth Only*, a mixture of *Truth* and *Beauty* (but consuming only one quality per variety due to linear sub-utility function), or a bundle containing *Beauty Only*[63]. We show that a "mixed and matched" bundle is always dominated by one of the "pure" bundles. Owing the pricing symmetry – all varieties with same attribute are priced equally – the indirect utility function from consuming the *Truth Only* (*TO*) bundle is:

$$V_A^{TO} = \frac{1}{p^T}\left(n^T\right)^{\frac{1-\theta}{\theta}} \tag{B.1}$$

Similarly, from *Mix and Match* (*MM*):

[62] Social welfare consists of consumers' indirect utility, as profits equal zero.

[63] We assume a consumer possesses a perfect knowledge about all potentially available varieties, and thus are able to make indirect utility comparisons between alternatives encompassing different number of varieties. An opposite would be the case when a consumer fist chooses quality for the varieties he is sure off, and then considers additional varieties previously not available to him.

$$V_A^{MM} = \left(\bar{n}^T \left(p^T \right)^{\frac{-\theta}{1-\theta}} + \bar{n}^B \left(\frac{p^B}{\lambda} \right)^{\frac{-\theta}{1-\theta}} \right)^{\frac{1-\theta}{\theta}} \tag{B.2}$$

And finally the indirect utility from consuming *Beauty Only* (*BO*) bundle is:

$$V_A^{BO} = \frac{\lambda}{p^B} \left(n^B \right)^{\frac{1-\theta}{\theta}} \tag{B.3}$$

Notice we dropped the superscript on λ to derive autarky standard selection criteria valid for both Home and Foreign countries. In the above superscript denotes type of consumption bundle, subscript indicates autarky, p^T and p^B stand for price of each *Truth* and *Beauty* made variety, respectively. n^T and n^B represent number of varieties available when the entire stock of labor is directed to a single standard based on Equation 3.12. $\bar{n}^T$ and $\bar{n}^B$ label number of varieties available when the stock of labor is divided to produce some varieties in *Truth* and some in *Beauty*. Due of the fixed amount of labor available in the economy, the number of varieties consumed in the *Truth Only* bundle exceeds the number of varieties under the *Mix and Match (M&M)*, which in turn is larger than number of *Beauty Only* varieties:

$$n^T > \bar{n}^T + \bar{n}^B > n^B \tag{B.4}$$

L is the stock of labor available, and label L^B as labor used to produce *Beauty*-made varieties. $\bar{n}^T, \bar{n}^B$ are defined as:

$$\bar{n}^T = \frac{L - L^B}{F^T \sigma} \tag{B.5A}$$

(B.5B) $$\bar{n}^B = \frac{L^B}{F^B \sigma}$$

First we derive a condition on λ for *Truth Only* to be preferred over *M&M*, or:

(B.6) $$V_A^{TO} > V_A^{MM}$$

After solving for a condition for λ in terms of consumer's perceived parameters we get:

(B.7) $$\lambda < \frac{p^B}{p^T}\left(\frac{n^T - \bar{n}^T}{\bar{n}^B}\right)^{\frac{1-\theta}{\theta}}$$, which corresponds to:

(B.8) $$\lambda < \frac{M^B}{M^T}\left(\frac{F^B}{F^T}\right)^{\frac{1-\theta}{\theta}}$$

M&M dominates *Beauty Only* if the indirect utility from consuming an assorted bundle exceeds the indirect utility from *Beauty Only*:

(B.9) $$V_A^{MM} > V_A^{BO}$$, which holds if:

(B.10) $$\lambda < \frac{p^B}{p^T}\left(\frac{\bar{n}^T}{n^B - \bar{n}^B}\right)^{\frac{1-\theta}{\theta}}$$ or, in cost terms:

(B.11) $$\lambda < \frac{M^B}{M^T}\left(\frac{F^B}{F^T}\right)^{\frac{1-\theta}{\theta}}$$

Notice the condition for *Truth Only* to be preferred to *M&M* (B.8) is identical with the condition for *M&M* to be preferred over *Beauty Only* (B.11). By the virtue of transitivity:

$$(B.12)\ \lambda < \frac{M^B}{M^T}\left(\frac{F^B}{F^T}\right)^{\frac{1-\theta}{\theta}} \Rightarrow (TO \succ MM) \wedge (MM \succ BO) \Rightarrow TO \succ BO \Rightarrow \text{TRUTH}$$

Otherwise *Beauty* prevails. Different qualities are substitutes in consumption: rather than putting resources into two different makes of the same variety, utility can be increased by consuming additional varieties. The *M&M* bundle is always dominated by one of the "pure strategies" with a uniform standard across all varieties consumed. The autarky equilibrium is identical with Krugman (1980). Define "*A*" such that:

$$(B.13) \qquad A \equiv \frac{M^B}{M^T}\left(\frac{F^B}{F^T}\right)^{\frac{1-\theta}{\theta}}$$

Substitute to Equation B.12 to obtain the following decision rules:

(B.14) $\lambda < A$ for *Truth* to prevail as autarky standard

(B.15) $\lambda > A$ for *Beauty* to prevail as autarky standard

In section 3.2 (model with identical fixed and marginal costs across varieties) the critical value was $A = 1$. Since by definition (from Section 3.1) $\lambda^H < 1$ and $\lambda^F > 1$, Home always chose *Truth*, and Foreign always chose *Beauty*.

The trade-off between number of varieties and their price adjusts the cutoff point (Equation B.13). The critical value for *Truth* or *Beauty* to prevail is a function of cost differentials of both marginal and fixed costs. Due to assumptions placed on cost shares, $\left(F^B/F^T\right)^{\frac{1-\theta}{\theta}} > 1$ and $M^B/M^T < 1$, it is ambiguous whether "*A*" is greater or smaller than one. Thus, we recognize two separate cases: $A < 1$ and $A > 1$. Table B.1 shows autarky prevailing standards in each country (assuming in borderline cases when a

country is indifferent between standards, it chooses standard prevailing in the other country to facilitate potential open trade).

Table B.2: Autarky Prevailing Standards in Each Country

AUTARKY	$A>1$	$A<1$
Home $\left(\lambda^H<1\right)$	*Truth* always prevails in autarky	$\lambda^H \in (0,A)$ *Truth* prevails $\lambda^H \in \langle A,1)$ *Beauty* prevails
Foreign $\left(\lambda^F>1\right)$	$\lambda^F \in (1,A\rangle$ *Truth* prevails $\lambda^F \in (A,\infty)$ *Beauty* prevails	*Beauty* always prevails in autarky

Open trade recommences depending on what standards prevail in autarky in each country (summarized in Table B.1). When identical autarky standard prevails in each country ($A > 1$ and $\lambda^F \in (1,A\rangle$; or $A < 1$ and $\lambda^H \in \langle A,1)$), we obtain the usual Krugman (1979, 1980) open trade result where each country benefits from a larger number of varieties at own (autarky) preferred standard.

A novel case to analyze is when different countries choose different standards ($\lambda^F > A > 1$; or $\lambda^H < A < 1$): Home chooses *Truth*, while Foreign chooses *Beauty* as their autarky prevailing standard. After adjusting for critical value of A (earlier $A = 1$), Figures 3.3 – 11 apply: non-standardized trade always dominates autarky, while standardized trade may be welfare worsening. Table B.2 summarizes numbers of varieties produced under autarky and harmonization from the perspective of the harmonizing country based on Equation 3.12. L is the amount of labor available in autarky, and γ represents the increase in L. At the moment we assume countries are of the same size, and observe the same increase in number of varieties available.

Table B.3: Numbers of Varieties in Autarky Unilateral Harmonization

Autarky	n^T	Autarky number of varieties with all labor available allocated to Truth	$n^T = \frac{L}{F^T \sigma}$
	n^B	Autarky number of varieties with all labor available allocated to Beauty	$n^B = \frac{L}{F^B \sigma}$
Complete Unilateral Harmonization	$\overline{n}^T$	Integrated number of varieties with all labor available allocated to Truth	$\overline{n}^T = \frac{\gamma L}{F^T \sigma}$
	$\overline{n}^B$	Integrated number of varieties with all labor available allocated to Beauty	$\overline{n}^B = \frac{\gamma L}{F^B \sigma}$

With unilateral harmonization the number of varieties consumed in open trade increases (in absolute value) γ times compared to autarky. For Home to completely unilaterally adjust to *Beauty*, the indirect utility from consuming integrated number of *Beauty*-made varieties must exceed the utility gained from consuming autarky number of *Truth*-made varieties. This happens if

$$\lambda^H > \left(\frac{1}{\gamma}\right)^{\frac{1-\theta}{\theta}} A \tag{B.16}$$

Similarly, for the Foreign country to unilaterally adjust to *Truth*, it must be true that

$$\lambda^F < \gamma^{\frac{1-\theta}{\theta}} A \tag{B.17}$$

where γ represents the increase in labor available relative to autarky. When $\gamma = 1$, the selection rules correspond to the autarky selection rule derived in B.12. The cutoff point depends on the relationship between the discount factor (λ) and the ratio of fixed and marginal costs adjusted for the elasticity of substitution (or, in consumers' terms, a tradeoff between prices and numbers of varieties) and scaled by γ.

B.2. Existence of Equilibrium in Open Trade with No Harmonization Required

Cases when the consumption bundle consists of varieties made of one specification only (autarky or harmonization) coincide with Krugman (1980), treating the "discount parameter" (λ) as a monotonic transformation. Therefore, we only address the existence of equilibrium in open trade with no harmonization required.

We define a heterogeneous good by its variety and attribute, *(j, Q)*, where j indexes the variety, and Q indexes the attribute. Given two possible standards, *Truth* (T) and *Beauty* (B), L consumers in each country (index domestic consumers 1 to L, and foreign consumers L+1 to 2L), n^H firms in the Home country and n^F firms in the Foreign country each producing a differentiated variety, open trade equilibrium with no harmonization required is defined to be a price vector $p^* \in R_+^e$ (e – the dimension – defined as a sum of all *Truth*- and *Beauty*-made varieties in the open economy, homogenous good, and wage), a consumption allocation $\left(d_{ij}^{Q*}\right)$ consisting of d_{ij}^{Q*} units of the heterogeneous good *(j, Q)* allocated to consumer i, $\forall i \in (1,...,L,...,2L), j \in \left(1,...,n^H,...,n^F\right), Q \in (B,T)$ and production allocations $\left(y_j^{Q*}\right) \forall j \in \left(1,...,n^H,...,n^F\right), Q \in (B,T)$, such that the following conditions are satisfied:

1. Firms' zero profit and profit maximization conditions: for each firm j producing a differentiated product, $y_j^Q, Q = T \vee Q = B$ solves:

(B.18) $p_j^{Q*} = AC_j^{Q*} \forall j \in \left(1,...,n^H,...,n^F\right) \wedge (Q = T \vee Q = B)$ (Zero profit)

(B.19) $MC_j^{Q*} = MR_j^{Q*} \forall j \in \left(1,...,n^H,...,n^F\right) \wedge (Q = T \vee Q = B)$ (Profit max.)

2. Utility maximization: for each consumer i ($i \in (1,...,L,...,2L)$) in each country - O $(O = H \vee O = F)$, $\left(x^*, c_j^{Q*}\right) \forall j \in \left(1,...,n^H,...,n^F\right), Q \in (B,T)$ solves:

(B.20)
$$\text{Max } U_{OT} = \left(\sum_{j=1}^{n^H}\left(d_{Oj}^T\right)^\theta + \sum_{k=n^H+1}^{n^F}\left(\lambda^O d_{Ok}^B\right)^\theta\right)^{\frac{1}{\theta}}$$
$$\left\{d_{Oj}^T\right\}_{j=1}^{n^H}, \left\{d_{Ok}^B\right\}_{j=n^H+1}^{n^B}, x$$
$$s.t. \sum_{j=1}^{n^H} p_j^T d_{Oj}^T + \sum_{k=n^H+1}^{n^F} p_k^B d_{Ok}^B = w$$

(For transparency we index differentiated goods produced at Home by the notation j, and differentiated goods produced in the Foreign country by the notation k.)

3. Markets clear:

(B.21) $\sum_{j=1}^{n^O} l_j^{yQ} = L$ (Labor market)

(B.22) $\sum_{j=1}^{n^H} p_j^T T_j^T = \sum_{k=n^H+1}^{n^F} p_k^B T_k^B$ (Balanced trade)

(B.23) $y_j^T = Ld_{Hj}^T + T_j^T \qquad y_k^B = Ld_{Fk}^B + T_k^B$ (Differentiated goods)

(B.24) $T_j^T = Ld_{Fj}^T \qquad T_k^B = Ld_{Hk}^B$ (Imports' distribution)

We now show all equilibrium conditions (B.18 – 24) are satisfied. Normalize wage to one. As number of firms in a perfectly competitive sector is indeterminate, assume one firm. Derive demand functions for the differentiated good $(O = H \vee O = F)$:

$$(B.25) \qquad d_{Oj}^{T} = \frac{\left(p_j^T\right)^{-\sigma}}{\sum_{j=1}^{n^H}\left(p_j^T\right)^{1-\sigma} + \sum_{k=n^H+1}^{n^F}\left(\frac{p_k^B}{\lambda^O}\right)^{1-\sigma}}\alpha$$

$$(B.26) \qquad d_{Oj}^{B} = \frac{\left(p_K^B\right)^{-\sigma}}{\sum_{j=1}^{n^H}\left(\lambda^O p_j^T\right)^{1-\sigma} + \sum_{k=n^H+1}^{n^F}\left(p_k^B\right)^{1-\sigma}}\alpha$$

The analyses generally follow Krugman (1980) treatment of transport cost with two exceptions: (1) countries in this model are of equal size, and (2) λ^O is country variant. Since the real prices to consumers of different qualities in the Home and Foreign countries will not be the same due to different weights assigned consumption of different qualities, we define a set of "real" prices paid by consumers:

(B.27) $\overline{p_k^B} = \frac{p_k^B}{\lambda^H}$ for Home consumers purchasing Foreign (*Beauty*) varieties, and

(B.28) $\overline{p_j^T} = \lambda^F p_j^T$ for Foreign consumers purchasing Home (*Truth* made) varieties.

Due to real price differences between the countries, consumption of each imported variety (of a different quality) will differ from consumption of the domestic made varieties. Dividing Equation B.25 by B.26 we found each Home consumer will

consume $\left[\left(p_j^T\right)^\sigma \Big/ \left(\left(p_k^B\right)^\sigma \left(\lambda^H\right)^{1-\sigma}\right)\right]$ units of a representative imported good for each unit of a representative domestic good he consumes. To explore impact on the producers, consider "adjusted" demand for the exported good: that is, demand perceived by consumers:

(B.29) $\overline{d_{Hk}^B} = \dfrac{d_{Hk}^B}{\left(\lambda^H\right)^\theta}$ for Foreign producers exporting to the Home country and

(B.30) $\overline{d_{Fj}^T} = \left(\lambda^F\right)^\theta d_{Fj}^T$ for Home producers exporting to the Foreign country

Taking into account adjusted demand, we construct a ratio of total demand by domestic consumers for each foreign product to demand for each domestic product:

(B.31) $\omega = \left(\dfrac{p_j^T}{p_k^B}\right)^\sigma \left(\lambda^H\right)^{\frac{1}{\sigma}-2}$ for the Home country and

(B.32) $\omega^* = \left(\dfrac{p_k^B}{p_j^T}\right)^\sigma \left(\lambda^F\right)^{\frac{1}{\sigma}-2}$ for the Foreign country

Consumer, having access to varieties not available in autarky, exhaust his entire differentiated goods budget such that:

(B.33) $\left(n^H p^T + \omega n^F \overline{p^B}\right) d^T = 1$ where d^T is the consumption of the representative domestic good. Similarly in the Foreign country:

(B.34) $\left(\omega^* n^H \overline{p^T} + n^F p^B\right) d^B = 1$

The elasticity of export demand facing any given firm is identical with the elasticity of domestic demand (σ). The autarky conclusions regarding the production are valid: production in the differentiated sector of each country (Home producing *Truth*-made only, Foreign producing *Beauty*-made only) is derived in Appendix B.1. Due to symmetry all goods of the same quality will be produced in the same quantity and at the same price: shorthand the notation: $p_j^T = p^T, p_k^B = p^B$ and $y_j^T = y^T, y_k^B = y^B$. Due to constant elasticity from the profit maximization condition itself we obtain profit maximizing price:

(B.36) $$p^Q = \frac{\sigma}{\sigma - 1} M^Q$$

Combine the profit maximizing and zero profit conditions to obtain equilibrium output:

(B.37) $$y^Q = \frac{F(\sigma - 1)}{M^Q}$$

From the labor market clearing condition (B.21) derive equilibrium number of firms

(B.38) $$n = \frac{L}{F\sigma}$$

The equilibrium number of firms and nominal prices in each country remain the same. Nevertheless, the model as specified with country-variant discount factors (λs) does not exhibit identical real wages even in autarky[64]. Once the trade opens, there exists a relative real wage ratio between Home and Foreign countries such that the trade is balanced. From Equation B.31 and 32 an open economy real wage is defined as:

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[64] Autarky real wage in the home country – assuming *Truth* prevails – is $\left(1/p^T\right)^\alpha$, while real wage in the Foreign – *Beauty* loving country – is $\left(\lambda^F/p^B\right)^\alpha$, where $\lambda^F > 1$. Therefore, real wage in the Foreign country is always less than the real wage in the Home country.

$$(B.39) \qquad r^O = \left(\frac{1}{\left[\left(p^T\right)^{1-\sigma} + \left(\frac{p^B}{\lambda^O}\right)^{1-\sigma} \right]^{\frac{1}{\sigma-1}}} \right)^{\alpha}$$

where O is H (Home) or F (Foreign). Define a relative real wage ratio such that:

$$(B.40) \qquad \psi = \frac{r^H}{r^F}$$

Combine B.33 and 34 to find the balanced trade condition: for the trade to be balanced it has to be true that:

$$(B.41) \qquad n\omega \overline{p^B d^T} = n\omega^* \overline{p^T d^B},$$

which, multiplied by the number of workers in each economy leads to the Home's balance of payments condition (measured in real wage units of the Foreign country):

$$(B.42) \qquad B = \psi L \left[\frac{\omega^*}{\omega^* + 1} - \frac{\omega}{\omega + 1} \right]$$

Using the Krugman (1980) argument, since ω and ω^* are both functions of ψ, B.42 can be used to determine open trade real relative wage ratio. At the equilibrium open trade real relative wage ratio ($\overline{\psi}$) the expression in the brackets in B.42 is zero, and trade is balanced. Since ω is increasing in ψ, and ω^* is increasing in ψ, $B(\omega)$ will be negative (positive) if and only if ψ is greater (less) than $\overline{\psi}$, which shows that $\overline{\psi}$ is the unique open trade relative real wage.

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