The "New" Economics of Trade Agreements: From Trade Liberalization to Regulatory Convergence?*

Gene M. Grossman
Princeton and NBER

Phillip McCalman
University of Melbourne

Robert W. Staiger
Dartmouth and NBER

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Abstract

What incentives do governments have to negotiate trade agreements that constrain their domestic regulatory policies? We study a model in which firms design products to appeal to local consumer tastes, but their fixed costs increase with the difference between versions of their product destined for different markets. In this setting, firms' profit-maximizing choices of product attributes are globally optimal in the absence of consumption externalities, but national governments have unilateral incentives to invoke regulatory protectionism to induce firm delocation. An efficient trade agreement requires commitments not to engage in such opportunistic behavior. A rule requiring mutual recognition of standards can be used to achieve efficiency, but one that requires only national treatment falls short. When product attributes confer local consumption externalities, an efficient trade agreement must coordinate the fine details of countries' regulatory policies.

Keywords: firm delocation, harmonization, international trade agreements, regulation, deep versus shallow integration

JEL Classification: F02, F12, F13

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1 Introduction

Negotiations at the multilateral, regional and bilateral levels have been remarkably successful at reducing the traditional barriers to international trade. The World Bank reports a weighted average applied tariff rate on all traded goods of less than 2.6% in 2017. In 1939, average applied tariffs were 23.3% in France, 32.6% in Germany, 29.6% in the United Kingdom, and 13.3% in the United States, and even higher in many smaller countries (see Bown and Irwin, 2015). Quota restrictions, which were ubiquitous in earlier periods, have been all but eliminated.

With this success, the trade community has shifted its attention to various non-tariff barriers (NTB's) that leave world markets still far from integrated. Among the NTB's that receive the most scrutiny are those that arise from differences in domestic regulations or what Sykes (1999a, 1999b) has termed "regulatory heterogeneity." International disciplines for regulatory procedures lie at the heart of the Technical Barriers to Trade (TBT) Agreement and the Sanitary and Phytosanitary (SPS) Agreement that were concluded as part of the Uruguay Round of trade negotiations. They have been the subject of further negotiation at the regional level under the recently concluded Trans Pacific Partnership (TPP11) and they provide the primary impetus for the Transatlantic Trade and Investment Partnership (TTIP) negotiations between the United States and Europe.

Governments regulate commercial behavior for myriad reasons. Regulations support cultural norms, address environmental, health and safety issues, confront problems arising from asymmetric information between producers and consumers, and protect societies from systemic risks in the financial, telecommunications, and IT sectors, among others. But the trade community has long recognized that governments might also use their regulatory authority to pursue mercantilist objectives. Regulations can baldly favor domestic over foreign firms, or they can be facially neutral but still impose unequal costs and thereby impede global competition. Moreover, as the economics literature on trade agreements has emphasized, if governments fail to take account of foreign interests when designing domestic policies, global inefficiencies will emerge even in the absence of any protectionist intent (see, for example, Bagwell and Staiger, 2002, and Grossman, 2017).

Lamy (2015, 2016) highlights a particular international externality that may arise from regulatory dissonance. Firms that are obliged to satisfy different regulations for their various markets must produce multiple versions of their products, often at the cost of foregone economies of scale. Lamy argues that, as the precautionary motive for regulation designed to protect consumers' health, safety and values displaces the protectionist motive for policies aimed at insulating producers from competition, the leveling of the trade playing field will become less about eliminating protective barriers and more about reducing differences between policies that have legitimate aims.

In Lamy's view, the new landscape for trade negotiations requires harmonization, or at least convergence, in regulatory measures. Yet, as Sykes (1999a, 1999b, 2000) cogently argues, international differences in incomes, cultures, risk preferences and tastes generally justify regulatory heterogeneity, even if one recognizes the added cost of satisfying a multitude of rules. Sykes notes that only very exceptionally will cooperation suggest the desirability of complete harmonization. The writings of Lamy on the one hand and Sykes on the other raise the immediate question of what is the appropriate trade-off in international trade agreements between heterogeneous tastes across international borders and the cost burdens imposed by disparate regulations.

In this paper, we begin the task of answering this question. We consider a trading environment in which individuals residing in different countries hold dissimilar valuations of the characteristics of goods and services, valuations that reflect their idiosyncratic local conditions, incomes, and cultures, or what Lamy (2016) refers to as their "collective preferences." National governments can impose regulations to serve the interests of their constituents. Yet, disparate regulations impose costs on firms, and ultimately consumers, the more so the greater are the cross-country differences in product standards. We characterize a "new trade agreement" (NTA) that achieves global efficiency by stipulating not only the cooperative trade taxes that form the heart of an "old trade agreement" (OTA), but also how governments should optimally set their standards in the light of the international externalities they create.

Our analysis extends Venables (1987), which is a model of trade in horizontally differentiated products under conditions of monopolistic competition and in the presence of a competitively produced "outside" good. Whereas Venables and subsequent authors incorporate a single dimension of product differentiation that generates a love of variety, we introduce a second dimension of differentiation for each brand along which consumers have collective preferences. The alternative versions of each brand are perfect substitutes in the eyes of consumers, but residents of the two countries value them differently. One interpretation is that the possible variants of a brand are horizontally differentiated and that residents of the two countries perceive different ideal varieties. Another interpretation is that variants are vertically differentiated and while consumers everywhere recognize these quality differences, those in one country value quality more highly than those in the other. In either case, a term that depends on the attributes of a brand enters utility as a country-specific "demand shifter" in an otherwise-standard, CES formulation. We allow firms to tailor their offerings to their destination markets, either to cater to consumers tastes and thereby stimulate demand, or to satisfy standards imposed by local regulatory authorities. Although firms can supply different versions of their brands, they bear extra fixed costs of design adaptation or from maintaining multiple facilities, as suggested by Lamy.

In our first pass, we assume that an individual's utility depends only on the characteristics of the goods she consumes herself. However, we recognize that motives for government regulation become stronger when the choices of which goods to consume confer externalities on others. Such consumption externalities arise naturally for many, although not all, of the goods and services that are subject to standards.[1] Drivers may care not only about the safety features of the cars they drive, but also about the features of other cars on the road. Individuals who worry about certain modes of production for cultural or religious reasons are likely to care about how goods consumed by others have been produced. And the functioning of the internet and the financial sector depends

[1] See Fontagne et al. (2013, pp 4-5) for an interesting discussion of alternative approaches to regulatory harmonization within the context of the TTIP negotiations that draws a distinction between regulatory issues where externalities are clearly present (e.g., genetically-modified organisms) and where externalities are arguably absent (e.g., chlorine-washed chicken).

on choices made by all consumers inasmuch as they affect compatibility and network externalities. Accordingly, after characterizing an NTA in a trading environment without consumption externalities, we revisit the issue for settings in which such externalities exist.

Our model incorporates shipping costs that generate home-market effects, as in Krugman (1980) and in the original Venables (1987) paper. As a consequence, firms sell relatively more in their local market than in their export market. This affects their optimal design choices. Profit-maximizing firms cater especially to local tastes given the relatively greater importance of that market to their bottom line. Given the extra fixed costs of designing second products that are very different from the core products sold domestically, firms in our model sell products in their export market that are further from the offshore ideal than the products offered there by local firms. In other words, exporters worldwide have legitimate cost reasons to produce goods that are less appealing to local consumers than those offered by local producers. And while local governments may not care about the profits of foreign producers, they do care about the prices and variety of goods available to their constituents. Accordingly, our model features an economic rationale for regulatory heterogeneity and even for "discriminatory" treatment of goods from different origins; we thus validate Sykes' concerns about the inefficiencies of complete harmonization.

In Section 3, we characterize an NTA that achieves global efficiency in a setting with international preference heterogeneity but no consumption externalities. We find as usual that net trade taxes should be set to zero in an efficient trade agreement to avoid wedges in the marginal rates of substitution between goods consumed in different countries. Moreover, consumption subsidies (or employment subsidies) are needed as in other settings with monopolistic competition and an outside good (see, for example, Helpman and Krugman, 1989, pp. 137–145) to compensate for the distortion otherwise caused by markup pricing in one sector and competitive pricing in the other. However, provided that consumption subsidies apply equally to local and imported goods, there is no need to stipulate the levels of such subsidies in a trade agreement; governments subject to national treatment will unilaterally set the subsidy rates needed to offset market power. Interestingly, we find that this attractive feature does not hold for the alternative policy of employment subsidies, indicating that even if the agreement contemplates the use of consumption subsidies to address the monopoly distortion, it would need to restrict the use of employment subsidies. Finally, the consummate NTA can stipulate the characteristics of goods from all sources in all markets. But the products that firms would design and sell to maximize profits in a world without regulation have exactly the characteristics that are globally efficient when consumption externalities are absent. Therefore, an NTA need not formalize detailed rules in this environment, it is enough that they stipulate that national governments refrain from any (binding) regulations.

Next, we ask whether an NTA is needed to achieve global efficiency or whether an OTA that respects governments' sovereignty in setting standards can do the trick, perhaps with what Sykes (1999a) terms "policed decentralization"; i.e., provisions that constrain broad aspects of governments' regulatory choices. First, in Section 3.2, we consider standard-setting under a free-trade agreement (FTA) that requires national treatment for consumption subsidies and prohibits employment subsidies but otherwise leaves governments free to set their domestic policies. We find in this setting strong incentives for "regulatory protectionism"; in the Nash equilibrium, each government imposes onerous burdens on import goods in an attempt to effect delocation. The motive for limiting tariffs that Ossa (2011) identified in the Venables model becomes a motive for regulatory disciplines, once trade taxes have been removed from the governments' arsenals. This confirms Sykes' (1999b) intuition that regulatory cooperation may be needed when governments are constrained in the use of their preferred protectionist instruments.

The delocation motive for onerous standards suggests that discrimination may be the primary source of inefficiency. So in Section 3.3 we consider an FTA with a national treatment provision that applies not only to consumption subsidies, but also to standards. If each government can set at most a single standard that must apply equally to local goods and imports, the outcome is never first best. This result is immediate, because the first best does not involve similar characteristics for the goods sold in a market from different sources; these characteristics will differ to reflect the different adaptation costs for firms with different home markets. So we allow the governments to set multiple standards, provided that they are equally available to all. Such an OTA also fails to secure the globally-efficient outcome, because the governments have no incentive to offer as options the standards that are efficient for foreign firms. The resulting Nash equilibrium with multiple standards provides an example of Sykes' (1999b) "facially neutral regulatory protectionism."

An alternative to negotiating rules about regulatory cooperation (and also to the nondiscrimination associated with national treatment, which still allows for regulatory protectionism) is a provision for mutual recognition. Under mutual recognition, which we consider in Section 3.4, each government is free to set one or more standards while pledging to accept for import any goods or services that satisfy standards in their country of origin.[2] When each government can set a single standard and commits to mutual recognition, the outcome again is not first best. In such circumstances, either firms satisfy the standard of their native country for export sales, in which case all firms produce only one version of their brand, or else firms elect to meet the standard of the destination market, in which case all products sold in the same market bear identical characteristics. In either case, there are only two types of goods supplied to the world market, whereas efficiency mandates that there should be four. However, when governments can designate multiple standards, an OTA that provides for mutual recognition does yield an efficient outcome. In the Nash equilibrium, each government announces (at least) two standards, one that maximizes profits for its firms in their local sales and the other that maximizes profits for its firms in their export sales. When the importing government is bound to accept goods that bear these latter characteristics, the outcome is the same as emerges without any regulation, which we have argued is first best in a Venables world without consumption externalities.

Finally, in Section 4, we allow for (negative) consumption externalities. In this setting, the optimal NTA has positive net tariffs, and the requisite consumption subsidies are different from

[2] In practice, agreements have placed certain legal limits on when firms can invoke mutual recognition. We discuss these limits and their (in)efficacy in Section 3.4 below.

the ones that offset monopoly distortions. The optimal policy combination induces individuals to substitute toward the goods that confer relatively smaller externalities; typically these are the locally-produced goods, except when imports are of higher quality. Finally, the optimal standards—while not fully harmonized across countries and not similar for imports and domestic goods—are no longer the same as those that profit-maximizing firms would design on their own. Without regulation, firms in both countries have insufficient incentive to differentiate the local and export versions of their brands, because consumer demands are insufficiently sensitive to deviations from the local ideal when individuals ignore the adverse effects of their product choices. The optimal NTA calls for standards that induce all firms to design products closer to the ideal in the destination markets compared to what they would choose if left unfettered to maximize profits. Interestingly, the efficient standards are *more* lenient for imports than for local products, reflecting the differential costs that the different firms face in meeting strict regulations.

In Section 4.3, we revisit the question of whether an OTA with mutual recognition can replicate the efficient outcome of an NTA, but this time in the presence of consumption externalities. We answer in the negative. Even if consumption externalities are entirely local in geographic scope, an NTA with detailed rules about countries' national regulations is needed to achieve global efficiency. Finally, we consider whether it might be possible to rely on a non-violation clause to eliminate incentives for inefficient standards that arise in the presence of delocation opportunities and consumption externalities. Building on Bagwell and Staiger (2001), Staiger and Sykes (2011) have shown that commitments to agreed measures of market access can temper countries' incentives to use product standards to manipulate the terms of trade. But new challenges arise for designing such a clause when product types confer externalities and insidious regulations can be used to delocate foreign firms. We cast doubt on whether a non-violation clause can obviate the need for detailed negotiations about product standards in this setting.

Before proceeding, we comment briefly on the relationship of our work to the existing literature on the use of strategic regulation in the open economy and the role that trade agreements might play in addressing the resulting inefficiencies. One branch of this literature assumes perfect competition and emphasizes the inefficiencies that arise from terms-of-trade externalities and international cost-shifting; see Bagwell and Staiger (2001), Klimenko (2009) and Staiger and Sykes (2011, 2017).[3] These issues of cost-shifting are by now relatively well understood and so we abstract from them here by invoking a markup pricing under which standards do not affect the terms of trade. A second branch of literature considers profit-shifting motives for regulation in a setting of international oligopoly; see Gandal and Shy (2001), Costinot (2008), and Klimenko (2009). These authors highlight the inefficiencies that result when governments set standards to influence the international distribution of excess profits. Costinot (2008) comes closest to our paper when he compares the

[3] International cost-shifting occurs when exporters do not pass on the full cost of meeting product standards to consumers in the country where the standards apply. Parenti and Vannoorenberghe (2019) analyze standard-setting in a competitive Ricardian trade model, but they shut down the standards-related terms-of-trade externality with a freely traded outside good that is produced by all countries. Under the assumption that a country cannot impose its own standards on imported goods, they focus on the gains that countries might achieve by coordinating their choices of standards when they differ over the valuation of a consumption externality.

properties of national treatment and mutual recognition as simple rules that might address the inefficiencies in non-cooperative standard-setting.[4] Unlike Costinot, however, we abstract from profit-shifting by casting our analysis in a setting with monopolistic competition and free entry. Our paper complements the existing literature inasmuch as we introduce firm delocation motives for insidious regulation and highlight how regulatory differences affect the fixed costs of serving multiple markets, with attendant implications for entry, exit, and welfare.[5]

Our work is also related to a broader literature on deep versus shallow integration (see Bagwell, et al., 2016, for a recent review). We refer here to "new trade agreements" and "old trade agreements" rather than to deep and shallow integration, but there is a clear mapping between these terms. Our choice of terminology reflects two considerations. First, our designations are inspired by Lamy (2015, 2016) and his view that "we are transitioning from an *old* world of trade to a *new* world of trade" (Lamy, 2015, p.1, italics added). And second, our nomenclature distinguishes our paper from the existing literature on deep versus shallow integration in general, inasmuch as our formal analysis focuses more narrowly on the costs and benefits of regulatory heterogeneity that are emphasized by Lamy and by Sykes (1999a, 1999b, 2000).

2 The Model

In this section, we extend the two-country model of Venables (1987) to allow for product standards and the possibility that efficient trade agreements might require regulatory cooperation. The Venables model features costly trade in horizontally-differentiated products. Trade costs generate home-market effects à la Krugman (1980) that create a "delocation" motive for unilateral policies to increase the presence of local producers. The model has been used previously by Helpman and Krugman (1989) to study trade policy for monopolistically-competitive industries and by Bagwell and Staiger (2015) to examine the incentives that countries have to negotiate reciprocal tariff cuts.

Our model introduces international taste differences. We characterize each brand with two dimensions of product differentiation.[6] One characteristic of a brand renders it an imperfect substitute for all other brands, as is typical in models of monopolistic competition. Consumers worldwide share a common, Dixit-Stiglitz love of variety along this dimension, so they all want to consume

[4] See also Geng (2019), who extends the analysis of Costinot to consider preference heterogeneity across countries in the valuation of a consumption externality.

[5] Campolmi et al (2014, 2018) extend Ossa's (2011) analysis of delocation to domestic policies, but they focus on fiscal instruments and do not consider product standards. In independent work, Mei (2019) studies standard-setting in a model of delocation. Like us, he emphasizes the fixed as well as variable cost impacts of standards in the presence of home-market effects and firm delocation. In his paper, however, fixed costs are not a function of the difference in standards across markets; consumers do not care directly about product characteristics, but only about the "eye-sore" generated by inferior products; and thus product attributes do not affect consumer demands. By contrast, we assume that domestic and foreign consumers have heterogeneous preferences over product characteristics that affect their purchase decisions, fixed costs rise with the distance between versions that firms offer in the two markets, and the endogenous choices of characteristics for sales in the two markets is fundamental to our analysis.

[6] Podhorsky (2013) also considers a model of monopolistic competition with two dimensions of product differentiation, albeit with common preferences in the two countries. She uses her model to study the global inefficiencies that may arise when countries non-cooperatively administer voluntary certification programs in the presence of imperfect consumer information about product characteristics.

all available brands. A second characteristic distinguishes "versions" of a given brand. Consumers view these alternatives as perfect substitutes, but with different valuations. For example, if the potential versions of a brand are *horizontally* differentiated along the second dimension, then the representative consumer in each country has an ideal specification for each brand, but with favorite versions that differ internationally. Alternatively, if the potential versions of a brand are *vertically* differentiated, individuals worldwide recognize a hierarchy among them, but consumers in one country have a greater willingness-to-pay for quality than those in the other. Firms are free to tailor variants of their brands to suit local tastes, but they face a (fixed) cost of product adaptation that increases with the distance in characteristic space between their offerings. Regulation might emerge from a governments' interests in altering the composition of goods available to their constituents.

For now, we assume that each consumer's utility depends only on her own consumption choices. Of course, a government's justification for regulation becomes stronger when decisions about which versions to buy and in what quantities confer externalities on other consumers. We will introduce consumption externalities that arise from product characteristics in Section 4 below.

2.1 Demand

The citizens of two countries, Home and Foreign, consume a homogeneous good and a set of differentiated products. There are N^J identical consumers in country J. The representative consumer there maximizes a quasi-linear utility function,

$$U^J = 1 + C_Y^J + \log\left(C_D^J\right) \ , \quad J \in \{H, F\} \ , \tag{1}$$

where C_Y^J is per-capita consumption of the homogeneous good Y in country J and C_D^J is a sub-utility index for per-capita consumption of differentiated products.[7] We designate good Y as numeraire and let P^J denote the utility-based price index for differentiated products in country J in units of the numeraire. Then utility maximization subject to a budget constraint implies

$$C_D^J = \frac{1}{P^J} \ , \quad J \in \{H, F\} \, . \tag{2}$$

The optimal consumption plan yields indirect utility to the representative consumer of

$$V\left(P^J, I^J\right) = I^J - \log P^J, \quad J \in \{H, F\} \, , \tag{3}$$

where I^J is per-capita disposable income in country J.

The goods that comprise the bundle C_D^J bear two distinct characteristics. One characteristic makes each brand unique and renders every pair as CES-substitutes with an elasticity of substitution

[7] We use the logarithmic form for sub-utility in order to simplify some of the expressions below. All of our substantive conclusions would apply as well if we were instead to work with a utility function of the form

$$U^J = C_Y^J + \frac{1}{\theta}\left(C_D^J\right)^\theta, \quad J \in \{H, F\} \, , \theta \in (0, 1) \, ,$$

which would imply a constant elasticity of demand for the bundle of differentiated products.

greater than one, so that consumers covet variety. The other characteristic of a brand i, denoted a_i^J, positions the variant sold in country J along some finite segment of the real line, $[a_{\min}, a_{\max}]$. This characteristic determines the local evaluation of the version of brand i sold in country J. Letting c_i^J denote the representative individual's consumption of brand i in country J, we take

$$C_D^J = \left\{ \sum_{i \in \Theta^J} A^J\left(a_i^J\right)\left(c_i^J\right)^\beta \right\}^{\frac{1}{\beta}}, \; J \in \{H, F\}, \tag{4}$$

with $A^J(a) > 0$ for all $a \in [a_{\min}, a_{\max}]$ and $\beta \in (0, 1)$, and where Θ^J represents the set of brands available in country J. In this formulation, $A_i^J \equiv A^J\left(a_i^J\right)$ acts as a "demand shifter"; the enjoyment that the representative consumer in country J derives from purchasing a given quantity of brand i depends upon the version of the brand that she consumes.

We impose some minimal but flexible structure on the demand shifters. Specifically, we write $A_i^J = A\left(a_i^J, \gamma^J\right)$ and adopt

Assumption 1 $A\left(a_i^J, \gamma^J\right)$ *is log-supermodular and* $A_{aa}\left(a_i^J, \gamma^J\right) < 0$, *for all* $a \in [a_{\min}, a_{\max}]$ *and for* $J \in \{H, F\}$,

where γ^J is any parameter that describes economic or social conditions that vary across countries. Assumption 1 readily captures *vertical differentiation* of the different versions of brand i. Suppose $A_a\left(a_i^J, \gamma^J\right) > 0$ for all a_i^J and that $\gamma^H > \gamma^F$. Then all consumers worldwide prefer versions of brand i with higher a_i, but consumers in the home country value increases in a_i relatively more than do those in the foreign country. When combined with an assumption that unit costs are increasing in a_i, we can interpret a_i as the "quality" of the product and say that country H has a relatively greater taste for quality. For example, a_i might refer to the "cleanliness" of some product and consumers in the the home country might have a greater willingness to pay for a clean environment; or social norms might differ, so that consumers in the home country are more averse to certain food additives or to methods of production that afford fewer worker rights.

However, Assumption 1 also can be interpreted in terms of *horizontal differentiation* of versions of brand i. Suppose the demand shifter is a decreasing function of the absolute difference between a_i^J and some country-specific ideal, γ^J, in country J; i.e., $A\left(a_i^J, \gamma^J\right) = \breve{A}\left(\left|a_i^J - \gamma^J\right|\right)$, with $\breve{A}'(\cdot) \leq 0$ for all $a_i \in [a_{\min}, a_{\max}]$ and $\gamma^H > \gamma^F$. When combined with an assumption that unit costs are the same for all a_i, we would not say that products with a higher a_i are better or worse than those with a lower a_i; residents of country H simply prefer higher values of a_i than do those of country F. As we show in the appendix, the function $\breve{A}\left(\left|a_i^J - \gamma^J\right|\right)$ is log-supermodular in a_i^J and γ^J. Thus, Assumption 1 can capture regulatory environments that arise from differences in local geographic or weather conditions, such as when local circumstances determine the appropriate safety equipment for automobiles. It can also reflect different local histories, customs, or institutions that might affect, for example, the consumers' tolerance for spicy foods or genetic modifications.

Returning to the general formulation of utility described by (1) and (4) for some $A(\cdot)$ function that satisfies Assumption 1, we recall from Venables (1987) and Ossa (2011) that the price index associated with (4) takes the form

$$P^J \equiv \left[\sum_{i \in \Theta^J} \left(A_i^J\right)^{\sigma} \left(p_i^J\right)^{1-\sigma} \right]^{-\frac{1}{\sigma-1}}, \ J \in \{H, F\}, \tag{5}$$

where $\sigma = 1/(1-\beta)$ is the elasticity of substitution between every pair of brands. Maximizing utility (or minimizing the price index subject to a given level of spending on differentiated goods) gives the per-capita demand for brand i in country J which, as usual, is given by

$$c_i^J = \left(A_i^J\right)^{\sigma} \left(p_i^J\right)^{-\sigma} \left(P^J\right)^{\sigma-1}, \ J \in \{H, F\}. \tag{6}$$

The aggregate demand for brand i by the N^J identical consumers in country J is $N^J c_i^J$.

2.2 Supply

The two countries have fixed endowments of a single factor of production that we call labor. Their labor supplies, L^H and L^F, are sufficiently large to ensure positive output of the numeraire good in each country in all circumstances that we consider.[8] The numeraire good is produced with constant returns to scale and traded in a perfectly-competitive world market. Firms in either country can produce one unit of output with one unit of labor, which fixes the common wage rate at one.

The differentiated products are produced and traded under conditions of monopolistic competition. Firms enter freely in both countries and develop a brand that is unique along the dimension that generates love of variety. Once the fixed costs have been paid, a firm i in location J can produce a version of its brand with characteristic a_i with constant returns to scale, using $\lambda(a_i)$ units of labor per unit of output. We adopt

Assumption 2 $\lambda'(a_i) \geq 0$ *and* $\eta'(a_i) \geq 0$,

where $\eta(a_i)$ is the semi-elasticity of unit cost with respect to the characteristic a_i; i.e., $\eta(a_i) \equiv d \log \lambda(a_i)/da_i$. With horizontal differentiation along the brand-specific dimension, $\lambda(a_i)$ is constant, so that all versions cost the same to produce. With vertical differentiation, $\lambda'(a_i) > 0$, so that higher quality costs more. In either case, the second part of Assumption 2 in combination with the second part of Assumption 1 will help to ensure that second-order conditions are satisfied.

Each firm incurs a fixed cost that depends on its design choices. If the firm selling brand i offers variants with characteristic a_i^H in the home market and a_i^F in the foreign market, then it bears a total fixed cost of $\Phi_i \equiv \Phi\left(\left|a_i^H - a_i^F\right|\right)$ units of labor, with $\Phi(0) > 0$, $\Phi'(\cdot) \geq 0$, and $\Phi''(\cdot) > 0$. In

[8] Here and henceforth we adopt the convention that country superscripts refer to the destination country and thus to variables or parameters related to demand, whereas country subscripts refer to the source country and thus to variables or parameters related to supply. Where needed, we apply both a superscript and a subscript to distinguish a good that is produced in one country and exported to the other.

other words, the firm pays for offering two versions of its brand an extra design or facility cost that is increasing and convex in the distance between them in the relevant characteristic space.[9]

Firms face variable trade costs, including both transport costs and trade taxes (or subsidies). The transport costs take the familiar "iceberg" form; that is, $1+\nu$ units must be shipped for delivery of one unit. For now, we also allow the governments to impose both tariffs (or import subsidies) and export taxes (or export subsidies). Let τ^J be the *ad valorem* tariff imposed on imports by country J, $J = H, F$, and let e_J denote the *ad valorem* tax imposed on goods that exit its ports. In each case, a negative value of the tax represents a subsidy. We summarize the trade impediments faced by a firm located in country J with the variable ι_J, which is one plus the ad valorem cost of serving the market in K; that is[10]

$$\iota_J = 1 + \nu + e_J + \tau^K,\ J = H, F. \tag{7}$$

For simplicity, we assume that there are no fixed costs of importing or exporting.

As is well known (see, for example, Helpman and Krugman, 1989, pp. 137-145 or Campolmi et. al, 2018), in settings such as this one, the monopoly-pricing distortion in the differentiated-product sector creates an efficiency-enhancing role for consumption subsidies and/or employment subsidies. In what follows, we allow for the possibility that the government in country J might subsidize the consumption of differentiated products at rate s^J. Then, if a firm i in country J sets a (common) factory-gate price of q_i, its local customers pay $p_i^J = (1 - s^J)q_i$ per unit while its foreign customers pay $p_i^K = (1-s^K)\iota_J q_i$ per unit. We do not introduce employment subsidies into our formal analysis, but we will comment on the potential role that such subsidies play in a trade agreement and on the complications they would present in our setting.[11]

We turn next to firms' pricing decisions, for the moment taking product characteristics as given. Each firm treats the price indices P^H and P^F as given when setting its prices. As can be confirmed from (6), this means that each firm perceives a constant elasticity of demand for its brand of $-\sigma$ in each market, regardless of the product characteristics associated with its brand and the policies in place. In this light, it is intuitive and easily established that each firm sets a factory-gate price for each of its variants that is a fixed markup over the pertinent unit cost. Specifically, the profit-maximizing f.o.b. price for the version of brand i produced in J and destined for J' is

$$q_{iJ}^{J'} = \frac{\sigma}{\sigma - 1}\lambda\left(a_{iJ}^{J'}\right),\ J = H, F \text{ and } J' = H, F, \tag{8}$$

[9] We also assume that $\Phi\left(\left|a_i^H - a_i^F\right|\right) \leq 2\Phi(0)$; i.e., the extra design costs are never so great as to give a firm the incentive to establish two separate facilities to manufacture alternative versions of its brand.

[10] We adopt the convention here and henceforth of using K to refer to the country that is "not J"; for example, if $J = H$, then $K = F$. In writing (7), we implicitly assume that transportation services are freely traded. We could instead assume that export taxes are levied on gross exports including those lost in transport, in which case $\iota_J = (1+\nu)(1+e_J) + \tau^K$. This alternative specification would yield similar results.

[11] The governments might also tax or subsidize production and entry. An employment subsidy combines a production subsidy and an entry subsidy at equal rates. In our setting, subsidization of production and entry at different rates is incompatible with global efficiency, so we do not consider such subsidies any further.

where $\sigma/(\sigma-1)$ is, as usual, the common markup factor.[12] Then, the consumer price of a typical local brand in country J is

$$p_J^J = \left(1 - s^J\right) q_J^J,\ J = H, F, \tag{9}$$

while the consumer price of an imported brand in country J is

$$p_K^J = \left(1 - s^J\right) \iota_K q_K^J,\ J = H, F. \tag{10}$$

Consider now a firm's choice of product designs for the versions it will sell on its local and export markets. This decision may be constrained by government regulation, but to identify the impetus for regulatory intervention, we begin by supposing that firms have free rein in designing their products. In view of the demands given by (6) and the pricing prescribed by (8)-(10), a firm producing brand i in country J chooses a_{iJ}^H and a_{iJ}^F to maximize net profits,

$$\begin{aligned}\pi_{iJ} = \sigma^{-\sigma}(\sigma-1)^{\sigma-1} \times \Big[& N^J \left(1-s^J\right)^{-\sigma} A^J \left(a_{iJ}^J\right)^{\sigma} \lambda\left(a_{iJ}^J\right)^{1-\sigma} \left(P^J\right)^{\sigma-1} \\ & + (1+\nu) N^K \left(1-s^K\right)^{-\sigma} \iota_J^{-\sigma} A^K \left(a_{iJ}^K\right)^{\sigma} \lambda\left(a_{iJ}^K\right)^{1-\sigma} \left(P^K\right)^{\sigma-1}\Big] - \Phi\left(\left|a_{iJ}^J - a_{iJ}^K\right|\right).\end{aligned} \tag{11}$$

If a firm were maximizing operating profits alone, it would design its variant for any market in the light of local tastes and production costs. This would yield $a_{iJ}^H = \hat{a}^H$ and $a_{iJ}^F = \hat{a}^F$, where $\hat{a}^J \equiv \arg\max_a A^J(a)^\sigma \lambda(a)^{1-\sigma}$, and $\hat{a}^H > \hat{a}^F$, by the first part of Assumption 1. Note that $\hat{a}^J$ happens to be the optimal variant in the eyes of consumers in country J, considering both the direct effect on utility and the indirect effect on prices. That is, viewing the consumer's problem as one of minimizing the price index P^J in (5), $\hat{a}^J$ is the consumer's favorite under the markup pricing described by (8)-(10). For this reason, we refer to $\hat{a}^J$ as the "ideal version" in country J.[13]

However, with design costs that reflect the difference between its offerings, firms do not supply the ideal version to any market. A small change in the design of the product destined for any market away from the consumers' ideal generates only a second-order loss in operating profits, but provides a first-order savings in design costs. Accordingly, the unregulated firm maximizes profits by designing its offerings so that $\hat{a}^H > a_{iJ}^H > a_{iJ}^F > \hat{a}^F$. Since all firms in a country make the same design choices, we henceforth drop the i subscript and use the notation $\widetilde{a}_J^H$ and $\widetilde{a}_J^F$ to denote the optimal, unregulated product characteristics of a brand that is produced in country J and offered to home and foreign consumers, respectively, and $\widetilde{\pi}_J$ to denote the net profits derived therefrom.

[12] If we define the "world" price, ρ_J, of the exports from country J as the offshore price after export taxes have been collected, but before transport costs, import tariffs and consumption subsidies have been imposed, then $\rho_J \equiv (1+e_J)\, q_J^K$. Notice that world prices are independent of any horizontal characteristics of the differentiated products, and hence independent of any horizontal product standards, while world prices rise one-for-one with the costs of vertical characteristics and hence the cost of vertical standards are completely passed through to consumers in the importing country. For these reasons, governments cannot use their regulatory policies or consumption subsidies to manipulate the terms of trade. While this feature of our model is special, it is also convenient, because it allows us to focus on the other motives for standard setting that are novel in this setting.

[13] With horizontal differentiation among versions of a brand, the ideal corresponds to the version that maximizes the demand shifter. With vertical differentation, a consumer's ideal reflects not only her taste for higher quality, but also her recognition that quality comes at a cost.

2.3 Equilibrium

The equilibrium under any regulatory regime can be solved recursively. First, we take the characteristics of the goods designed by firms in both countries, $\mathbf{a}$, and the number of brands in both countries, $\mathbf{n}$, as given.[14] We use (8), (9), and (10) to solve for prices, $\mathbf{p}$, and then (5) to solve for the price indices, $\mathbf{P}$. Then, the maximization of net profits, $\boldsymbol{\pi}_J$, from (11)—given $\mathbf{n}, \mathbf{P}$, and any constraints imposed by the regulatory regime—yields $\mathbf{a}(\mathbf{n})$ and $\boldsymbol{\pi}(\mathbf{n})$. Finally, if strictly positive numbers of brands are produced in both countries, a pair of zero-profit conditions,

$$\pi_J(\mathbf{n}) = 0, \; J = H, F, \tag{12}$$

determines the number of producers in each. Otherwise, $n_J = 0$ for some J, and $\pi_J \leq 0$.

An *unregulated equilibrium* arises when the governments place no constraints on the choices of characteristics. We offer three observations about this equilibrium that will prove useful later on. First, we highlight the ordering of the profit-maximizing choices of product design.

Lemma 1 *Let trade taxes and consumption subsidies take any values such that $\iota_H > 1$ and $\iota_F > 1$. In the unregulated equilibrium, the profit-maximizing choices of characteristics are such that $\hat{a}^H > \widetilde{a}_H^H > \widetilde{a}_F^H$ and $\widetilde{a}_H^F > \widetilde{a}_F^F > \hat{a}^F$.*

Firms in both countries design their offerings strictly between the nation-specific optima, $\hat{a}^H$ and $\hat{a}^F$, in order to conserve on fixed costs. But when $\iota_H > 1$ and $\iota_F > 1$, all firms make a relatively greater share of their sales in their local market. Therefore, home firms have a relatively greater incentive to cater to the tastes of home consumers ($\widetilde{a}_H^H > \widetilde{a}_F^H$) and foreign firms have a relatively greater incentive to cater to the tastes of foreign consumers ($\widetilde{a}_H^F > \widetilde{a}_F^F$).

Second, we note the response of the numbers of firms in each country to exogenous changes in product characteristics, as might be induced by binding regulation. Suppose that we start at the unregulated equilibrium and make a small change in some $a_J^{J'}$. Then we have the following response in the numbers of brands consistent with zero profits.[15]

Lemma 2 *Let trade taxes and consumption subsidies take any values such that $\iota_H > 1$ and $\iota_F > 1$ and consider the unregulated equilibrium with profit-maximizing choices of characteristics, $\widetilde{\boldsymbol{a}}$. Beginning at $\widetilde{\boldsymbol{a}}$, a small increase in any product characteristic $a_J^{J'}$ induces exit by home firms $\left(dn_H/da_J^{J'} < 0\right)$ and entry by foreign firms $\left(dn_F/da_J^{J'} > 0\right)$ for all $J \in \{H, F\}$ and $J' \in \{H, F\}$.*

To see the intuition, consider the effects of a small increase in the characteristic of the good produced by home firms for the home market. Since $\widetilde{a}_H^H$ maximizes profits for home firms, a marginal change has no effect on home-firm profits at the initial price index, P^H. But the fact that $\widetilde{a}_H^H < \hat{a}^H$

[14] We use boldface variables to denote vectors containing all values of the variable in the world, so that, for example, $\boldsymbol{a} = \left(a_H^H, a_H^F, a_F^H, a_F^F\right)$ and $\mathbf{n} = (n_H, n_F)$, where n_J is number of producers in country J.

[15] See the appendix for the proof of all claims not provided in the text.

implies that P^H falls for a given $\mathbf{n}$.[16] Considering the home bias in consumption induced by the impediments to trade when $\iota_H > 1$, a fall in the home price index has a relatively more powerful (negative) effect on the profits of home firms, which earn a disproportionate share of the profits in the home market, than it does on the profits of foreign firms. So, home firms exit and foreign firms enter. A similar argument applies to a small increase in a_F^H, because $\widetilde{a}_F^H < \hat{a}^H$ as well.

Now consider a marginal increase in the product characteristic of the good produced by foreign firms for the foreign market. Again, this has no direct effect on maximized profits. But $\widetilde{a}_F^F > \hat{a}_F$, so an increase in this characteristic moves it further from the level that maximizes $A^F(a)^\sigma \lambda(a)^{1-\sigma}$, raising the foreign price index P^F for given $\mathbf{n}$. An increase in P^F raises profits relatively more for foreign firms than for home firms, since foreign firms also earn a disproportionate share of profits in their local market. The change in a_F^F induces entry by foreign firms, which in turn generates exit by home firms. A similar argument applies to a small increase in a_H^F, because $\widetilde{a}_H^F > \hat{a}^F$ as well.

Third, we record the (non)-response of the price indices to small changes in product characteristics beginning at the unregulated equilibrium. The total effect of a small change in some $a_J^{J'}$ combines the direct effect and the indirect effects of the induced changes in the numbers of brands, as described in Lemma 2. Combining these effects, we find

Lemma 3 *Let trade taxes and consumption subsidies take any values such that $\iota_H > 1$ and $\iota_F > 1$ and consider the unregulated equilibrium with profit-maximizing choices of characteristics, $\widetilde{\mathbf{a}}$. Beginning at $\widetilde{\mathbf{a}}$, a small change in any product characteristic $a_J^{J'}$ has no first-order effect on the home price index $\left(dP^H/da_J^{J'} = 0\right)$ or on the foreign price index $\left(dP^F/da_J^{J'} = 0\right)$, for $J \in \{H, F\}$ and $J' \in \{H, F\}$.*

To understand why this is so, note that given optimal pricing from (8), profits for home firms are a function of P^H, P^F, a_H^H, and a_H^F, while profits for foreign firms are a function of P^H, P^F, a_F^H, and a_F^F. Now suppose there is a small change in some $a_J^{J'}$, starting from unregulated equilibrium with characteristics $\widetilde{\mathbf{a}}$. Since $\widetilde{a}_J^{J'}$ maximizes profits for firms in J, there can be no first-order effect on profits there. And there is no direct effect at all on the profits of firms in K. Therefore, the adjustments in the two price indices, P^H and P^F, must be such as to leave profits equal to zero for both home and foreign firms. This requires that the two price indices remain unchanged.

In a *regulated equilibrium*, the firms' choices of product characteristics are made subject to the constraints imposed by policy. In the strictest regulatory regime, the governments stipulate directly the characteristics of the goods that can be sold in their markets, in which case firms are left only with a choice of whether to serve the market or not. More permissively, the governments might specify sets of allowable characteristics. We will consider both strict and permissive regulations below, focusing in particular on the policies that can generate efficient outcomes and those that satisfy broad institutional rules such as *national treatment* and *mutual recognition*.

In what follows, we focus on regulated equilibria in which active firms in both locations opt to serve both markets. This is by no means guaranteed in our setting, because the products that

[16] Recall that $\left[A^H(a)\right]^\sigma \lambda(a)^{1-\sigma}$ is maximized at $\hat{a}^H$ and that $a_H^H < \hat{a}^H$ in the unregulated equilbrium. Therefore, a small increase in a_H^H toward $\hat{a}^H$ raises $\left(A^H\right)^\sigma \left(p_H^H\right)^{1-\sigma}$ (see (11)) and therefore reduces P^H (see (5)).

satisfy standards in the export market may be so different from those that do so in the local market that firms cannot earn sufficient profits to cover the cost of providing such disparate versions of their brand. However, it is intuitive and easy to establish that firms will opt to serve both markets for any pair of feasible standards provided that the ratio of the marginal design cost to the marginal production cost is sufficiently small. To avoid a taxonomy, we take this to be the case.

2.4 National and Global Welfare Measures

In this section, we develop expressions for national welfare in each country, and for global welfare, as functions of the tax and subsidy rates applied by the two governments and their regulatory restrictions. Recall from (3) that, for the representative consumer in country J, $V^J = I^J - \log P^J$. Per-capita disposable income in country J is the sum of an individual's labor income, L^J/N^J, and her share of rebated tax revenues (or of subsidy financing), since $\pi_J = 0$.

Aggregate tax revenue in country J, R^J, reflects the government's collections from import tariffs and export taxes less its outlays for consumption subsidies. Noting the pricing equations (8)-(10) and the per-capita demands for differentiated products (6), we have

$$R^J = \frac{\sigma}{\sigma - 1} \left[\tau^J N^J n_K \lambda_K^J c_K^J + e_J N^K n_J \lambda_J^K c_J^K - s^J N^J \left(n_J \lambda_J^J c_J^J + n_K \iota_K \lambda_K^J c_K^J \right) \right] \ ,$$

where $\lambda_J^{J'} \equiv \lambda \left(a_J^{J'} \right)$ and where we have omitted the functional dependence of the equilibrium numbers of firms and the consumption levels on the tax rates and the product characteristics induced by the regulatory regime. We can simplify this expression by noting that spending on differentiated products by the representative consumer in J is $n_J p_J^J c_J^J + n_K p_K^J c_K^J$ and that the optimal level of spending on such goods equals one according to (2). Using again the pricing equations, it follows that government outlays for consumption subsidies amount to $N^J s^J / \left(1 - s^J\right)$, and so

$$R^J = \frac{\sigma}{\sigma - 1} \left(\tau^J N^J n_K \lambda_K^J c_K^J + e_J N^K n_J \lambda_J^K c_J^K \right) - N^J \frac{s^J}{1 - s^J}.$$

Then we can write aggregate national welfare in country J, Ω^J, as

$$\Omega^J = L^J + \frac{\sigma}{\sigma - 1} \left(\tau^J N^J n_K \lambda_K^J c_K^J + e_J N^K n_J \lambda_J^K c_J^K \right) - N^J \frac{s^J}{1 - s^J} - N^J \log P^J \ . \tag{13}$$

Now let $\Omega \equiv \Omega^H + \Omega^F$ denote global welfare. Using (13), we have

$$\Omega = \sum_J L^J + \sum_J z^J N^J n_K \frac{\sigma}{\sigma - 1} \lambda_K^J c_K^J - \sum_J N^J \log P^J - \sum_J N^J \frac{s^J}{1 - s^J}, \tag{14}$$

where $z^J \equiv \tau^J + e_K$ is the net trade tax on goods exported from K to J. Note that the prices of imported goods in J do not depend separately on τ^J and e_K, but only on the net trade tax, z^J, which is the sum of the two (see (10)). Therefore, the consumption levels c_K^J and the price index P^J also depends only on z^J, as do the profit-maximizing characteristics in any regulatory regime and the equilibrium numbers of brands. In short, global welfare depends on the choices of z^H and z^F, and not on the combination of import tariff and export tax that are used to achieve these net taxes; the latter determine only the international distribution of trade tax revenues.[17]

3 New and Old Trade Agreements

In this section, we consider the efficiency properties of various types of trade agreements. We begin by solving the problem that would confront a global social planner. Implicitly, we imagine that the governments can cooperate fully in choosing their trade, fiscal, and regulatory policies. Once we identify the efficient outcome, we ask what form a trade agreement must take to deliver efficiency. We describe a New Trade Agreement (NTA) that limits the use of trade taxes, that imposes national treatment on governments' use of consumption subsidies, and that speaks directly to their choices of product standards. In other contexts, trade agreements that mandate cooperative choices of regulations have been called "deep integration." Following our description of an efficient NTA, we examine shallower forms of integration that we refer to collectively as Old Trade Agreements (OTAs). In our terminology, an OTA restricts choices of trade taxes and requires that consumption subsidies respect national treatment. However, it does not dictate product standards for the two countries. We consider in turn the properties of (i) a Free Trade Agreement (FTA) that imposes zero tariffs and export taxes but that leaves the governments entirely free to set their regulatory policies, (ii) an FTA like the above that gives governments freedom to choose their regulations subject to a rule of *national treatment*, and (iii) an FTA like the above that gives governments freedom to choose their regulations subject to a rule of *mutual recognition*.

3.1 An Efficient Trade Agreement

To identify the first-best trade agreement(s), we seek the net trade taxes, $\mathbf{z}$, the consumption subsidies, $\mathbf{s}$, and the product characteristics, $\mathbf{a}$, that maximize global welfare Ω in (14). In the appendix, we show that the first-order conditions for maximizing Ω are satisfied when $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$, for any value of $\mathbf{a}$. (We also show that the global second-order conditions are satisfied at the optimal value for $\mathbf{a}$.) The intuition is straightforward. The efficient consumption subsidies offset the monopoly distortion that arises due to markup pricing of differentiated products alongside competitive pricing of the homogeneous good. Without the subsidy, the relative consumer price of differentiated products would exceed the marginal rate of transformation in production and consumers would purchase too little of these goods. Meanwhile, net trade taxes different from zero can only harm world welfare once the optimal consumption subsidies are in place, because they distort consumers' allocation of spending between domestic and imported varieties.

As we noted above, a consumption subsidy is not the only policy instrument that can be used to achieve the first best in the current setting. Campolmi et al. (2018) solve the global social planner's problem in a model of monopolistic competition with multiple sectors, albeit without heterogeneous

[17] This property of global welfare with trade taxes is familiar from Bagwell and Staiger (2001) and others.

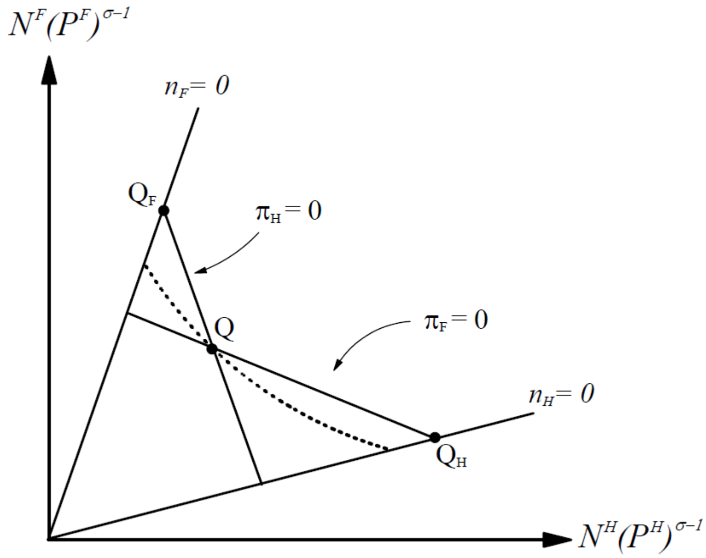

Figure 1: Efficient Trade Agreement

preferences or product standards. They show that the efficient allocation can be achieved with a combination of zero net trade taxes and subsidies to employment in the differentiated products sector that are set at the same rate in the two countries and that together offset the intersectoral misallocation of labor generated by monopoly pricing. In our setting, the global social planner has a degree of freedom; letting s be the (common) subsidy for consumption of differentiated products and ω be the (common) rate of employment subsidy, efficiency is achieved by any combination of s and ω that satisfies $(1-s)(1-\omega) = 1 - 1/\sigma$; see the appendix for a proof. We will return below to discuss how this indeterminacy might be handled in an efficient NTA.

Before that, we examine how the globally-efficient product characteristics are determined, borrowing Figure 1 from Venables (1987). Our Figure 1 is drawn with $N^H\left(P^H\right)^{\sigma-1}$ and $N^F\left(P^F\right)^{\sigma-1}$ on the axes. We fix the product characteristics at the levels $\tilde{\mathbf{a}}$ that would emerge in an unregulated equilibrium and with $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$ (and $\omega = 0$). The downward-sloping line labelled $\pi_H = 0$ gives the combinations of $N^H\left(P^H\right)^{\sigma-1}$ and $N^F\left(P^F\right)^{\sigma-1}$ that are consistent with zero profits for home firms. Similarly, the downward-sloping line labelled $\pi_F = 0$ gives the combinations of $N^H\left(P^H\right)^{\sigma-1}$ and $N^F\left(P^F\right)^{\sigma-1}$ that are consistent with zero profits for foreign firms. The former must be steeper than the latter, as drawn.[18]

Also depicted in the figure are combinations of $N^H\left(P^H\right)^{\sigma-1}$ and $N^F\left(P^F\right)^{\sigma-1}$ that imply $n_H = 0$ and $n_F = 0$, respectively. These combinations are readily derived from the expressions for P^F and P^H. As shown in the figure, the $n_H = 0$ locus is a ray from the origin with slope $(1+\nu)^{1-\sigma}\left(A_F^H/A_F^F\right)^{\sigma}\left(\lambda_F^H/\lambda_F^F\right)^{1-\sigma}\left(N^F/N^H\right)$, while the $n_F = 0$ locus is a ray from the origin with slope $(1+\nu)^{\sigma-1}\left(A_H^H/A_H^F\right)^{\sigma}\left(\lambda_H^H/\lambda_H^F\right)^{1-\sigma}\left(N^F/N^H\right)$. Price indices that lie inside the cone

[18] The slope of $\pi_H = 0$ is $-(1+\nu)^{\sigma-1}\left(A_H^H/A_H^F\right)^{\sigma}\left(\lambda_H^H/\lambda_H^F\right)^{1-\sigma}$, whereas the slope of the $\pi_F = 0$ is $-(1+\nu)^{1-\sigma}\left(A_F^H/A_F^F\right)^{\sigma}\left(\lambda_F^H/\lambda_F^F\right)^{1-\sigma}$. The ordering of their relative slopes follows from the fact that $\nu > 1$, $\left(A_H^H\right)^{\sigma}\left(\lambda_H^H\right)^{1-\sigma} > \left(A_F^H\right)^{\sigma}\left(\lambda_F^H\right)^{1-\sigma}$ and $\left(A_F^F\right)^{\sigma}\left(\lambda_F^F\right)^{1-\sigma} > \left(A_H^F\right)^{\sigma}\left(\lambda_H^F\right)^{1-\sigma}$, considering that $\tilde{a}_H^H > \tilde{a}_F^H$ and $\tilde{a}_F^F < \tilde{a}_H^F$.

bounded by these two rays imply $n_H > 0$ and $n_F > 0$. For illustrative purposes, we have depicted the intersection of the two zero-profit lines as falling inside the cone, hence the equilibrium *sans* regulation is at Q, with active producers in both countries.

Finally, the figure shows a dotted curve through the point Q. Note from (14) that, with $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$, global welfare depends only on the two price indices. The points on the dotted curve are combinations of $N^H \left(P^H\right)^{\sigma-1}$ and $N^F \left(P^F\right)^{\sigma-1}$ that deliver the same global welfare Ω as at point Q. It is straightforward to show that the slope of the iso-welfare curve at any point is given by $-\left(P^F/P^H\right)^{\sigma-1}$ and that the curve is globally convex, as drawn. Moreover, when Q falls inside the cone defined by $n_H = 0$ and $n_F = 0$, the slope of the iso-welfare curve through Q lies between the slope of the $\pi_H = 0$ line and that of the $\pi_F = 0$ line. An infinitesimal change in any product characteristic away from the profit-maximizing levels has no first-order effect on any firm's profits and therefore no effect on the price indices (see Lemma 3); in other words, the first-order conditions for maximizing Ω are satisfied at Q. A small but discrete change in some product characteristic would shift the zero-profit line for the affected firms out and to the right; either we would slide up and to the left along the initial $\pi_H = 0$ line, or down and to the right along the initial $\pi_F = 0$. In either case, world welfare would fall. In other words, the second-order conditions for maximizing Ω are satisfied *locally* at Q.

But consider now a large change in some characteristic, moving for example a_F^H far away from the foreign firms' profit-maximizing choice. The further is a_F^H from $\tilde{a}_F^H$, the greater is the shortfall of foreign firms' profits relative to its maximum and so the greater is the shift in the zero-profit line for these firms. A large shift might take us all the way to point Q_F, where all foreign firms exit the market.[19] If global welfare at Q_F were greater than that at Q, an NTA with onerous regulations for foreign firms that causes massive exit would deliver greater global welfare than one that leaves them free to choose their profit-maximizing characteristics, as underlies the trading equilibrium at Q. Moreover, in such circumstances, the trade negotiators could achieve even higher global welfare than at Q_F by reoptimizing the choice of standards that apply to home firms in absence of foreign competitors. In the appendix, we denote the point of greatest global welfare when $n_F = 0$ as Q_F'. Then we prove that the point Q_F' always yields a smaller sum of utilities than does point Q, when the latter point lies inside the international diversification cone. Hence, the trade negotiators cannot change any product characteristic from its profit-maximizing level and improve thereby on the outcome at Q. Evidently, the profit-maximizing product characteristics are globally efficient when coupled with zero net trade taxes and markup-offsetting consumption subsidies.

We summarize our findings in

Proposition 1 *Let* $\widetilde{\boldsymbol{a}}$ *be the vector of product characteristics that result from profit-maximizing design choices in an unregulated equilibrium when* $z^H = z^F = 0$ *and* $s^H = s^F = 1/\sigma$. *Then the maximum world welfare is achieved in a monopolistically-competitive equilibrium when* $z^H = z^F = 0$, $s^H = s^F = 1/\sigma$, *and* $\boldsymbol{a} = \widetilde{\boldsymbol{a}}$.

[19] Complete delocation might not be possible, if the range of the characteristic space is relatively narrow.

The efficiency of the unregulated equilibrium with optimal consumption subsidies reflects several of our special (but common) assumptions. First, we have assumed that the demand shifters enter utility multiplicatively, in (4). Second, we have posited a constant elasticity of substitution between brands, so that all demand functions have constant price elasticities. Together, these features imply that the elasticity of demand is independent of product characteristics. Spence (1975) showed that a monopolist provider of goods of variable quality provides the socially optimal product when the demand elasticity is independent of quantity and quality. Our result extends his to a setting with monopolistic competition, endogenous variety, and costly trade. Meanwhile, Dixit and Stiglitz (1977) showed that monopolistically-competitive markets achieve a (constrained) optimal trade-off between quantities and variety when demands are CES.[20] Thus, our Proposition 1 is related to these earlier findings, but distinct from them.

How could a globally efficient outcome be attained in our setting by a cooperative NTA? First, the agreement would need to stipulate zero net trade taxes on all goods. This is true as well of an OTA in a setting with only one dimension of product differentiation and an internationally-shared taste for variety; see Campolmi et al. (2018). Without such a provision, the governments would be tempted to use trade policies to induce delocation, as is well known from the work of Venables (1987) and Ossa (2011). That is, they would try to use trade instruments to increase the share of local firms in the global market, since these firms supply goods at lower delivered prices by avoiding shipping costs and, in our context, also deliver products that are more consonant with local tastes.

Second, the agreement could stipulate that $s^H = s^F = 1/\sigma$. However, such a provision would not actually be needed, because, as we show in the appendix, each government faces a unilateral incentive to set its consumption subsidy at the indicated level when it selfishly maximizes local welfare, in any environment with zero net trade taxes. A consumption subsidy subject to national treatment affords no opportunity to favor local firms at the expense of foreign firms. Accordingly, when faced with the freedom to set any subsidy it wants, each government can do no better than to choose the universally preferred subsidy. Alternatively, the agreement could achieve efficiency by designating a universal employment subsidy $\omega = 1/\sigma$ or by stipulating any combination of consumption and employment subsidies such that $(1-s)(1-\omega) = 1 - 1/\sigma$. However, the employment subsidies do not have the same desirable property as the consumption subsidies; namely, the governments would not unilaterally set such subsidies at their globally optimal levels without a provision in the agreement requiring as much. In fact, the governments have the same unilateral incentive to use employment subsidies for delocation as they do for tariffs. Even if the agreement contemplates the use of consumption subsidies to address the monopoly distortion, it would need to regulate the use of employment subsidies to remedy the incentive to delocate. A simple NTA could prohibit the use of employment subsidies and then leave the countries free to choose their optimal consumption subsidies (subject to national treatment).

Finally, the agreement could cover product standards; it might, for example, require the home

[20] Dhingra and Morrow (2019) and Campolmi et. al (2018) recently extended the result of Dixit and Stiglitz (1977) to a setting with heterogeneous firms, albeit without any endogenous choice of quality or other product characteristics.

government to set its product standards such that $\left(a_H^H, a_F^H\right) = \left(\tilde{a}_H^H, \tilde{a}_F^H\right)$ and the foreign government to set its standards such that $\left(a_H^F, a_F^F\right) = \left(\tilde{a}_H^F, \tilde{a}_F^F\right)$. Notice that such a provision would not harmonize standards, nor would it even satisfy principles of national treatment. Clearly, having identical design requirements for goods produced in different countries is inefficient in our setting, because the home-market effect implies that firms should optimally tailor their locally-sold brand closer to local tastes, and then they face different design costs for serving their export market as compared to firms that are local in that market.

An agreement that specifies the fine details of each country's product characteristics is not actually required for efficiency. The coincidence of globally-efficient product standards with the profit-maximizing product attributes provides flexibility in the design of the efficient NTA. Suppose, for example, the agreement were to require the home government to permit the range of product characteristics $\left[\tilde{a}_F^H, \tilde{a}_H^H\right]$ and the foreign government to allow the range of characteristics $[\tilde{a}_F^F, \tilde{a}_H^F]$. Such an agreement treats local and offshore firms symmetrically in each market, so it satisfies national treatment. Faced with such (symmetric) freedom of choice, the firms would make their (different) profit-maximizing choices, and global efficiency would be achieved. A different agreement that achieves the same economic effect would have both governments *commit to* refrain from regulation entirely.

We summarize our characterization of an efficient NTA in a corollary to Proposition 1.

Corollary 1 *Let $\widetilde{\mathbf{a}}$ be the vector of product characteristics that results from profit-maximizing design choices in an unregulated equilibrium when $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$. Then global efficiency is attained by an international agreement that sets all net trade taxes to zero and that requires $\mathbf{a} = \widetilde{\mathbf{a}}$. Alternatively, global efficiency is attained by an international agreement that sets net trade taxes to zero and that requires both countries to refrain from regulating imports. In either case, the NTA should stipulate an optimal combination of consumption and employment subsidies, or else prohibit employment subsidies and allow governments to choose any consumption subsidies subject to national treatment.*

It might be tempting to conclude from this discussion that no NTA is needed at all; i.e., that a cooperative trade agreement to maximize joint welfare can be silent about product standards in the absence of consumption externalities. Such a conclusion is not warranted. In the next section, we compare the efficient NTA with an agreement that dictates free trade and induces markup-offsetting consumption subsidies, but that imposes no restraint on regulation. We find that when stripped of their ability to use trade policy (and employment subsidies) to effect delocation, the two governments have strong incentives to use their regulatory practices for such purposes.

3.2 Can a Free Trade Agreement be Silent about Regulation?

In this section, we study the unilateral incentives that governments have for regulating product characteristics in the context of an OTA that calls for free trade, prohibits employment subsidies, and requires that consumption subsidies satisfy national treatment.[21] We assume that consumption subsidies are positioned to offset monopoly pricing, as they would be by the unilateral choice of each government given that the OTA stipulates zero net trade taxes. We ask if governments would make efficient regulatory choices if they were allowed to choose their standards freely and noncooperatively. By answering this question, we will begin to understand whether governments need to discuss their standard-setting in international negotiations.

With $\boldsymbol{\tau} = \boldsymbol{e} = 0$ and $\boldsymbol{s} = 1/\sigma$, the government of country J seeks to maximize its constituent's welfare with respect to the choice of a_H^J and a_F^J. Substituting $\mathbf{z} = 0$ and $\boldsymbol{s} = 1/\sigma$ into (13), domestic welfare in country J is given in this context by

$$\Omega^J = L^J - N^J \log P^J - N^J \frac{1}{\sigma - 1} \ .$$

Thus, the objective of each government is simply to minimize the local price index. We do not impose national treatment on the governments' standards choices at this point, although we will return to this issue in Section 3.3 below. We aim to characterize the Nash equilibrium that results when the governments choose their regulatory policies freely and noncooperatively.

Let us return to Figure 1, which shows product characteristics at their profit-maximizing levels, and ask whether the home government has any incentive to impose regulations. Consider first the possibility that it might regulate local firms; i.e., it might require home products to have characteristics different from the profit-maximizing choices. Any regulation that requires a discretely different product characteristic than the profit-maximizing choice—be it one that is closer to the home ideal $\hat{a}^H$ or one that is further away—would reduce profits for the typical home firm. Therefore, the introduction of such a policy would shift the $\pi_H = 0$ line to the right. As is clear from the figure, such regulation would result in a *higher* domestic price index, P^H, after the entry and exit of firms in each country that would be needed to restore zero profits for all firms. Clearly, any such standard would reduce home welfare.

Now suppose that the home government contemplates imposing standards on foreign products. No matter whether the home government insists that foreign firms produce versions a bit closer to $\hat{a}^H$ or ones that are a bit further away, binding regulations will reduce profits for foreign firms (before any adjustment in the numbers of firms), inasmuch as such regulations force them to produce versions of their brands discretely different from the ones that maximize profits. Thus, the $\pi_F = 0$ curve shifts to the right, resulting in a *lower* domestic price index, P^H, and a higher foreign price index P^F. In this case, the binding standards applied to imports raise welfare for home residents at the expense of foreign residents.

How do we understand the welfare improvement that comes from imposing standards on imports? Suppose the standards require foreign suppliers to increase a_F^H above $\widetilde{a}_F^H$, by producing goods closer to the home ideal. Such regulations would benefit home consumers directly, because it delivers to them products that they find more appealing at a cost (if any) that they are willing

[21] Our assumptions on the treatment of employment and consumption subsidies conform broadly with the treatment of (specific) production/employment subsidies and consumption tax/subsidies in the WTO.

to pay. At the same time, as Lemma 2 tells us, when the dust settles on the new equilibrium, there will be fewer home firms and more foreign firms than before. But the deleterious effects of the entry and exit do not fully reverse the beneficial effect from having a more suitable imported product, as revealed by the fact that P^H ultimately must fall.[22]

Now suppose that regulation by the home government requires foreign producers to produce goods with lower a and thus further from the home ideal. In this case, the direct effect on the welfare of home consumers is negative. But, according to Lemma 2, home firms would enter while foreign firms would exit. Evidently, the benefits from delocation would outweigh the cost of the diminished appeal of imports to consumers, because—as the figure shows—a small but discrete reduction in a_F^H from the profit-maximizing level $\widetilde{a}_F^H$ also would cause P^H to fall.

In short, starting from the efficient outcome that could be achieved by an NTA, governments that are free to regulate products differently according to their source will see an incentive to apply pernicious standards to import products. The incentive for regulation might be either to mandate products that appeal more to local consumers or to reduce their appeal. In fact, near the efficient characteristics, both incentives for regulation exist at once. Evidently, the globally efficient outcome cannot be achieved with a free trade agreement that is silent on regulation.

Where does the process of non-cooperative regulation lead us? We note first that, no matter what pair of standards apply to imports in the two countries, it is a best response for each government to allow its local firms to choose their characteristics free from regulation, or else to mandate exactly the profit-maximizing choices. Then, as we show in the appendix, for every pair of standards that applies to local products (or for any pair of profit-maximizing choices, if local products are unregulated), each government has a unilateral incentive to push the standard that applies to its imports to an extreme. Each government's incentive for more extreme import standards persists until either it reaches a boundary of the product space and can go no further, or else one of the governments manages to drive all offshore firms from the market. We summarize in

Proposition 2 *Suppose $\tau^H = \tau^F = e_H = e_F = 0$ and $s^H = s^F = 1/\sigma$. Suppose governments are free to choose any standards for local and imported products, without need for national treatment. Then, in the Nash equilibrium of the standard-setting game, either (i) $n_J = 0$ for some $J \in \{H, F\}$, or (ii) $\bar{a}_H^F \in \{a_{\min}, a_{\max}\}$ and $\bar{a}_F^H \in \{a_{\min}, a_{\max}\}$. The equilibrium level of global welfare is less than that attained under an NTA.*

Recall that Lamy (2015, 2016) argued forcefully for regulatory convergence as a *desideratum* in the next phase of trade negotiations. A comparison of Propositions 1 and 2 provides support for his position. Let us say that an NTA delivers *regulatory convergence* if it calls for product standards that reduce firms' total design costs, relative to the outcome under an initial OTA. Then

[22] How could it be that regulation that harms foreign profits ultimately leads to entry of foreign firms and exit by home firms? The answer lies in the asymmetric effects of competition in the home market. When a_F^H moves closer to $\hat{a}^H$, this depresses the home price index, which increases competition in the home market. Such enhanced competition is detrimental to all firms, but especially so for home firms that rely on the home market for a relatively larger share of their profits. With entry and exit, the price index rises above its level after the impact effect alone, but it does not return to its initial, high level.

the efficient NTA that we characterized in Proposition 1 indeed requires regulatory convergence relative to the standards that emerge in a Nash equilibrium of an FTA that leaves countries free to set their own standards, as described in Proposition 2. This is clearly true if the Nash standards are set at their extreme limits, as in Proposition 2(ii). Moreover, as we show in the appendix, it also true if the Nash standards result in complete delocation, as in Proposition 2(i).

Finally, we note in passing that the planner might be able to achieve greater global welfare with an OTA that does not insist upon global free trade. The key to designing a smarter OTA is to set trade taxes that dampen governments' incentives to use standards for delocation. In a setting with positive tariffs and offsetting export subsidies, a change in regulatory policy that generates entry by local firms and exit by foreign firms imposes a cost in foregone revenue for the local tax authority. This adverse revenue effect runs counter to the favorable implications of delocation for the local price index. As we illustrate in the appendix, a smarter OTA often can be designed to deliver less extreme standards and higher global welfare than result under an FTA. However, as we also show, there do not exist any values of import taxes and export subsidies that would permit an OTA to achieve the first best, if the governments are left free to set their standards noncooperatively.

3.3 An FTA with National Treatment

Evidently, governments have powerful incentives to use standards as instruments for delocation under an FTA that imposes no restraints on regulatory practice. Our findings suggest a potential role for national treatment to prevent governments from saddling imports with especially onerous regulations. In this section, we examine whether a simple mandate that standards conform with national treatment can be used to achieve the cooperative outcome in place of the more complex direct negotiations over standards required for an NTA. We begin by assuming that each country specifies a single version of each product that can be sold within its borders. We then turn to the possibility that the governments might specify a set of permissible products, but with the restriction that the same set must be available to all producers regardless of nationality.

As in Section 3.2, we suppose that the countries have concluded an FTA that mandates free trade and induces subsidies that counteract markup pricing; i.e., we take $\tau^J = e_J = 0$ and $s^J = 1/\sigma$ for $J = H, F$. The agreement now includes as well a mandate for national treatment in regulatory policy. We ask, What characteristics $\bar{a}^H$ and $\bar{a}^F$ will the two governments choose if there are no further constraints on their choices? When all brands sold in country J bear the same characteristics, $\bar{a}^J$, the demand shifters take on the common value $\bar{A}^J \equiv A\left(\bar{a}^J, \gamma^J\right)$. In the appendix, we show that the governments' best-response functions satisfy

$$\frac{\Phi'\left(\bar{a}^H - \bar{a}^F\right)}{\Phi\left(\bar{a}^H - \bar{a}^F\right)} \frac{d(\bar{a}^H - \bar{a}^F)}{d\bar{a}^J} = \sigma \frac{A_a\left(\bar{a}^J, \gamma^J\right)}{A\left(\bar{a}^J, \gamma^J\right)} + (1 - \sigma)\, \eta\left(\bar{a}^J\right), \quad J = H, F. \tag{15}$$

The Nash equilibrium is the pair of standards that satisfy these two equations.[23]

[23] This assumes that firms in both countries are active in the Nash equilibrium, which we show in the appendix is true whenever the countries do not differ too greatly in size.

The equilibrium regulations, which we denote by $\bar{a}_{NT}^{H}$ and $\bar{a}_{NT}^{F}$, have the property that $\left[A\left(\bar{a}_{NT}^{H},\gamma^{H}\right)\right]^{\sigma}\left[\lambda\left(\bar{a}_{NT}^{H}\right)\right]^{1-\sigma}=\left[A^{F}\left(\bar{a}_{NT}^{F},\gamma^{F}\right)\right]^{\sigma}\left[\lambda\left(\bar{a}_{NT}^{F}\right)\right]^{1-\sigma}$; i.e., local products are equally attractive to consumers in each country once price differences have been taken into account. The same is true for imports, which bear the same markup and an additional but common cost for shipping. It follows from (15) that the equilibrium standards under national treatment are independent of shipping costs. This is so, because the price index for country J that is consistent with zero profits is multiplicatively separable in a term that reflects all consumer prices and a term that depends on the pair of regulations, $\bar{a}_{NT}^{H}$ and $\bar{a}_{NT}^{F}$. Given this multiplicative separability, shipping costs do not affect the marginal incentives for either government to choose a standard, even though they do affect the welfare level that each attains in equilibrium. The insensitivity of the Nash equilibrium standards to shipping costs contributes to the inefficiency of such an equilibrium, because the standards under an efficient NTA certainly do vary with such costs..

It is obvious that an FTA with national treatment and only a single permissible product type in each country cannot achieve the first best inasmuch as efficiency requires that local and remote firms serve a given market with *different* products.[24] It is tempting to think that this inefficiency is a consequence of our having restricted governments to choose a single standard, whereas the globally efficient outcome requires at least two alternative designs in each country. To check this hypothesis, we now allow each government to specify a set of standards and to allow firms to satisfy any standard in the set. If national treatment is sufficient for global efficiency without need for further restrictions on regulation, then the Nash equilibrium of such a standard-setting game ought to achieve the efficient outcome. In fact, it does not.

The problem that arises in such an environment is that each government wants to reduce the profits of foreign firms relative to domestic firms in order to effect delocation. As we have seen, this leads each government to prescribe extreme characteristics for imported products in the absence of national treatment. When national treatment applies, offshore firms can avoid the adverse consequences of very extreme standards by choosing to conform to the more moderate standards that apply to local firms. The offshore firms cannot be induced to accept a level of profits below the one they could earn under the standard targeted for domestic firms, and so no further delocation is possible beyond what can be achieved with a single standard. Accordingly, neither government can unilaterally achieve higher domestic welfare by offering a set of permissible standards than what it can achieve by naming only one. Faced with this knowledge, a government's best response always includes a strategy of announcing $\bar{a}_{NT}^{J}$ alone, or else it can announce $\bar{a}_{NT}^{J}$ along with other standards that will be ignored by all firms.

We summarize in

[24] In fact, the performance of an FTA may not even be improved by the introduction of national treatment. This can be seen by focusing on the Nash equilibrium of an FTA without national treatment, as described in Proposition 2(ii). From this starting point, the introduction of national treatment has two offsetting effects on joint surplus. On the one hand, by limiting the scope for delocation, $\bar{a}_{H}^{F}$ and $\bar{a}_{F}^{H}$ are moved away from their extremes and toward their efficient levels; on the other hand, as only one standard will now be set by each country, $\bar{a}_{H}^{H}$ and $\bar{a}_{F}^{F}$ will be moved *away* from their efficient, profit-maximizing levels (which recall, absent national treatment, is where they would be set).

Proposition 3 *Suppose $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$. Suppose each government is free to choose any standard or set of standards as long as they are offered to all firms irrespective of origin. Then, in the Nash equilibrium of the standard-setting game, the outcome is equivalent to one in which each government names a single standard, $\bar{a}^H_{NT}$ and $\bar{a}^F_{NT}$. The equilibrium standards are independent of N^H, N^F, and ν and do not achieve the maximal level of global welfare that is attained by an NTA.*

In short, national treatment alone cannot extricate the countries from the prisoner's dilemma that arises from the urge to delocate.[25]

We noted earlier that beginning from the policies that would emerge in the Nash equilibrium of an FTA that is silent on standards, an efficient NTA requires regulatory convergence. Arguably, the outcomes in Proposition 3 provide a better starting point for considering the desirability of regulatory convergence, inasmuch as the current GATT/WTO rules do stipulate national treatment for standards. But a comparison of Propositions 1 and 3 again vindicates Pascal Lamy's (2015, 2016) argument. Namely, the efficient standards under an efficient NTA impose lesser fixed costs than those that firms bear in the Nash equilibrium of an OTA with national treatment.

This claim can be confirmed by comparing the first-order conditions in (15) that characterize the Nash standards under national treatment to those prescribed by profit-maximization, which we recognize as the globally efficient standards. For the representative home firm, the optimal choices of $\tilde{a}^H_H$ and $\tilde{a}^F_H$ when $\mathbf{z} = 0$ and $\mathbf{s} = 1/\sigma$ satisfy

$$\frac{\Phi'\left(\tilde{a}^H_H - \tilde{a}^F_H\right)}{\Phi\left(\tilde{a}^H_H - \tilde{a}^F_H\right)} \frac{d\left(\tilde{a}^H_H - \tilde{a}^F_H\right)}{d\tilde{a}^J_H} = \Lambda^J_H\left(\tilde{a}^H_H, \tilde{a}^F_H\right)\left[\sigma \frac{A_a\left(\tilde{a}^J_H, \gamma^J\right)}{A\left(\tilde{a}^J_H, \gamma^J\right)} + (1-\sigma)\,\eta\left(\tilde{a}^J_H\right)\right], \; J = H, F, \tag{16}$$

where $\Lambda^J_H\left(\tilde{a}^H_H, \tilde{a}^F_H\right)$ is the fraction of its global operating profits that the representative home firm earns in market J. But with $\Lambda^J_H\left(\tilde{a}^H_H, \tilde{a}^F_H\right) < 1$ for $J = H, F$, it follows from (15) and (16) that $\left|\tilde{a}^H_H - \tilde{a}^F_H\right| < \left|\bar{a}^H_{NT} - \bar{a}^F_{NT}\right|$; and thus that an efficient NTA delivers regulatory convergence for home firms. A similar comparison of first-order conditions can be used to confirm that an NTA provides regulatory convergence to foreign firms as well. Intuitively, given its product characteristic in one market, a profit-maximizing firm considers the per-unit (demand and unit cost) benefits from moving its product characteristic in the other market closer to the ideal there only in proportion to the importance of that market in its global operating profits, and so is unwilling to bear the added fixed cost of designing a product as close to the local ideal in that market as does a government when choosing its unilateral best response under national treatment.

3.4 An FTA with Mutual Recognition

Countries might instead rely on mutual recognition as means to neutralize the insidious use of standards for delocation. Under mutual recognition, each government respects the legitimacy of

[25] Our results here differ from those of Mei (2019), who reports that national treatment eliminates the possibility of firm delocation in his model and leads to efficient outcomes in the absence of consumption externalities, reflecting the very different modeling environments across the two papers (see note 5).

the other's regulatory aims; therefore, any product that meets standards in an exporting country is considered acceptable for sale in the importing country. Mutual recognition gives exporting firms a choice of whether to meet the standards in the destination market or those in their own country.[26]

The European Union has explicitly introduced mutual recognition into its customs treaty as an alternative to detailed rules to harmonize standards (see Ortino, 2007, p.310). In its 1985 White Paper on completing the internal market, the European Commission argued that "... the alternative [to mutual recognition] of relying on a strategy based totally on harmonization would be over-regulatory, would take a long time to implement, would be inflexible and could stifle innovation." Mutual recognition in the European context has been interpreted by the European Court of Justice to oblige acceptance of another member's standards whenever a producer is already established in its home country and when it lawfully provides goods or services to the home market that are similar to the ones it intends to supply abroad (Ortino, 2007, p. 312). We will come back to this latter requirement below, after we examine how well mutual recognition can perform in comparison to an agreement that includes more detailed rules on product standards.

We begin again with the case of a single standard in each country. In this setting, the home and foreign governments announce standards $\bar{a}^H$ and $\bar{a}^F$, respectively. Mutual recognition implies that a firm in country J can export to market K a product with characteristic $\bar{a}^K$ or one with characteristic $\bar{a}^J$, whichever yields greater profits. We ask, what standards will the governments choose in Nash equilibrium, if they have already agreed to zero trade taxes and a level playing field for subsidies?

Of course, the governments must anticipate what products firms will produce for any given pair of standards. Presumably, the standard in country J will be closer to $\hat{a}^J$ and that in the country K closer to $\hat{a}^K$, the two levels that the governments would choose in autarky. This creates a trade-off for the firms; if a firm in J meets the standard in K for its export sales, it earns greater operating profits than if it exports the less-appropriate goods that it sells locally. However, by producing a product with $\hat{a}^J$ also for its exports to K, it minimizes design costs. Evidently, firms will meet offshore standards for exports when the extra design costs are small, and they will meet local standards and invoke mutual recognition when the extra design costs are large.[27]

Let us suppose first that the extra cost of producing two versions is modest, so that the governments anticipate that firms will opt to meet standards in their destination markets. In such circumstances, the governments have the same incentives as with national treatment. The Nash equilibrium regulations with mutual recognition, $\bar{a}^H_{MR}$ and $\bar{a}^F_{MR}$, are the same in this case as the pair $\bar{a}^H_{NT}$ and $\bar{a}^F_{NT}$ that result with national treatment , i.e., they satisfy (15) for $J = H$ and $J = F$.

But now suppose that brand adaptation is rather costly, so that each government anticipates that offshore firms will invoke mutual recognition when exporting. Then the government in J

[26] In practice, the presumption of mutual recognition may be rebutted by a government that can show that its different standards are justified and not introduced as a means to impede or disadvantage non-local firms.

[27] There are also intermediate cases when firms in one country produce two versions of their brand and firms in the other invoke mutual recognition, or when some firms in a country make one choice and others do the opposite, and all are indifferent. To conserve on space and the reader's patience, we do not consider these intermediate cases here.

realizes that its standard $\bar{a}^J$ will influence the design choices only of native firms. Accordingly, it should select the standard $\bar{a}^J$ that maximizes profits for firms in J.[28]

In the appendix, we solve for the Nash equilibrium in such circumstances. We find that $\hat{a}^H > \bar{a}^H_{MR} > \bar{a}^F_{MR} > \hat{a}^F$ and that, unlike $\bar{a}^H_{NT}$ and $\bar{a}^F_{NT}$, that standards that emerge with mutual recognition do depend on the size of the shipping costs. Of course, mutual recognition with a single standard in each country does not achieve the first best, because global efficiency requires four different types of products (two different types from each of two different countries), whereas mutual recognition with one standard per country gives rise to only two.

So now we allow each government to set two standards, instead of just one. The government of country J announces $\bar{a}^{J1}$ and $\bar{a}^{J2}$. Firms located in that country must produce a version with one of these characteristics for local sales, but they can choose to meet any of the four legal standards for their sales in country K.

By familiar arguments, each government will choose the product characteristics that maximize profits for its representative national firm. But these are just the pair of standards that would emerge under a globally efficient NTA. We conclude that the governments have a viable alternative to negotiating a detailed NTA when consumption externalities are absent; instead they can negotiate an FTA and agree to mutual recognition of their partner's standards.

Moreover, the same efficient outcome can be attained if each government designates a range of permissible products, $\left[\bar{a}^{J1}, \bar{a}^{J2}\right]$, so long as the range in each country includes the products that it would produce under an efficient NTA. Under mutual recognition, firms would choose for local and export sales those characteristics that maximize profits in each market and then invoke mutual recognition for the exports. But, in this case, the product design and all sales and market composition would be the same as under the efficient NTA.

We note one caveat to these arguments. Recall the terms of the European Union treaty, as interpreted by the European Court of Justice. Under that treaty, a firm can invoke mutual recognition in its export market only if a similar good is supplied – or in the language of the treaty, has been "lawfully marketed" – in its local market. In our setting, global efficiency requires firms to supply *different* goods in the two markets. If an OTA includes mutual recognition but also a restriction such as applies in the European Union, then firms would presumably need to sell some minimal amounts of the variants they export to local consumers in order to qualify for legal sales abroad. This too would introduce an inefficiency.[29] The efficient outcome can be achieved in our

[28] The argument is the same as before. The local price indices are determined by the intersection of a pair of zero-profit lines, as in Figure 1. The slope of the zero-profit line for home firms in the space of $N^H \left(P^H\right)^{\sigma-1}$ and $N^F \left(P^F\right)^{\sigma-1}$ is $-\left(1+\nu\right)^{\sigma-1} \left(A^H_H/A^F_H\right)^{\sigma} \left(\lambda^H_H/\lambda^F_H\right)^{1-\sigma}$, except that now A^H_H, A^F_H, λ^H_H, and λ^F_H are determined by the home standard, $\bar{a}^H$. Similarly, for foreign firms the zero profit line has a slope $-\left(1+\nu\right)^{1-\sigma} \left(A^H_F/A^F_F\right)^{\sigma} \left(\lambda^H_F/\lambda^F_F\right)^{1-\sigma}$ that is determined by $\bar{a}^F$. By the same arguments as before, the home government chooses the $\bar{a}^H$ (now a single number) that maximizes home firm profits; any other choice would yield a zero-profit line shifted up and to the right, which would deliver a higher price index, P^H. This would be the same product that home firms would choose themselves, if they were only allowed one type of product. Analogous arguments apply to $\bar{a}^F$, which must be the profit-maximizing choice by a representative foreign firm.

[29] It is interesting to note that the concept of "lawfully marketed" is not defined in the mutual recognition regulations of the European Union treaty, nor is there any case law from the European Court of Justice on this concept (European

setting only by an FTA that places no such restrictions on the invocation of mutual recognition.

We state

Proposition 4 *Suppose $\tau^H = \tau^F = e_H = e_F = 0$ and $s^H = s^F = 1/\sigma$. Suppose that each government is free to choose two or more standards for local sales and that firms can invoke mutual recognition for export sales of any product that can legally be sold in its native market. Then, in the Nash equilibrium of the standard-setting game, each government will set two or more standards and the outcome achieves the first best.*

4 Consumption Externalities

Until now, we have assumed that an individual's utility depends only on the characteristics of the products she consumes herself. With constant-elasticity demand functions and multiplicative demand-shifters, binding regulations create global inefficiency in such a setting. They are used by welfare-maximizing governments only to encourage delocation and should be banned (or rendered non-binding) in a cooperative trade agreement.

Now we introduce consumption externalities, which presumably broaden the scope for efficiency-enhancing standards. We assume that individuals bear a utility cost from consuming an inferior version of a product, as before, but they also care about the types of products consumed by fellow nationals.[30] Such externalities might arise, for example, if the safety or environmental impacts of a product depend on collective choices, or if social norms generate a distaste for certain versions of a good regardless of whether an individual consumes them herself or sees her compatriots doing so.

It is convenient to specify the subutility from differentiated products as

$$C_D^J = \left\{ \sum_{i \in \Theta^J} \left\{ A^{*J} + \xi \left[A^J \left(a_i^J \right) - A^{*J} \right] \right\} \left(c_i^J \right)^{\beta} + (1-\xi) \left[A^J \left(a_i^J \right) - A^{*J} \right] \left(c_{i\mu}^J \right)^{\beta} \right\}^{\frac{1}{\beta}} ,$$

$$0 < \xi < 1, \; J = \{H, F\} , \quad (17)$$

where $A^{*J} \equiv \max_{a_i^J \in [a_{\min}, a_{\max}]} A^J \left(a_i^J \right)$ is the demand shifter associated with the most appealing version of brand i to consumers in country J (regardless of price) and $c_{i\mu}^J$ denotes mean consumption in the same country. Here, ξ measures (inversely) the extent of the consumption externality. When $\xi \to 1$, an individual cares only about the characteristics of brand i that she consumes herself and

Parliament, 2018, note 3). It is therefore difficult to assess the magnitude of the inefficiency that, according to our findings here, would be introduced by this restriction on the application of mutual recognition. A European Commission guidance document (European Commission, 2013) intended to provide user-friendly guidance on the concept reports that economic operators have faced difficulties "when trying to demonstrate that a product has been lawfully marketed in another Member State," suggesting that the restriction is not costless to meet. But the guidance document also makes it clear that proof of actual *sales* is not necessary (for example, a product label can serve as evidence that a good is lawfully marketed).

[30] In principle, consumption externalities might also have global dimensions; i.e., consumers in a country might also care about the types of goods that are purchased abroad. Since such non-pecuniary externalities introduce an obvious need for international cooperation, we restrict our attention here to externalities that are local in scope.

suffers a loss in utility to the extent that her version differs from the best imaginable. Then (17) converges to (4). But when $\xi \to 0$, the consumer cares almost entirely about the types of goods consumed in the aggregate and only negligibly about the particular type that she purchases herself. Then, she benefits the same from buying any version of a brand i, but loses utility when others purchase inferior types The negative effect of environmentally-unfriendly goods often takes this form; consuming a dirty good may provide the same use-value to an individual as consuming the cleanest good, but collective consumption of dirty goods has adverse consequences for all.

The specification of C_D^J in (17) has several attractive properties for our purposes. First, consumers purchase positive quantities of every brand for all values of ξ; i.e., all goods provide positive value to individuals even when collective demands generate negative externalities. Indeed, when $\xi \to 0$, the use-value is the same for all feasible versions of a brand and so consumers ignore its negative attributes entirely. Second, the negative externality disappears when $a_i^J = a^{*J} \equiv \arg\max_a A^J(a)$; this allows us to distinguish spillovers that arise from consumption *per se* from those associated with product type. The former may be important in practice, but they give rise to the usual arguments for Pigouvian taxes. Here we focus instead on externalities that might motivate standards. Finally, when $c_i^J = c_{i\mu}^J$ (as must be true with identical consumers in each country), the aggregate C_D^J is independent of ξ. This property of (17) is especially useful here, because it implies that the size of ξ does not affect the globally-optimal product characteristics, consumption per brand, or numbers of home and foreign firms. We have already characterized these magnitudes in Section 3. Now we need only to investigate how the market equilibrium in the absence of corrective policies differs from the social optimum and then identify a set of interventions that can be incorporated in a trade agreement to induce the globally efficient outcomes.

4.1 Inefficiency when $\xi < 1$

With the utility function given in (17), each individual in country J perceives the demand shifter $A_i^J \equiv (1-\xi) A^{*J} + \xi A\left(a_i^J, \gamma^J\right)$ when calculating her optimal purchases of brand i. This generates the per-capita demands in (6), where the price index for differentiated products continues to be computed as in (5). However, this latter price index—which we now term the "*brand-level* price index"—no longer is the same as the one that guides the allocation of spending to differentiated products, nor is it the one that enters the indirect utility function in (3). Rather, we show in the appendix that

$$V\left(\mathcal{P}^J, I^J\right) = I^J - \log \mathcal{P}^J, \quad J \in \{H, F\},$$

where

$$\mathcal{P}^J = \left[\frac{\sum_{i\in\Theta^J}\left(A_i^J\right)^\sigma \left(p_i^J\right)^{1-\sigma}}{\sum_{i\in\Theta^J}\left(\frac{\mathcal{A}_i^J}{A_i^J}\right)\left(A_i^J\right)^\sigma \left(p_i^J\right)^{1-\sigma}}\right]^{\frac{\sigma}{\sigma-1}} P^J \tag{18}$$

and $\mathcal{A}_i^J \equiv A\left(a_i^J, \gamma^J\right)$ is the demand shifter that accounts for externalities.

We will refer to $\mathcal{P}^J$ as the "*industry-level* price index." Notice that when $\xi = 1$, the industry-level and brand-level price indices coincide, i.e., $\mathcal{P}^J = P^J$. But in the presence of consumption externalities ($\xi < 1$), we have $A_i^J > \mathcal{A}_i^J$, which implies that $\mathcal{P}^J > P^J$; i.e., the industry-level price index that determines aggregate spending on differentiated products as a group is greater than the brand-level price index that guides individual consumption choices at the variety level. The negative externalities diminish each consumer's enthusiasm for the group of differentiated goods and so each spends less on this bundle of goods than she would with the same prices but no externalities. At the same time, when $\xi < 1$, there is a *relative* distortion of consumption across brands *away from* varieties whose characteristics are closer to a^{*J} and *towards* those whose characteristics are relatively far from the best feasible versions. This can be seen from (6), which implies that the ratio $c_i^J/c_{i'}^J$ of consumption of two brands i and i' is $c_i^J/c_{i'}^J = \left[\left(A_i^J\right)^\sigma \left(p_i^J\right)^{-\sigma}\right] / \left[\left(A_{i'}^J\right)^\sigma \left(p_{i'}^J\right)^{-\sigma}\right]$. The externalities do not affect relative prices (given policies), which are determined by profit-maximizing markups and arbitrage conditions. Then, if variety i is further from a^{*J} than variety i', $c_i^J/c_{i'}^J$ is *decreasing* in ξ. In other words, individuals overconsume inferior goods when they ignore the externalities their consumption choices confer on others.

4.2 A New Trade Agreement in the Presence of Consumption Externalities

In order to characterize the policies that are needed to achieve global efficiency in the presence of consumption externalities, we first introduce notation for the efficient magnitudes. In particular, we apply a superscript or subscript E to denote an efficient outcome. For example, the efficient characteristic for any good produced in some country J' and consumed in some J is $a_{J'}^{JE}$ and the efficient per-capita consumption of such a good is $c_{J'}^{JE}$. Similarly, the efficient numbers of home and foreign firms are n_{HE} and n_{FE}. As before, boldface symbols without country indices denote vectors of all global values; e.g., $\mathbf{n}_E = (n_{HE}, n_{FE})$.

A trade agreement that achieves global efficiency specifies trade policies and consumption subsidies to implement the efficient numbers of firms, $\mathbf{n}_E$, and the efficient per-capita consumption levels of each brand in each country, $\boldsymbol{c}^E$, given the efficient product characteristics, $\boldsymbol{a}^E$. We first characterize the trade policies and consumption subsidies that deliver the efficient per-brand consumption levels and the efficient numbers of home and foreign firms, when product characteristics are set at their efficient levels. Once we have characterized the requisite taxes and subsidies, we will address whether product standards are in fact needed to ensure that firms supply the socially optimal versions of their brands.

Let $p_J^{JE}(\xi)$ and $p_K^{JE}(\xi)$ denote the consumer prices in country J that induce the representative consumer to purchase the efficient quantities c_J^{JE} and c_K^{JE} when the externality parameter is ξ, and let $P^{JE}(\xi)$ denote the country's efficient brand-level price index. Specifically, we need $p_J^{JE}(\xi)$ and $p_K^{JE}(\xi)$ to ensure

$$c_{J'}^{JE} = \left(A_{J'}^{JE}\right)^\sigma \left(p_{J'}^{JE}(\xi)\right)^{-\sigma} \left(P^{JE}(\xi)\right)^{\sigma-1}, \ J \in \{H, F\} \text{ and } J' \in \{H, F\}, \tag{19}$$

where $A_{J'}^{JE} \equiv A\left(a_{J'}^{JE}, \gamma^J\right)$ is the efficient demand shifter for a good produced in J' and sold in J. Inserting the efficient consumption quantities into the zero-profit conditions delivers the efficient numbers of home and foreign firms.

We can use (19) to express the efficient consumer prices for any ξ in terms of the efficient prices that would apply absent externalities. Letting $p_{J'}^{JE}(1)$ denote these latter prices, we have

$$p_{J'}^{JE}(\xi) = p_{J'}^{JE}(1)\left[\left(\frac{A_{J'}^{JE}(\xi)}{\mathcal{A}_{J'}^{JE}}\right)\left(\frac{P^J(\xi)}{\mathcal{P}^{JE}}\right)^{\left(\frac{\sigma-1}{\sigma}\right)}\right],\ J \in \{H,F\} \text{ and } J' \in \{H,F\},$$

where $\mathcal{P}^{JE}$ is the efficient industry-level (and brand-level) price index in country J when $\xi = 1$.

In the appendix, we establish that $p_H^{HE}(\xi) < p_H^{HE}(1)$ and $p_F^{HE}(\xi) > p_F^{HE}(1)$ for all $\xi < 1$; i.e., the presence of negative consumption externalities raises the efficient home price of all imports goods and lowers those of domestic products. The same is true in the foreign country when versions of brand i are horizontally differentiated relative to a country-specific favorite, but $p_F^{FE}(\xi) > p_F^{FE}(1)$ and $p_H^{FE}(\xi) < p_H^{FE}(1)$ when versions of a brand differ in quality.

To understand these findings, consider first the efficient prices in the home country. Recall that $a_H^{HE} > a_F^{HE}$; i.e., the efficient characteristics of local brands are greater than those of imported brands, because the home firms make a disproportionate share of their sales in the home market (and $\hat{a}^H > \hat{a}^F$). Regardless of whether product differentiation is vertical or horizontal, the efficient import goods confer greater (negative) externalities on home consumers than do the efficient domestic products. To make efficient consumption choices, home consumers must face elevated prices for import goods and reduced prices for domestic goods in the presence of such externalities.

But now consider the efficient prices in the foreign country. Recall that $a_F^{FE} < a_H^{FE}$, because foreign firms also make a disproportionate share of their sales in their local market. If the different versions of a brand happen to be horizontally differentiated, then a_F^{FE} is closer to the foreign ideal than is a_H^{FE}; therefore, the imported brands confer greater negative externalities there as well. If follows that $p_F^{FE}(\xi) < p_F^{FE}(1)$ and $p_H^{FE}(\xi) > p_H^{FE}(1)$ in such circumstances. However, if the different versions of a brand are vertically differentiated, then the negative externality is strictly decreasing in the characteristic that measures product quality. Then, it is local brands with their lower quality that confer the greater negative externalities. Thus, imports are *overpriced* and domestic goods are *underpriced* in this case.

The implications for the efficient net trade taxes are immediate. In the home country, efficiency requires that import prices be raised relative to the prices of local brands, which implies $\tau^{HE}(\xi) + e_{FE}(\xi) > 0$; either the home country should levy a positive tariff on imports or the foreign country should tax its exports. For foreign-country imports, the signs of the efficient trade taxes depend on the form of product differentiation: If versions of a brand are horizontally differentiated, then imports in F also should bear positive net trade taxes; if they are vertically differentiated, then flows from H to F should be subsidized.

The consumption subsidies needed to induce the efficient price of differentiated products relative to the numeraire good are given by

$$s^{JE}(\xi) = \frac{1}{\sigma} + \left(\frac{\sigma-1}{\sigma}\right)\left[1 - \frac{p_J^{JE}(\xi)}{p_J^{JE}(1)}\right],\ J = H, F. \tag{20}$$

The first term on the right-hand side in (20) is, as before, the subsidy needed to offset the markup pricing of differentiated products. As we have just noted, the second term is positive for $J = H$, but varies according to the form of product differentiation for $J = F$. It may seem surprising that the optimal home consumption subsidy is *larger* in the presence of a negative consumption externality than in its absence. But the larger subsidy generates extra demand for local brands, while the combined consumption subsidy and net trade tax discourage consumption of import brands, as is optimal considering the greater externality that imports cause. In the foreign country, the same logic applies when imported brands cause the greater externality—as they do with horizontal product differentiation—but the logic is reversed when imports into F are of higher quality than locally-produced goods and thus confer a smaller externality.

Finally, as we confirm in the appendix, the efficient consumption subsidies and net trade taxes in combination with the vector of efficient product attributes deliver the same industry-level price indices as when there are no externalities. We also establish that the extra consumption subsidies and the net trade taxes implied by efficient intervention in the presence of externalities are revenue neutral, implying that global welfare under the efficient policies amounts to

$$\Omega(\xi) = \sum_J L^J - \sum_J N^J \log \mathcal{P}^{JE} - \sum_J N^J \frac{1}{\sigma-1},$$

which is independent of ξ. The optimal policies induce consumers to internalize the externalities caused by their purchase decisions and so protect the world economy from any utility loss.

We turn now to the efficient product characteristics, assuming that the efficient net trade taxes and consumption subsidies are in place. Recall that, with $\xi = 1$, an NTA need not specify particular standards. Instead, the governments can commit to eschew product standards knowing that firms will choose the efficient characteristics when maximizing profits. We ask now whether the details of product regulation need to be addressed in an NTA in the presence of consumption externalities.

To see that product standards indeed are required in an optimal NTA when $\xi < 1$, we evaluate the change in profits for a small change in design around $\mathbf{a}^E$ when the efficient taxes are in place. We know that profits are maximized at $\mathbf{a}^E$ when $\xi = 1$, so the first-order changes in profits are zero in such circumstances. When $\xi < 1$, by contrast, $\frac{\partial \pi_H}{\partial a_H^F} > 0 > \frac{\partial \pi_H}{\partial a_H^H}$ and $\frac{\partial \pi_F}{\partial a_F^F} > 0 > \frac{\partial \pi_F}{\partial a_F^H}$ when evaluated at $\mathbf{a}^E$; i.e., firms in both countries will insufficiently differentiate the local and export versions of their brands in the absence of binding regulations, compared to what is globally efficient. This follows from the fact that firms respond to market demands and consumer demands are insufficiently sensitive to deviations from the local ideal when buyers ignore the adverse affects of their decisions on their compatriots' well-being.

We summarize with

Proposition 5 *Suppose consumption of differentiated products confers externalities, as reflected in (17). Then global efficiency requires $z^H > 0$ and $s^H > 1/\sigma$ for all forms of product differentiation that satisfy Assumption 1. It requires $z^F > 0$ and, $s^F > 1/\sigma$ if versions of a brand are horizontally differentiated, but $z^F < 0$ and, $s^F < 1/\sigma$ if versions of a brand are vertically differentiated. Regulation is needed to ensure efficient product designs. The optimal standards induce firms to design products closer to the ideal in each destination markets compared to their profit-maximizing choices.*

Notice that Proposition 5 implies that, in the presence of consumption externalities, efficient regulatory standards require native producers to produce goods tailored more closely to local tastes than what is required of offshore producers; i.e., $\hat{a}^H > a_H^{HE} > a_F^{HE}$ and $a_H^{FE} > a_F^{FE} > \hat{a}^F$. This feature of efficient regulation may seem surprising, but it has a natural interpretation in our context. It simply reflects the more favorable benefit-to-cost ratio that results from moving local brands closer to the local ideal as compared to that for imported brands, in view of the greater market potential that firms enjoy in their local markets in the presence of shipping costs. We emphasize, however, that the more lenient treatment of imports with respect to product standards must be coupled with additional taxes (in the form of positive net trade taxes) that shift demand away from these goods inasmuch as they impose the greatest consumption externalities.

4.3 Can Mutual Recognition Address Externalities?

In Section 3.4, we demonstrated that, in the absence of consumption externalities, global efficiency can be achieved under an OTA without the need for detailed international rules on product standards, provided that each government can set (at least) two standards subject to the principle of mutual recognition. In this section, we revisit the same question, asking whether an OTA with mutual recognition can generate the globally efficient outcome when consumption externalities are present. We will answer this question in the negative.[31]

Recall that when there are no consumption externalities and an OTA allows each country to announce two standards subject to mutual recognition, each government selects as its two standards one that is profit maximizing for its firms' local sales and the other that is profit maximizing for its firms' export sales. Each country selects these standards, because its own incentives are aligned with those of its firms. If a country chooses the profit-maximizing standards for its own firms, those firms have no reason to select any other option than the one intended for them, even though they have the freedom under mutual recognition to choose any of the four standards available in the world. And by choosing product characteristics for each market to maximize their profits, each country's firms make choices that minimize the country's industry-level price index.

When consumption choices confer externalities, the profit-maximizing product attributes no longer correspond to the efficient standards, and this changes everything. To see why, suppose we start with efficient standards and ask whether any firm or government has an incentive to deviate. There are two problems that arise. First, since none of these standards has been set at the profit-

[31] Our finding mirrors those of Costinot (2008) and Mei (2019), although the settings are quite different.

maximizing level, firms will not select into the standard that would be efficient for them if there is a better option available among the four efficient standards from which they can choose. Second, putting this problem to the side, let us suppose hypothetically that firms *would* select into the standards that are efficient for them. Now consider the incentives facing the home government. Instead of setting the efficient standard a_H^{FE} for its firms' export sales, suppose it were to announce a standard slightly closer to the one that would maximize its firms' profits given the other three standards in place. Such a (small) deviation would induce delocation, to the benefit of the home country. Meanwhile, foreign consumers would bear the full cost of the greater externalities.

We conclude that the effectiveness of mutual recognition for achieving efficiency is limited to situations where there are no important externalities that motivate regulation. This suggests the merits of an approach that lies somewhere between the OTA with mutual recognition characterized in Proposition 4 and the NTA described in the corollary to Proposition 1: Countries could negotiate directly over product standards, as in an NTA, but only *selectively* for those goods where externality problems are sufficiently severe; and they could apply mutual recognition for standards that are *not* directly negotiated, with exceptions to mutual recognition allowed if the existence of harmful externalities can be proven.[32]

4.4 Can a Non-violation Clause Address Externalities?

If an OTA with mutual recognition cannot deliver efficient regulatory policies in the presence of consumption externalities, might a "non-violation" clause of the sort incorporated into the GATT/WTO conceivably do so? Non-violation claims are intended to insulate signatories from the adverse effects of internal policy adjustments by partner countries subsequent to their concluding an OTA. If governments might be tempted to manipulate these policies in order to boost their *terms of trade* and thereby shift some of the costs of their policies onto trading partners, then a clause that preserves partners' market access after any internal policy change can prevent such opportunistic behavior; see Bagwell and Staiger (1999, 2002) and Staiger and Sykes (2017).[33]

Can one find an interpretation or modification of the non-violation clause that also eliminates incentives for the opportunistic application of product standards to effect *delocation*, once trade taxes have been constrained by negotiated agreement and where the presence of consumption externalities prevents the attainment of efficient standards through mutual recognition? For a modified non-violation clause to succeed, the allowable policy adjustments by country J must preserve the welfare of country K, $V\left(\mathcal{P}^K, I^K\right)$.

Two challenges arise when attempting to design a workable non-violation clause in this context. First, product standards alter the very nature of the goods that are traded. How should the WTO

[32] In essence, the exceptions to mutual recognition that we describe here amount to a "rebuttable presumption" that regulatory requirements imposed by the host country on a foreign provider will violate the mutual recognition clause, mirroring the design of the European Union's mutual recognition clause (see Ortino, 2007, p. 312.).

[33] Market access commitments in the GATT/WTO are interpreted as commitments to conditions of competition between exporting and import-competing firms. Bagwell and Staiger (2002) provide a formal definition of market access within the context of the terms-of-trade theory of trade agreements and argue that it can be interpreted as a commitment to a given volume of exports at a given exporter price.

interpret "market access" when stricter standards may impose higher costs on foreign firms? Should the WTO assess harm to market access using the sales volume at the original exporter price, as has been proposed for terms-of-trade externalities? Defining market access is challenging whenever we attempt to apply the logic of non-violation to product standards, but when the underlying incentives relate to terms-of-trade externalities straightforward modifications to the non-violation clause can suffice.[34] In the present context, it is not clear what modifications to the non-violation clause, if any, would eliminate the temptation to delocate with product standards.[35]

Second, the presence of consumption externalities further complicates the design of a workable non-violation clause. The logic of non-violation requires that allowable standards in country J preserve the welfare of country K, including the external diseconomies that result from individual consumption choices. In the present context, it no longer suffices that the adjudicating authority be sensitive to sales volumes and the resulting *brand-level* price index P^K; now it must also assess the effect of regulatory policies in J on the *industry-level* price index $\mathcal{P}^K$ in K. As is clear from (18), $\mathcal{P}^K$ depends not only on market magnitudes, but also on product attributes and the strength of the consumption externalities. This new challenge is in some sense more fundamental than the first, because it means that preserving market access—however defined—will not guarantee the preservation of welfare. Enforcement of a non-violation clause for product standards in the present context will require detailed information about the extent of consumption externalities that is not likely to be available to the adjudicating authority.[36]

5 Conclusions

Old trade agreements cover traditional protectionist instruments, such as tariffs and quotas. New trade agreements extend international cooperation to a broader set of policy instruments, including domestic regulations and product standards. In this paper, we have introduced cross-country preference heterogeneity into a familiar model of trade in differentiated products. We have used our model to study the need for international cooperation on regulatory practices in an environment where firms design their offerings to appeal to local tastes while facing fixed costs that increase with the difference in characteristics of versions destined for different markets.

In the absence of externalities, the product attributes chosen by profit-maximizing firms are globally optimal, but governments have unilateral incentives to use insidious regulations in an effort to induce firm delocation. An efficient trade agreement requires commitments not to engage

[34] As Staiger and Sykes (2011) describe, in the context of the terms-of-trade theory of trade agreements the non-violation clause can be applied to the case of product standards without further modification if market access is defined with respect to the exporter price of the "raw" unregulated product.

[35] The issue can be seen most clearly, for example, in the case of vertical standards. In his analysis of delocation using tariffs, Ossa (2011) points out that fixing the value of a country's manufactured exports and imports also fixes the numbers of foreign and domestic firms. In contrast, when vertical product standards are used for delocation, fixing the value of trade does not fix the composition of firms and so does not eliminate delocation.

[36] In the context of the terms-of-trade theory of trade agreements, knowledge of the externalities would of course be important for determining the levels of market access that an efficient trade agreement would implement; but conditional on these levels of market access, only knowledge of market magnitudes would be required to assess changes in market access (see note 33) and thereby administer the non-violation clause in an OTA.

in such opportunistic behavior, in addition to the familiar adherence to zero net tariffs and national treatment for consumption subsidies. An OTA with national treatment for standards cannot achieve the first best, because the governments lack unilateral incentives to offer foreign firms the opportunity to produce the profit-maximizing varieties for their export sales. An NTA in which standards are negotiated directly can achieve the first best, and would lead to a degree of regulatory convergence. But explicit negotiation over standards is not the only way to achieve the first best: an OTA with mutual recognition of partners' standards can generate the optimal policies, provided that governments can announce multiple standards and that exporting firms can invoke the clause even for variants of their brand that they do not sell at home.

In the presence of consumption externalities—even ones that do not cross international borders—the requirements for cooperation are more severe. In the absence of regulation, individuals overconsume variants that confer greater externalities and underconsume those that do less harm to fellow citizens. With a caveat that applies to a country that imports high-quality goods among versions of a brand that are vertically differentiated, the optimal NTA combines positive net tariffs that switch demand to goods that confer lesser externalities with product standards that force all firms to deviate less from the local ideals despite the extra fixed costs of doing so. In this setting, neither national treatment nor mutual recognition suffices to achieve a globally efficient outcome in an agreement that leaves governments with sovereignty over local regulations. Taken together, these findings suggest that countries could negotiate selectively over product standards where externality problems are sufficiently severe, and then rely on mutual recognition to achieve efficient policies for standards that were not directly negotiated.

Our model assumes that all firms within a country are homogeneous and that governments seek to maximize the welfare of their representative citizen. But we believe that the extension of our results to a world of heterogeneous firms and to a more general set of government objectives is both feasible and potentially interesting. For example, Bagwell and Lee (2018a,b) extend the analysis of delocation incentives associated with import tariffs and export subsidies to settings with heterogeneous firms, focusing on implications for the treatment of export subsidies in trade agreements. We believe that an analogous extension of our framework to incorporate heterogeneous firms would yield interesting insights into the treatment of product standards in a setting where firms of different underlying productivity are impacted differently by the (fixed) costs of complying with distinct standards in various markets. The extension of our framework to include governments with political/distributional objectives would also be interesting, especially given the rich set of tax and non-tax instruments that are featured in our analysis and that could potentially be subjected to political pressures. These and other extensions strike us as fruitful areas for future work.

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Appendix to:

The "New" Economics of Trade Agreements: From Trade Liberalization to Regulatory Convergence?

Gene M. Grossman, Phillip McCalman and Robert W. Staiger

1 $\breve{A}\left(\left|a_i^J - \gamma^J\right|\right)$ satisfies Assumption 1

Let $A^J = \breve{A}\left(\left|a_i^J - \gamma^J\right|\right)$, $\breve{A}' < 0$, $\breve{A}'' < 0$, $\gamma^H > \gamma^F$. We consider three regions.

(i) $a > \gamma^H > \gamma^F$, then $\frac{\partial A^H}{\partial a} = A'(a - \gamma^H) < 0$ and $\frac{\partial A^F}{\partial a} = A'(a - \gamma^F) < 0$ and $A'(a - \gamma^H) > A'(a - \gamma^F)$. Meanwhile, $A^H > A^F$. So we have

$$\frac{d \log A^H(a)}{da} = \frac{A'(a - \gamma^H)}{A^H} > \frac{A'(a - \gamma^F)}{A^F} = \frac{d \log A^F(a)}{da}.$$

(ii) $\gamma^H > a > \gamma^F$, then $\frac{\partial A^H}{\partial a} = -A'(a - \gamma^H) > 0$ and $\frac{\partial A^F}{\partial a} = A'(a - \gamma^F) < 0$. Meanwhile, A^H and A^F are both positive. So we have

$$\frac{d \log A^H(a)}{da} = \frac{A'(a - \gamma^H)}{A^H} > 0 > \frac{A'(a - \gamma^F)}{A^F} = \frac{d \log A^F(a)}{da}.$$

(iii) $\gamma^H > \gamma^F > a$, then $\frac{\partial A^H}{\partial a} = -A'(a - \gamma^H) > 0$ and $\frac{\partial A^F}{\partial a} = -A'(a - \gamma^F) > 0$ and $-A'(a - \gamma^H) > -A'(a - \gamma^F)$. Meanwhile, $A^F > A^H$. So we have

$$\frac{d \log A^H(a)}{da} = \frac{-A'(a - \gamma^H)}{A^H} > \frac{-A'(a - \gamma^F)}{A^F} = \frac{d \log A^F(a)}{da}.$$

So $\breve{A}\left(\left|a_i^J - \gamma^J\right|\right)$ is log-supermodular in a_i^J and γ^J. In addition,

$$A_{aa} = \frac{\breve{A}''\breve{A} - \left(\breve{A}'\right)^2}{\breve{A}^2}$$

is always negative when $\breve{A}'' < 0$.

2 Proof of Lemma 2

Lemma 2 *Let trade taxes and consumption subsidies take any values such that* $\iota_H > 1$ and $\iota_F > 1$ *and consider the unregulated equilibrium with the profit-maximizing choices of characteristics, a. Beginning at this equilibrium, a small increase in the product characteristic of any firm for any market induces exit by home firms* ($dn_H/da_J^{J'} < 0$) *and entry by foreign firms* ($dn_F/da_J^{J'} > 0$) *for all* $J \in \{H, F\}$ *and* $J' \in \{H, F\}$).

Proof To prove Lemma 2, we make use of the zero-profit conditions

$$\frac{1}{\sigma-1}\left[N^J \tilde{c}_J^J\left(a_J^J, P^J\left(\boldsymbol{n}, a_H^J, a_F^J\right)\right)+(1+\nu) N^K \tilde{c}_J^K\left(a_J^K, P^K\left(\boldsymbol{n}, a_H^K, a_F^K\right)\right)\right]=\Phi\left(\left|a_J^J-a_J^K\right|\right), \; J=H, F.$$

where $\tilde{c}_J^J=\lambda_J^J c_J^J\left(a_J^J, P^J\left(\boldsymbol{n}, a_H^J, a_F^J\right)\right)$ and $\tilde{c}_J^K=\lambda_J^K c_J^K\left(a_J^K, P^K\left(\boldsymbol{n}, a_H^K, a_F^K\right)\right)$.

We prove the claims of Lemma 2 for standards in the home-country market, with the proof for standards in the foreign-country market proceeding in an analogous fashion.

2.1 $\frac{dn_H}{da_H^H}<0$ and $\frac{dn_F}{da_H^H}>0$

Totally differentiating the zero-profit conditions with respect to n_H, n_F and a_H^H yields

$$\begin{aligned}\frac{N^H}{\sigma-1}&\left[\frac{\partial \tilde{c}_H^H}{\partial a_H^H} da_H^H+\frac{\partial \tilde{c}_H^H}{\partial P^H} \frac{\partial P^H}{\partial a_H^H} da_H^H+\frac{\partial \tilde{c}_H^H}{\partial P^H} \frac{\partial P^H}{\partial n_H} dn_H+\frac{\partial \tilde{c}_H^H}{\partial P^H} \frac{\partial P^H}{\partial n_F} dn_F\right] \\ &+(1+\nu) \frac{N^F}{\sigma-1}\left[\frac{\partial \tilde{c}_H^F}{\partial P^F} \frac{\partial P^F}{\partial n_H} dn_H+\frac{\partial \tilde{c}_H^F}{\partial P^F} \frac{\partial P^F}{\partial n_F} dn_F\right]=\left[\Phi'\left(\left|a_H^H-a_H^F\right|\right)\right] da_H^H \quad (21)\end{aligned}$$

$$\begin{aligned}\frac{N^F}{\sigma-1}&\left[\frac{\partial \tilde{c}_F^F}{\partial P^F} \frac{\partial P^F}{\partial n_H} dn_H+\frac{\partial \tilde{c}_F^F}{\partial P^F} \frac{\partial P^F}{\partial n_F} dn_F\right] \\ &+(1+\nu) \frac{N^H}{\sigma-1}\left[\frac{\partial \tilde{c}_F^H}{\partial P^H} \frac{\partial P^H}{\partial a_H^H} da_H^H+\frac{\partial \tilde{c}_F^H}{\partial P^H} \frac{\partial P^H}{\partial n_H} dn_H+\frac{\partial \tilde{c}_F^H}{\partial P^H} \frac{\partial P^H}{\partial n_F} dn_F\right]=0. \quad (22)\end{aligned}$$

But the home firm chooses a_H^H to satisfy the first-order condition for profit maximization,

$$\frac{\partial \pi_H^H}{\partial a_H^H}=\frac{N^H}{\sigma-1} \frac{\partial \tilde{c}_H^H}{\partial a_H^H}-\Phi'\left(\left|a_H^H-a_H^F\right|\right)=0,$$

which we may substitute into (21) to arrive at the home and foreign totally differentiated zero-profit conditions evaluated at the profit-maximizing choices:

$$\frac{N^H}{\sigma-1}\left[\frac{\partial \tilde{c}_H^H}{\partial P^H} \frac{\partial P^H}{\partial a_H^H} da_H^H+\frac{\partial \tilde{c}_H^H}{\partial P^H} \frac{\partial P^H}{\partial n_H} dn_H+\frac{\partial \tilde{c}_H^H}{\partial P^H} \frac{\partial P^H}{\partial n_F} dn_F\right]+(1+\nu) \frac{N^F}{\sigma-1}\left[\frac{\partial \tilde{c}_H^F}{\partial P^F} \frac{\partial P^F}{\partial n_H} dn_H+\frac{\partial \tilde{c}_H^F}{\partial P^F} \frac{\partial P^F}{\partial n_F} dn_F\right]=0 \quad (23)$$

$$\frac{N^F}{\sigma-1}\left[\frac{\partial \tilde{c}_F^F}{\partial P^F} \frac{\partial P^F}{\partial n_H} dn_H+\frac{\partial \tilde{c}_F^F}{\partial P^F} \frac{\partial P^F}{\partial n_F} dn_F\right]+(1+\nu) \frac{N^H}{\sigma-1}\left[\frac{\partial \tilde{c}_F^H}{\partial P^H} \frac{\partial P^H}{\partial a_H^H} da_H^H+\frac{\partial \tilde{c}_F^H}{\partial P^H} \frac{\partial P^H}{\partial n_H} dn_H+\frac{\partial \tilde{c}_F^H}{\partial P^H} \frac{\partial P^H}{\partial n_F} dn_F\right]=0. \quad (24)$$

Solving (24) for dn_F, substituting into (23), and simplifying yields

$$\frac{dn_H}{da_H^H}=\frac{-\frac{\partial P^H}{\partial a_H^H} \frac{\partial P^F}{\partial n_F}}{\frac{\partial P^H}{\partial n_H} \frac{\partial P^F}{\partial n_F}-\frac{\partial P^H}{\partial n_F} \frac{\partial P^F}{\partial n_H}}. \quad (25)$$

The denominator of the expression in (25) is strictly positive provided for $\iota^H > 1$ and $\iota^F > 1$ (a condition stated in the lemma), while the term in the numerator comprises the product of two negative terms and hence is positive as well. Hence, $\frac{dn_H}{da_H^H} < 0$ as claimed in Lemma 2.

To establish that $\frac{dn_F}{da_H^H} > 0$, we solve (24) for dn_H and substitute the resulting expression into (23) and simplify to arrive at

$$\frac{dn_F}{da_H^H} = \frac{\frac{\partial P^H}{\partial a_H^H}\frac{\partial P^F}{\partial n_H}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}} \tag{26}$$

which is positive.

2.2 $\frac{dn_H}{da_F^H} < 0$ and $\frac{dn_F}{da_F^H} > 0$

Totally differentiating the zero-profit conditions with respect to n_H, n_F and a_F^H yields

$$\frac{N^H}{\sigma-1}\left[\frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial a_F^H}da_F^H + \frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial n_H}dn_H + \frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial n_F}dn_F\right] + (1+\nu)\frac{N^F}{\sigma-1}\left[\frac{\partial \tilde{c}_H^F}{\partial P^F}\frac{\partial P^F}{\partial n_H}dn_H + \frac{\partial \tilde{c}_H^F}{\partial P^F}\frac{\partial P^F}{\partial n_F}dn_F\right] = 0 \tag{27}$$

$$\frac{N^F}{\sigma-1}\left[\frac{\partial \tilde{c}_F^F}{\partial P^F}\frac{\partial P^F}{\partial n_H}dn_H + \frac{\partial \tilde{c}_F^F}{\partial P^F}\frac{\partial P^F}{\partial n_F}dn_F\right] + (1+\nu)\frac{N^H}{\sigma-1}\left[\frac{\partial \tilde{c}_F^H}{\partial a_F^H}da_F^H + \frac{\partial \tilde{c}_F^H}{\partial P^H}\frac{\partial P^H}{\partial a_F^H}da_F^H + \frac{\partial \tilde{c}_F^H}{\partial P^H}\frac{\partial P^H}{\partial n_H}dn_H + \frac{\partial \tilde{c}_F^H}{\partial P^H}\frac{\partial P^H}{\partial n_F}dn_F\right] = \frac{\Phi'\left(\left|a_F^H - a_F^F\right|\right)}{q-\lambda}da_F^H. \tag{28}$$

But the foreign firm chooses a_F^H to satisfy the first-order condition for profit maximization,

$$\frac{\partial \pi_F^H}{\partial a_F^H} = (1+\nu)\frac{N^H}{\sigma-1}\frac{\partial \tilde{c}_F^H}{\partial a_F^H} - \Phi'\left(\left|a_F^H - a_F^F\right|\right) = 0,$$

which we may substitute into (28) to arrive at the home and foreign totally differentiated zero-profit conditions evaluated at the profit-maximizing choices:

$$\frac{N^H}{\sigma-1}\left[\frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial a_F^H}da_F^H + \frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial n_H}dn_H + \frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial n_F}dn_F\right] + (1+\nu)\frac{N^F}{\sigma-1}\left[\frac{\partial \tilde{c}_H^F}{\partial P^F}\frac{\partial P^F}{\partial n_H}dn_H + \frac{\partial \tilde{c}_H^F}{\partial P^F}\frac{\partial P^F}{\partial n_F}dn_F\right] = 0 \tag{29}$$

$$\frac{N^F}{\sigma-1}\left[\frac{\partial\tilde{c}_F^F}{\partial P^F}\frac{\partial P^F}{\partial n_H}dn_H+\frac{\partial\tilde{c}_F^F}{\partial P^F}\frac{\partial P^F}{\partial n_F}dn_F\right]$$
$$+(1+\nu)\frac{N^H}{\sigma-1}\left[\frac{\partial\tilde{c}_F^H}{\partial P^H}\frac{\partial P^H}{\partial a_F^H}da_F^H+\frac{\partial\tilde{c}_F^H}{\partial P^H}\frac{\partial P^H}{\partial n_H}dn_H+\frac{\partial\tilde{c}_F^H}{\partial P^H}\frac{\partial P^H}{\partial n_F}dn_F\right]=0. \quad (30)$$

Solving (29) for dn_F, substituting into (30), and simplifying yields

$$\frac{dn_H}{da_F^H}=\frac{-\frac{\partial P^H}{\partial a_F^H}\frac{\partial P^F}{\partial n_F}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F}-\frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}}. \quad (31)$$

As before, the denominator of the expression in (31) is strictly positive provided that $\iota_H > 1$ and $\iota_F > 1$, while the term in the numerator comprises the product of two negative terms and hence is positive as well. Hence, $\frac{dn_H}{da_F^H} < 0$ as claimed in Lemma 2.

To establish that $\frac{dn_F}{da_F^H} > 0$, we solve (29) for dn_H and substitute the resulting expression into (30) and simplify to arrive at

$$\frac{dn_F}{da_F^H}=\frac{\frac{\partial P^H}{\partial a_F^H}\frac{\partial P^F}{\partial n_H}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F}-\frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}} \quad (32)$$

which is positive.
QED

3 Proof of Lemma 3

Lemma 3 *Let trade taxes and consumption subsidies take any values such that* $\iota_H > 1$ and $\iota_F > 1$ *and consider the unregulated equilibrium with the profit-maximizing choices of characteristics, a. Beginning at this equilibrium, a small change in any product characteristic* $a_{J'}^J$ *has no first-order effect on the home price index* $\left(dP^H/da_{J'}^J=0\right)$ *or on the foreign price index* $\left(dP^F/da_{J'}^J=0\right)$.

Proof The proof follows from the derivative expressions in the proof of Lemma 2. In general, the eight derivatives boil down to the following two calculations that need to be performed for all $J \in \{H, F\}$ and $J' \in \{H, F\}$, where D^J is an indicator variable that is equal to 1 for $J = H$ and equal to -1 for $J = F$:

$$\begin{aligned}\frac{dP^J}{da_{J'}^J} &= \frac{\partial P^J}{\partial a_{J'}^J}+\frac{\partial P^J}{\partial n_H}\frac{dn_H}{da_{J'}^J}+\frac{\partial P^J}{\partial n_F}\frac{dn_F}{da_{J'}^J} \quad (33)\\ &= \frac{\partial P^J}{\partial a_{J'}^J}+\frac{\partial P^J}{\partial n_H}\left(\frac{-D^J\frac{\partial P^J}{\partial a_{J'}^J}\frac{\partial P^K}{\partial n_F}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F}-\frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}}\right)+\frac{\partial P^J}{\partial n_F}\left(\frac{D^J\frac{\partial P^J}{\partial a_{J'}^J}\frac{\partial P^K}{\partial n_H}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F}-\frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}}\right)\\ &= \frac{\partial P^J}{\partial a_{J'}^J}\left[1-\left(\frac{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F}-\frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F}-\frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}}\right)\right]=0\end{aligned}$$

$$\begin{aligned}\frac{dP^K}{da^J_{J'}} &= \frac{\partial P^K}{\partial n_H}\frac{dn_H}{da^J_{J'}} + \frac{\partial P^K}{\partial n_F}\frac{dn_F}{da^J_{J'}} \\ &= \frac{\partial P^K}{\partial n_H}\left(\frac{-D^J \frac{\partial P^J}{\partial a^J_{J'}}\frac{\partial P^{J'}}{\partial n_F}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}}\right) + \frac{\partial P^K}{\partial n_F}\left(\frac{D^J \frac{\partial P^J}{\partial a^J_{J'}}\frac{\partial P^K}{\partial n_H}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}}\right) \\ &= \frac{\partial P^J}{\partial a^J_{J'}}\left(\frac{\frac{\partial P^K}{\partial n_F}\frac{\partial P^K}{\partial n_H} - \frac{\partial P^K}{\partial n_F}\frac{\partial P^K}{\partial n_H}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}}\right) = 0.\end{aligned} \tag{34}$$

QED

4 Proof of Proposition 1

Proposition 1 *Let $\widetilde{\boldsymbol{a}}$ be the vector of product characteristics that result from profit-maximizing design choices in an unregulated equilibrium when $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$. Then the maximum world welfare is achieved in a monopolistically-competitive equilibrium when $z^H = z^F = 0$, $s^H = s^F = 1/\sigma$, and $\bar{a} = \widetilde{\boldsymbol{a}}$.*

Proof We begin with the expression for world welfare:

$$\Omega = \sum_J L^J - N^H \log(P^H) - N^F \log(P^F) + \frac{\sigma}{\sigma-1} z^H n_F N^H \tilde{c}^H_F + \frac{\sigma}{\sigma-1} z^F n_H N^F \tilde{c}^F_H - N^H \frac{s^H}{1-s^H} - N^F \frac{s^F}{1-s^F}.$$

We first prove that global efficiency requires $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$. We then turn to the efficiency of $\bar{a} = \widetilde{\boldsymbol{a}}$.

Evaluating the derivatives of Ω with respect to net trade taxes and consumption subsidies at the levels $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$ yields

$$\begin{aligned}\left.\frac{d\Omega}{dz^H}\right|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} &= -\frac{N^H}{P^H}\frac{dP^H}{dz^H} - \frac{N^F}{P^F}\frac{dP^F}{dz^H} + \frac{\sigma}{\sigma-1} n_F N^H \tilde{c}^H_F \\ \left.\frac{d\Omega}{dz^F}\right|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} &= -\frac{N^H}{P^H}\frac{dP^H}{dz^F} - \frac{N^F}{P^F}\frac{dP^F}{dz^F} + \frac{\sigma}{\sigma-1} n_H N^F \tilde{c}^F_H \\ \left.\frac{d\Omega}{ds^H}\right|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} &= -\frac{N^H}{P^H}\frac{dP^H}{ds^H} - \frac{N^F}{P^F}\frac{dP^F}{ds^H} - N^H\left(\frac{\sigma}{\sigma-1}\right)^2 \\ \left.\frac{d\Omega}{ds^F}\right|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} &= -\frac{N^H}{P^H}\frac{dP^H}{ds^F} - \frac{N^F}{P^F}\frac{dP^F}{ds^F} - N^F\left(\frac{\sigma}{\sigma-1}\right)^2.\end{aligned}$$

To establish that $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$ are efficient, we show that $\frac{d\Omega}{dz^H}|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} = 0$ and $\frac{d\Omega}{ds^F}|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} = 0$, with $\frac{d\Omega}{dz^F}|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} = 0$ and $\frac{d\Omega}{ds^F}|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} =$

0 then following under analogous arguments.[37]

Efficient net trade taxes: $z^H = z^F = 0$. We first show that $\frac{d\Omega}{dz^H}|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} = 0$, noting that p_H^H, p_H^F and p_F^F are independent of z^H with z^H impacting directly only the price of the foreign brand in the home market p_F^H. As noted in the text, total per capita spending on differentiated goods equals one, and so we have

$$n_H p_H^H c_H^H + n_F p_F^H c_F^H = 1; \quad n_H p_H^F c_H^F + n_F p_F^F c_F^F = 1. \tag{35}$$

Using (35) we can then write

$$\begin{aligned} -\frac{N^H}{P^H}\frac{dP^H}{dz^H} &= \left(\frac{1}{\sigma-1}\right) N^H \left[p_H^H c_H^H \frac{dn_H}{dz^H} + p_F^H c_F^H \frac{dn_F}{dz^H}\right] - n_F N^H \tilde{c}_F^H \\ -\frac{N^F}{P^F}\frac{dP^F}{dz^H} &= \left(\frac{1}{\sigma-1}\right) N^F \left[p_H^F c_H^F \frac{dn_H}{dz^H} + p_F^F c_F^F \frac{dn_F}{dz^H}\right], \end{aligned}$$

and therefore

$$\begin{aligned} &\left.\frac{d\Omega}{dz^H}\right|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} \\ &= \frac{1}{\sigma-1}\left[\left(p_H^H N^H c_H^H + p_H^F N^F c_H^F\right)\frac{dn_H}{dz^H} + \left(p_F^F N^F c_F^F + p_F^H N^H c_F^H\right)\frac{dn_F}{dz^H}\right] + \frac{1}{\sigma-1} n_F N^H \tilde{c}_F^H. \end{aligned}$$

When $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$ we also have

$$\begin{aligned} p_J^J &= \lambda_J^J \\ p_K^J &= (1+\nu)\lambda_K^J, \end{aligned} \tag{36}$$

and therefore

$$\begin{aligned} &\left.\frac{d\Omega}{dz^H}\right|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} \\ &= \frac{1}{\sigma-1}\left\{\left[N^H \tilde{c}_H^H + (1+\nu) N^F \tilde{c}_H^F\right]\frac{dn_H}{dz^H} + \left[N^F \tilde{c}_F^F + (1+\nu) N^H \tilde{c}_F^H\right]\frac{dn_F}{dz^H}\right\} + n_F N^H \tilde{c}_F^H. \end{aligned} \tag{37}$$

Our goal is to show that the right-hand side of (37) is equal to zero. Evidently, as (37) makes clear, this will be true if, beginning from $z^H = z^F = 0$ and $s^H = s^F = 1/\sigma$, a small increase in the net tariff on home imports generates additional tariff revenue (in the amount $n_F N^H \tilde{c}_F^H$) that is just offset by the loss in differentiated goods production associated with the induced entry and exit (in the amount $[N^H \tilde{c}_H^H + (1+\nu) N^F \tilde{c}_H^F]\frac{dn_H}{dz^H} + [N^F \tilde{c}_F^F + (1+\nu) N^H \tilde{c}_F^H]\frac{dn_F}{dz^H}$).

[37] We consider the second-order conditions in detail in the context of the efficient standards choices.

To derive expressions for $\frac{dn_H}{dz^H}$ and $\frac{dn_F}{dz^H}$, we use the home and foreign zero-profit conditions

$$\frac{1}{\sigma-1}\left[N^H\tilde{c}_H^H(P^H(z^H,n_H,n_F))+(1+\nu)\,N^F\tilde{c}_H^F(P^F(n_H,n_F))\right]=\Phi\left(\left|a_H^H-a_H^F\right|\right) \tag{38}$$

$$\frac{1}{\sigma-1}\left[N^F\tilde{c}_F^F(P^F(n_H,n_F))+(1+\nu)\,N^H\tilde{c}_F^H(P_F^H(z^H),P^H(z^H,n_H,n_F))\right]=\Phi\left(\left|a_F^H-a_F^F\right|\right), \tag{39}$$

where we have suppressed the dependency of consumption and price indices on product characteristics and have made explicit the direct dependency of consumption, prices and price indices on z^H. Totally differentiating (38) and (39) yields

$$\frac{dn_H}{dz^H}=\frac{(1+\nu)\frac{d\tilde{c}_F^H}{dp_F^H}\frac{dp_F^H}{dz^H}\left[\frac{N^H}{N^F}\frac{d\tilde{c}_H^H}{dP^H}\frac{dP^H}{dn_F}+(1+\nu)\frac{d\tilde{c}_H^F}{dP^F}\frac{dP^F}{dn_F}\right]-\frac{\partial P^H}{\partial z^H}\frac{dP^F}{dn_F}\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F}-(1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}{\left(\frac{dP^H}{dn_H}\frac{dP^F}{dn_F}-\frac{dP^H}{dn_F}\frac{dP^F}{dn_H}\right)\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F}-(1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}, \tag{40}$$

and

$$\frac{dn_F}{dz^H}=\frac{-(1+\nu)\frac{d\tilde{c}_F^H}{dp_F^H}\frac{dp_F^H}{dz^H}\left[\frac{N^H}{N^F}\frac{d\tilde{c}_H^H}{dP^H}\frac{dP^H}{dn_H}+(1+\nu)\frac{d\tilde{c}_H^F}{dP^F}\frac{dP^F}{dn_H}\right]+\frac{\partial P^H}{\partial z^H}\frac{dP^F}{dn_H}\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F}-(1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}{\left(\frac{dP^H}{dn_H}\frac{dP^F}{dn_F}-\frac{dP^H}{dn_F}\frac{dP^F}{dn_H}\right)\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F}-(1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}. \tag{41}$$

Substituting (40) and (41) back into (37) and rearranging then yields

$$\left.\frac{d\Omega}{dz^H}\right|_{z^H=z^F=0,\ s^H=s^F=1/\sigma}=0 \qquad \Leftrightarrow$$

$$\begin{aligned}
&[N^H\tilde{c}_H^H+(1+\nu)N^F\tilde{c}_H^F]\left\{(1+\nu)\frac{d\tilde{c}_F^H}{dp_F^H}\frac{dp_F^H}{dz^H}\left[\frac{N^H}{N^F}\frac{d\tilde{c}_H^H}{dP^H}\frac{dP^H}{dn_F}+(1+\nu)\frac{d\tilde{c}_H^F}{dP^F}\frac{dP^F}{dn_F}\right]\right|\\
&\qquad -\frac{\partial P^H}{\partial z^H}\frac{dP^F}{dn_F}\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F}-(1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]\bigg\}\\
&-\bigg\{[N^F\tilde{c}_F^F+(1+\nu)N^H\tilde{c}_F^H]\{(1+\nu)\frac{d\tilde{c}_F^H}{dp_F^H}\frac{dp_F^H}{dz^H}\left[\frac{N^H}{N^F}\frac{d\tilde{c}_H^H}{dP^H}\frac{dP^H}{dn_H}+(1+\nu)\frac{d\tilde{c}_H^F}{dP^F}\frac{dP^F}{dn_H}\right]\\
&\qquad -\frac{\partial P^H}{\partial z^H}\frac{dP^F}{dn_H}\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F}-(1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]\bigg\}\\
&\qquad +n_FN^H\tilde{c}_F^H\left[\frac{dP^H}{dn_H}\frac{dP^F}{dn_F}-\frac{dP^H}{dn_F}\frac{dP^F}{dn_H}\right]\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F}-(1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]=0.
\end{aligned}$$

We now make use of the following:

$$\begin{aligned}
\frac{d\tilde{c}_H^H}{dP^H} &= (\sigma-1)\frac{\tilde{c}_H^H}{P^H};\ \frac{d\tilde{c}_H^F}{dP^F}=(\sigma-1)\frac{\tilde{c}_H^F}{P^F};\ \frac{d\tilde{c}_F^F}{dP^F}=(\sigma-1)\frac{\tilde{c}_F^F}{P^F};\\
\frac{d\tilde{c}_F^H}{dP^H} &= (\sigma-1)\frac{\tilde{c}_F^H}{P^H};\ \frac{d\tilde{c}_F^H}{dp_F^H}=-\sigma\frac{\tilde{c}_F^H}{p_F^H},
\end{aligned}$$

and also

$$\begin{aligned}
\frac{dP^H}{dn_F} &= \frac{1}{1-\sigma}P^H p_F^H c_F^H;\ \frac{dP^H}{dn_H} = \frac{1}{1-\sigma}P^H p_H^H c_H^H;\ \frac{dP^F}{dn_F} = \frac{1}{1-\sigma}P^F p_F^F c_F^F;\ \frac{dP^F}{dn_H} = \frac{1}{1-\sigma}P^F p_H^F c_H^F; \\
\frac{\partial P^H}{\partial z^H} &= P^H n_F \tilde{c}_F^H;\ \frac{dp_F^H}{dz^H} = \lambda_F^H.
\end{aligned}$$

With this, the above can be simplified to

$$\left.\frac{d\Omega}{dz^H}\right|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} = 0 \quad \Leftrightarrow \tilde{c}_H^H[n_F\tilde{c}_F^F - 1] - (1+\nu)\,\tilde{c}_H^F[n_F\,(1+\nu)\,\tilde{c}_F^H - 1] = 0.$$

But, using (35) and (36), we then have

$$\begin{aligned}
&\tilde{c}_H^H[n_F\tilde{c}_F^F - 1] - (1+\nu)\,\tilde{c}_H^F[n_F\,(1+\nu)\,\tilde{c}_F^H - 1] \\
&= -\tilde{c}_H^H n_H\,(1+\nu)\,\tilde{c}_H^F + (1+\nu)\,\tilde{c}_H^F n_H \tilde{c}_H^H \\
&= 0.
\end{aligned}$$

This establishes that global efficiency requires $z^H = z^F = 0$.

Efficient consumption subsidies: $s^H = s^F = 1/\sigma$. We next show that $\frac{d\Omega}{ds^F}|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} = 0$, noting that p_H^F and p_F^F are independent of s^H with s^H impacting directly only the prices of the home and the foreign brand in the home market, p_H^H and p_F^H. Again using (35) we can then write

$$\begin{aligned}
-\frac{N^H}{P^H}\frac{dP^H}{ds^H} &= \frac{1}{\sigma-1}N^H\left(p_H^H c_H^H \frac{dn_H}{ds^H} + p_F^H c_F^H \frac{dn_F}{ds^H}\right) + \frac{\sigma}{\sigma-1}n_H N^H \tilde{c}_H^H + \frac{\sigma}{\sigma-1}n_F(1+\nu)N^H\tilde{c}_F^H \\
-\frac{N^F}{P^F}\frac{dP^F}{ds^H} &= \frac{1}{\sigma-1}N^F\left(p_H^F c_H^F \frac{dn_H}{ds^H} + p_F^F c_F^F \frac{dn_F}{ds^H}\right),
\end{aligned}$$

and therefore

$$\begin{aligned}
\left.\frac{d\Omega}{ds^H}\right|_{z^H=0=z^F,\ s^H=\frac{1}{\sigma}=s^F} &= \frac{1}{\sigma-1}\left[\left(p_H^H N^H c_H^H + p_H^F N^F c_H^F)\right]\frac{dn_H}{ds^H} + \left(p_F^F N^F c_F^F + p_F^H N^H c_F^H\right)\frac{dn_F}{ds^H}\right] \\
&\quad + \frac{\sigma}{\sigma-1}[n_H N^H \tilde{c}_H^H + n_F(1+\nu)N^H\tilde{c}_F^H] - N^H\left(\frac{\sigma}{\sigma-1}\right)^2.
\end{aligned}$$

Using (36) and (35) then delivers

$$\begin{aligned}
&\left.\frac{d\Omega}{ds^H}\right|_{z^H=0=z^F,\ s^H=\frac{1}{\sigma}=s^F} = \\
&\quad \frac{1}{\sigma-1}\left[\left(N^H\tilde{c}_H^H + (1+\nu)N^F\tilde{c}_H^F\right)\frac{dn_H}{ds^H} + \left(N^F\tilde{c}_F^F + (1+\nu)N^H\tilde{c}_F^H\right)\frac{dn_F}{ds^H} - N^H\frac{\sigma}{\sigma-1}\right]. \qquad (42)
\end{aligned}$$

Our goal is to show that the right-hand side of (42) is equal to zero.

To derive expressions for $\frac{dn_H}{ds^H}$ and $\frac{dn_F}{ds^H}$, we again use the home and foreign zero-profit conditions, which we now write as

$$\frac{1}{\sigma-1}\left[N^H \tilde{c}_H^H(p_H^H(s^H), P^H(s^H, n_H, n_F)) + (1+\nu)\, N^F \tilde{c}_H^F(P^F(n_H, n_F))\right] = \Phi\left(\left|a_H^H - a_H^F\right|\right) \tag{43}$$

$$\frac{1}{\sigma-1}\left[N^F \tilde{c}_F^F(P^F(n_H, n_F)) + (1+\nu)\, N^H \tilde{c}_F^H(P_F^H(s^H), P^H(s^H, n_H, n_F))\right] = \Phi\left(\left|a_F^H - a_F^F\right|\right) \tag{44}$$

Totally differentiating (43) and (44) yields

$$\frac{dn_H}{ds^H} = \frac{(1+\nu)\frac{d\tilde{c}_F^H}{dp_F^H}\frac{dp_F^H}{ds^H}\left[\frac{N^H}{N^F}\frac{d\tilde{c}_H^H}{dP^H}\frac{dP^H}{dn_F} + (1+\nu)\frac{d\tilde{c}_H^F}{dP^F}\frac{dP^F}{dn_F}\right] - \frac{\partial P^H}{\partial s^H}\frac{dP^F}{dn_F}\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F} - (1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}{\left(\frac{dP^H}{dn_H}\frac{dP^F}{dn_F} - \frac{dP^H}{dn_F}\frac{dP^F}{dn_H}\right)\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F} - (1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}$$
$$- \frac{\frac{d\tilde{c}_H^H}{dp_H^H}\frac{dp_H^H}{ds^H}\left[\frac{d\tilde{c}_F^F}{dP^F}\frac{dP^F}{dn_F} + (1+\nu)\frac{N^H}{N^F}\frac{d\tilde{c}_F^H}{dP^H}\frac{dP^H}{dn_F}\right]}{\left(\frac{dP^H}{dn_H}\frac{dP^F}{dn_F} - \frac{dP^H}{dn_F}\frac{dP^F}{dn_H}\right)\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F} - (1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]},$$

and

$$\frac{dn_F}{ds^H} = \frac{-(1+\nu)\frac{d\tilde{c}_F^H}{dp_F^H}\frac{dp_F^H}{ds^H}\left[\frac{N^H}{N^F}\frac{d\tilde{c}_H^H}{dP^H}\frac{dP^H}{dn_H} + (1+\nu)\frac{d\tilde{c}_H^F}{dP^F}\frac{dP^F}{dn_H}\right] + \frac{\partial P^H}{\partial s^H}\frac{dP^F}{dn_H}\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F} - (1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}{\left(\frac{dP^H}{dn_H}\frac{dP^F}{dn_F} - \frac{dP^H}{dn_F}\frac{dP^F}{dn_H}\right)\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F} - (1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}$$
$$+ \frac{\frac{d\tilde{c}_H^H}{dp_H^H}\frac{dp_H^H}{ds^H}\left[\frac{d\tilde{c}_F^F}{dP^F}\frac{dP^F}{dn_H} + (1+\nu)\left(\frac{N^H}{N^F}\right)\frac{d\tilde{c}_F^H}{dP^H}\frac{dP^H}{dn_H}\right]}{\left(\frac{dP^H}{dn_H}\frac{dP^F}{dn_F} - \frac{dP^H}{dn_F}\frac{dP^F}{dn_H}\right)\left[\frac{d\tilde{c}_H^H}{dP^H}\frac{d\tilde{c}_F^F}{dP^F} - (1+\nu)^2\frac{d\tilde{c}_H^F}{dP^F}\frac{d\tilde{c}_F^H}{dP^H}\right]}.$$

Substituting these expressions back into (42), using the price derivatives recorded above and in addition noting that

$$\frac{\partial P^H}{\partial s^H} = -P^H\frac{\sigma}{\sigma-1};\ \ \frac{dp_F^H}{ds^H} = -q_F^H(1+\nu);\ \ \frac{dp_H^H}{ds^H} = -q_H^H,$$

and using as well the expressions for efficient prices in (36), we then have

$$\frac{d\Omega}{ds^H}\big|_{z^H=z^F=0,\ s^H=s^F=1/\sigma} = 0.$$

This establishes that global efficiency requires $s^H = s^F = 1/\sigma$. Notice that this argument doesn't require product characteristics to be set at the efficient level, only that $z^H = z^F = 0$.

Efficient employment subsidies. While we do not introduce employment subsidies into our formal analysis, we have noted in the text that in our setting the global social planner has a degree of freedom when choosing between a consumption subsidy and an employment subsidy for addressing the monopoly markup distortion. Specifically, we claimed that, with s denoting the (common) subsidy for consumption of differentiated products and ν denoting the (common) rate of employment subsidy, efficiency is achieved by any combination of s and ν that satisfies $(1-s)(1-\omega) = 1 - 1/\sigma$. With ω set to 0 we have just established that efficiency implies $s = 1/\sigma$. We now argue that with s set to 0 efficiency can be equally well attained by setting $\omega = 1/\sigma$.

To see this, note that the joint global revenue needed for a home-country employment subsidy at rate ω_H and foreign-country employment subsidy at rate ω_F is given by

$$N^H \left[\frac{\omega_H}{(1-\omega_H)(1-s^H)} n_H p_H^H c_H^H + \frac{\omega_F(1+\nu)}{(1-\omega_F)(1-s^H)\iota_F} n_F p_F^H c_F^H \right] \\ + N^F \left[\frac{\omega_F}{(1-\omega_F)(1-s^F)} n_F p_F^F c_F^F + \frac{\omega_H(1+\nu)}{(1-\omega_H)(1-s^F)\iota_H} n_H p_H^F c_H^F \right]$$

which, with $s^H = s^F \equiv s = 0$ and $z^H = 0 = z^F$ and when $\omega_H = \omega_F \equiv \omega$, collapses to $\left(N^H + N^F\right)\omega/(1-\omega)$. A comparison with the expression for world welfare in (14) then confirms that the first best can be achieved with $s = 1/\sigma$ or with $\omega = 1/\sigma$, or, more generally, with any combination of s and ω that satisfies $(1-s)(1-\omega) = 1 - 1/\sigma$.

Efficient standards $\bar{a} = \widetilde{\boldsymbol{a}}$. We next prove that global efficiency is achieved when we also have $\bar{a} = \widetilde{\boldsymbol{a}}$. With net trade taxes and consumption subsidies set at their efficient levels $z^H = z^F = 0$ and $s^H = s^F = \frac{1}{\sigma}$, the expression for world welfare becomes

$$\Omega = \sum_J L^J - N^H \log(P^H) - N^F \log(P^F) - \frac{N^H + N^F}{\sigma - 1}. \tag{45}$$

The first-order conditions are

$$\frac{d\Omega}{da_K^J} = -\frac{N^H}{P^H}\frac{dP^H}{da_K^J} - \frac{N^F}{P^F}\frac{dP^F}{da_K^J} = 0 \text{ for all } J \in \{H, F\} \text{ and } K \in \{H, F\},$$

and by Lemma 3 these conditions are satisfied at the profit-maximizing characteristics choices.

This establishes that the first-order conditions for global efficiency are satisfied at the profit maximizing characteristics choices, $\widetilde{\boldsymbol{a}}$.

Second-order conditions. We now consider in detail the second-order conditions for efficiency, focusing on the planner's choice of standards. To illustrate why this choice raises particular questions about the second-order conditions, we first derive the slope of the world welfare contours in Figure 1. With net tariffs and consumption subsidies fixed at the efficient levels, world welfare is given by:

$$\Omega = \sum_J L^J - N^H \log(P^H) - N^F \log(P^F) - N^H \frac{1}{\sigma - 1} - N^F \frac{1}{\sigma - 1}.$$

Using

$$P^H \equiv \left\{\frac{[N^H(P^H)^{\sigma-1}]}{N^H}\right\}^{\frac{1}{\sigma-1}}$$
$$P^F \equiv \left\{\frac{[N^F(P^F)^{\sigma-1}]}{N^F}\right\}^{\frac{1}{\sigma-1}},$$

we now transform the expression for world welfare to the equivalent expression

$$\Omega = \sum_J L^J - N^H \log\left\{\left(\frac{[N^H(P^H)^{\sigma-1}]}{N^H}\right)^{\frac{1}{\sigma-1}}\right\} - N^F \log\left\{\left(\frac{[N^F(P^F)^{\sigma-1}]}{N^F}\right)^{\frac{1}{\sigma-1}}\right\} - N^H\frac{1}{\sigma-1} - N^F\frac{1}{\sigma-1},$$

or

$$\Omega = \sum_J L^J - \frac{1}{\sigma-1}$$
$$\times \left\{N^H \log\left([N^H(P^H)^{\sigma-1}]\right) + N^F \log\left([N^F(P^F)^{\sigma-1}]\right) - N^H[\log(N^H)-1] - N^F[\log(N^F)-1]\right\}. \tag{46}$$

Totally differentiating yields

$$\frac{d[N^F(P^F)^{\sigma-1}]}{d[N^H(P^H)^{\sigma-1}]}|_{d\Omega=0} = -\left(\frac{P^H}{P^F}\right)^{1-\sigma}. \tag{47}$$

According to (47), for $\sigma > 1$, the slope is flatter than -1 to the right of the N^F/N^H ray (where $P^H > P^F$) and it is steeper than -1 to the left of the N^F/N^H ray (where $P^H < P^F$). Figure 1 depicts the world welfare indifference curve passing through the point labeled Q, which corresponds to the equilibrium under profit-maximizing choices of product characteristics when net tariffs and consumption subsidies are set at the efficient levels.

This raises the question whether the second-order conditions for the planner's choice of standards are globally met. Specifically, we seek conditions under which the point labeled Q in Figure 1 is preferred to the extremes where either the planner sets product attributes to maximize global welfare when $n_F = 0$ or $n_H = 0$.

To explore this question, we first define the following variables:

$$Y \equiv [N^F(P^F)^{\sigma-1}]; \quad X \equiv [N^H(P^H)^{\sigma-1}]$$
$$Z_H \equiv (\sigma-1)\,\Phi(|a_H^H - a_H^F|); \quad Z_F \equiv (\sigma-1)\,\Phi(|a_F^H - a_F^F|)$$
$$\mu_H \equiv (1+\nu)^{\sigma-1}\left(\frac{A_H^H}{A_H^F}\right)^{\sigma}\left(\frac{\lambda_H^H}{\lambda_H^F}\right)^{1-\sigma} > 1; \quad \mu_F \equiv (1+\nu)^{\sigma-1}\left(\frac{A_F^F}{A_F^H}\right)^{\sigma}\left(\frac{\lambda_F^F}{\lambda_F^H}\right)^{1-\sigma} > 1$$
$$B_H \equiv \frac{Z_H}{(1+\nu)^{1-\sigma}(A_H^F)^{\sigma}(\lambda_H^F)^{1-\sigma}}; \quad B_F \equiv \frac{Z_F}{(A_F^F)^{\sigma}(\lambda_F^F)^{1-\sigma}}.$$

Then we have

$$\begin{aligned} \pi_H &= 0: \quad Y = B_H - \mu_H X \\ \pi_F &= 0: \quad Y = B_F - \frac{1}{\mu_F} X \end{aligned}$$

The point Q in Figure 1 is defined by $\pi_H = 0$ and $\pi_F = 0$ yielding

$$X = \frac{B_H - B_F}{\mu_H - \frac{1}{\mu_F}}; \quad Y = \frac{\mu_H B_F - \frac{1}{\mu_F} B_H}{\mu_H - \frac{1}{\mu_F}},$$

where these expressions are evaluated at the profit-maximizing product characteristic choices for both home and foreign firms. Notice that we have $\mu_H > \frac{1}{\mu_F}$, so we must have $B_H > B_F$ for $X > 0$ at the point Q.

Now let $\mu_H^{'}$ be the slope of the home zero profit line and and $B_H^{'}$ be its intercept when the planner sets the attributes $\bar{a}_H^H$ and $\bar{a}_H^F$ for home produced goods *at the levels that maximize global welfare when* $n_F = 0$. Note that $Y = \mu_H^{'} \left(\frac{N^F}{N^H} \right) X$ is the equation that satisfies $n_F = 0$ in these circumstances. We solve for the corresponding $Q_F^{'} = \left(X^{'}, Y^{'} \right)$, where

$$X^{'} = \frac{B_H^{'}}{\mu_H^{'} \left(1 + \frac{N^F}{N^H} \right)}; \qquad Y^{'} = \frac{B_H^{'}}{1 + \frac{N^H}{N^F}}$$

Global welfare at this $Q_F^{'}$ is

$$\Omega_{Q_F^{'}} = - \left(N^H + N^F \right) \log B_H^{'} + N^H \log \mu_H^{'} + N^H \log \left(1 + \frac{N^F}{N^H} \right) + \log N^F \log \left(1 + \frac{N^H}{N^F} \right)$$

Suppose that when the planner sets $z^H = 0$, it is possible for her to find a a_F^F and a_F^H with $a_F^F < a_F^H$, *while leaving the standards for home firms as above,* such that when $n_F > 0$ firms in both countries earn zero profits. Take an arbitrary pair of such standards, $\check{a}_F^F$ and $\check{a}_F^H$ and call the resulting point $\check{Q} = \left(\check{X}, \check{Y} \right)$. Notice, of course, that these standards are not optimal for the planner when firms are active in both countries. At the point of intersection of the zero profit lines,

$$\check{X} = \frac{B_H^{'} - \check{B}_F}{\mu_H^{'} - \frac{1}{\check{\mu}_F}}, \qquad \check{Y} = \frac{\mu_H^{'} \check{B}_F - \frac{1}{\check{\mu}_F} B_H}{\mu_H^{'} - \frac{1}{\check{\mu}_F}}$$

Note that the $B_H^{'}$ and $\mu_H^{'}$ are the same as above (since we haven't changed the standards facing home firms), while we use a check above the B_F and μ_F to remind ourselves that these are associated with the arbitrary standards, $\check{a}_F^F$ and $\check{a}_F^H$. The resulting global welfare is

$$\Omega_{\check{Q}} = -N^H \log \left(B_H^{'} - \check{B}_F \right) - N^F \log \left(\mu_H^{'} \check{B}_F - \frac{1}{\check{\mu}_F} B_H^{'} \right) + \left(N^H + N^F \right) \log \left(\mu_H^{'} - \frac{1}{\check{\mu}_F} \right)$$

The difference is

$$\begin{aligned}\Omega_{\check{Q}} - \Omega_{Q'_F} &= N^H \log \frac{\mu'_H B'_H - B'_H/\check{\mu}_F}{\mu'_H B'_H - \mu'_H \check{B}_F} + N^F \log \frac{\mu'_H B'_H - B'_H/\check{\mu}_F}{\mu'_H \check{B}_F - B'_H/\check{\mu}_F} - N^H \log(1 + \frac{N^F}{N^H}) - N^F \log(1 + \frac{N^H}{N^F}) \\ &= N^H \log \frac{D_1 + D_2}{D_1} + N^F \log \frac{D_1 + D_2}{D_2} - N^H \log(1 + \frac{N^F}{N^H}) - N^F \log(1 + \frac{N^H}{N^F})\end{aligned}$$

where $D_1 \equiv \mu'_H B'_H - \mu'_H \check{B}_F > 0$ and $D_2 \equiv \mu'_H \check{B}_F - B'_H/\check{\mu}_F > 0$.

To show $\Omega_{\check{Q}} - \Omega_{Q'_F} \geq 0$, requires

$$\left(N^H\right)^{N^H} \left(N^F\right)^{N^F} (D_1 + D_2)^{N^H + N^F} - \left(N^H + N^F\right)^{N^H + N^F} (D_1)^{N^H} (D_2)^{N^F} \geq 0$$

Now normalize so that $N^H + N^F = 2$ and re-arrange to get,

$$\left(N^H\right)^{N^H} \left(2 - N^H\right)^{2 - N^H} - 4 \left(\frac{D_1}{D_1 + D_2}\right)^{N^H} \left(\frac{D_2}{D_1 + D_2}\right)^{2 - N^H} \geq 0$$

Note that $(D_1)^{N^H} (1 - D_1)^{2 - N^H}$ is maximized at $D_1/(1 - D_1) = N^H/\left(2 - N^H\right) \Rightarrow \frac{D_1}{D_1 + D_2} = N^H/2$ and $\frac{D_2}{D_1 + D_2} = \left(2 - N^H\right)/2$. So the expression above is greater than or equal to

$$\left(N^H\right)^{N^H} \left(2 - N^H\right)^{2 - N^H} - 4 \left(\frac{N^H}{2}\right)^{N^H} \left(\frac{2 - N^H}{2}\right)^{2 - N^H} = 0$$

So we have proven that $\Omega_{\check{Q}} - \Omega_{Q'_F} \geq 0$, i.e., the planner prefers $\check{Q}$ to Q'_F for arbitrary $\check{a}^F_F$ and $\check{a}^H_F$ such that $n_F > 0$ and all firms break even. But Q is the social optimum when all firms are active. Clearly $\Omega_Q \geq \Omega_{\check{Q}}$. So

$$\Omega_Q - \Omega_{Q'_F} \geq 0$$

An analogous argument shows that Q also welfare-dominates an extreme where the planner sets attributes to maximize global welfare when $n_H = 0$.

Unilateral incentives to deviate from efficient consumption subsidies. We next show that there is no need for an NTA that stipulates zero net trade taxes on all goods and covers product standards to also cover consumption subsidies provided that National Treatment (NT) is imposed, as we observed in the text. To this end, we position the home and foreign consumption subsidies initially at the efficient level $1/\sigma$, and ask whether a country has a unilateral incentive to deviate (with trade taxes and standards all held to efficient levels). A first observation is that the world prices are functions of trade taxes but independent of consumption subsidies in this model, so there is no need to negotiate over consumption subsidies for purposes of eliminating terms-of-trade manipulation. Hence we need only consider the incentive to use consumption subsidies for purposes of delocation.

With net trade taxes set to zero, the home country's choice of consumption subsidy s^H will impact p_H^H and p_F^H according to

$$p_H^H = (1 - s^H)q_H^H; \quad p_F^H = (1 - s^H)(1 + \nu)q_F^H,$$

and similarly the foreign country's choice of consumption subsidy s^F will impact p_F^F and p_H^F according to

$$p_F^F = (1 - s^F)q_F^F; \quad p_H^F = (1 - s^F)(1 + \nu)q_H^F.$$

Focusing on the home-country choice of s^H and beginning from the efficient point, in the context of Figure 1 a slight increase in s^H will shift both the home zero-profit line and the foreign zero-profit in (toward the y-axis). Totally differentiating the home zero-profit line with respect to s^H and $(P^H)^{\sigma-1}$ yields

$$\left.\frac{d\left[N^H(P^H)^{\sigma-1}\right]}{ds^H}\right|_{\pi_H=0} = \frac{-\sigma(P^H)^{\sigma-1}}{1-s^H}.$$

Hence, the home zero-profit line shifts in (toward the y-axis in Figure 1) with a small increase in s^H by the amount $-\sigma(P^H)^{\sigma-1}/(1-s^H)$. But totally differentiating the foreign zero-profit line with respect to s^H and $(P^H)^{\sigma-1}$ yields

$$\left.\frac{d\left[N^H(P^H)^{\sigma-1}\right]}{ds^H}\right|_{\pi_F=0} = \frac{-\sigma(P^H)^{\sigma-1}}{1-s^H}.$$

Hence, the foreign zero-profit line shifts in with a small increase in s^H by the exact same amount $-\sigma(P^H)^{\sigma-1}/\left(1-s^H\right)$. This implies that $(P^F)^{\sigma-1}$ is left unchanged by the increase in s^H, and hence implies that foreign welfare (which is given by $\Omega^F = L^F - N^F \log\left(P^F\right) - N^F \frac{1}{\sigma-1}$) is unaffected by the small increase in s^H. But given that s^H was initially positioned at the efficient level, it is impossible for home welfare to rise if foreign welfare does not fall. We may thus conclude that the home country cannot improve its welfare with a small unilateral deviation from $s^H = 1/\sigma$. And with

$$\left.\frac{d\left[N^H(P^H)^{\sigma-1}\right]}{ds^H}\right|_{\pi_H=0} = \frac{-\sigma(P^H)^{\sigma-1}}{1-s^H} = \left.\frac{d\left[N^H(P^H)^{\sigma-1}\right]}{ds^H}\right|_{\pi_F=0}$$

starting from any level of s^H, it is easy to see that the same argument applies globally for unilateral deviations from $s^H = 1/\sigma$ of any size.

Therefore, we may conclude that in the presence of NT, an NTA does not need to cover the consumption subsidies for each country.

Unilateral incentives to deviate from efficient employment subsidies. Finally, we noted in the text that, unlike with consumption subsidies, there *is* a unilateral incentive to deviate from efficient policies with a small employment subsidy, implying that employment subsidies must be constrained in an efficient NTA. To see this, let us begin from free trade and efficient consumption subsidies and no employment subsidy, plus efficient standards, and consider the home country welfare, which is given by

$$\Omega^H\left(\boldsymbol{a}^E, \boldsymbol{p}^E\right) = L^H - N^H \log P^H\left(\boldsymbol{a}^E, \boldsymbol{p}^E\right) - N^H \frac{1}{\sigma - 1}.$$

Suppose, beginning from these efficient policies, the home country were to introduce a small employment subsidy. The revenue consequences of a sufficiently small employment subsidy would be inconsequential (second order); but a small employment subsidy would increase the profits of home firms and shift the home zero profit line in (toward the y-axis in Figure 1) while leaving the profits of foreign firms unchanged and thereby leaving the foreign zero profit line unaffected. This implies that P^H would fall (while P^F would rise), yielding a first order increase in home welfare Ω^H. Hence, and distinct from consumption subsidies, countries have a unilateral incentive to deviate from efficient policies with employment subsidies.[38]
QED

An efficient agreement doesn't need to specify a consumption subsidy. As long as the choice of consumption subsidy satisfies national treatment (and net trade barriers are zero), countries will unilaterally chose the efficient consumption subsidy. For any fixed set of characteristics welfare is given by:

$$\Omega = -\log P^H - \log P^F + z^H n_F \tilde{c}_F^H + z^F n_H \tilde{c}_H^F - s^H G^H - s^F G^F \tag{48}$$

where

$$\begin{aligned} G^J &= n_J \frac{\sigma}{\sigma - 1} \tilde{c}_J^J + n_K \iota_J \frac{\sigma}{\sigma - 1} \tilde{c}_K^J = \frac{C_D^J P^J}{1 - s^J} = \frac{1}{1 - s^J} = Q^J C_D^J \\ P^J &= \left[n_J \left(A_J^J\right)^\sigma \left(p_J^J\right)^{1-\sigma} + n_K \left(A_K^J\right)^\sigma \left(p_K^J\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} = Q^J(1 - s^J) \end{aligned}$$

where

$$Q^J = \left[n_J \left(A_J^J\right)^\sigma \left(q_J^J\right)^{1-\sigma} + n_K \left(A_K^J\right)^\sigma \left(\iota_J q_K^J\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

Consider an initial situation where $z^H = z^F = 0$ and using the above conditions, the welfare function can be written as:

$$\Omega = -\log Q^H - \log Q^F - \log(1 - s^H) - \log(1 - s^F) - s^H Q^H C_D^H - s^F Q^F C_D^F$$

$$\left.\frac{d\Omega}{ds^H}\right|_{z^H = z^F = 0} = -\frac{1}{Q^H} \frac{dQ^H}{ds^H} - \frac{1}{Q^F} \frac{dQ^F}{ds^H} + \frac{1}{1 - s^H} - Q^H C_D^H - s^H \frac{dQ^H C_D^H}{ds^H} - s^F \frac{dQ^F C_D^F}{ds^H}$$

[38] We have illustrated the incentive to defect from efficient policies with employment subsidies by focusing on the delocation incentives that exist with such policies, but there are also terms-of-trade incentives that arise with employment subsidies and that are absent with consumption subsidies in this model.

Using (9) we can simplify this expression since $\frac{1}{1-s^H} = Q^H C_D^H$.

$$\left.\frac{d\Omega}{ds^H}\right|_{z^H=z^F=0} = -\frac{1}{Q^H}\frac{dQ^H}{ds^H} - \frac{1}{Q^F}\frac{dQ^F}{ds^H} - s^H\frac{dQ^H C_D^H}{ds^H} - s^F\frac{dQ^F C_D^F}{ds^H}$$

To evaluate this expression consider

$$\begin{aligned}\frac{dQ^H}{ds^H} &= \frac{1}{1-\sigma}\frac{Q^H}{\left(Q^H\right)^{1-\sigma}}\left[\left(A_H^H\right)^\sigma\left(q_H^H\right)^{1-\sigma}\frac{dn_H}{ds^H} + \left(A_F^H\right)^\sigma\left(\iota q_F^H\right)^{1-\sigma}\frac{dn_H}{ds^H}\right] \\ &= \frac{Q^H}{1-\sigma}\left[\frac{\left(A_H^H\right)^\sigma\left(q_H^H\right)^{1-\sigma}}{\left(Q^H\right)^{1-\sigma}}\frac{dn_H}{ds^H} + \frac{\left(A_F^H\right)^\sigma\left(\iota q_F^H\right)^{1-\sigma}}{\left(Q^H\right)^{1-\sigma}}\frac{dn_H}{ds^H}\right]\end{aligned}$$

Note that $n_H\left(A_H^H\right)^\sigma\left(q_H^H\right)^{1-\sigma}/\left(Q^H\right)^{1-\sigma}$ is the expenditure share of Home for Home's production. So $P^H C_D^H n_H\left(A_H^H\right)^\sigma\left(q_H^H\right)^{1-\sigma}/\left(Q^H\right)^{1-\sigma} = n_H p_H^H c_H^H$. Since $P^H C_D^H = 1$, $n_H\left(A_H^H\right)^\sigma\left(q_H^H\right)^{1-\sigma}/\left(Q^H\right)^{1-\sigma} = n_H p_H^H c_H^H$, so $\left(A_H^H\right)^\sigma\left(q_H^H\right)^{1-\sigma}/\left(Q^H\right)^{1-\sigma} = p_H^H c_H^H$. Using this property, $\frac{dQ^H}{ds^H} = Q^H\left(p_H^H c_H^H\frac{dn_H}{ds^H} + p_F^H c_F^H\frac{dn_F}{ds^H}\right)/(1-\sigma)$ Similar steps give $\frac{dQ^F}{ds^H} = Q^F\left(p_H^F c_H^F\frac{dn_H}{ds^H} + p_F^F c_F^F\frac{dn_F}{ds^H}\right)/(1-\sigma)$.

From (9) it follows that $\frac{dQ^F C_D^F}{ds^H} = \frac{d\left(\frac{1}{1-s^F}\right)}{ds^H} = 0$. However, this implies $\frac{dQ^F C_D^F}{ds^H} = q_F^F c_F^F\frac{dn_F}{ds^H} + \iota q_H^F c_H^F\frac{dn_H}{ds^H} = 0$. Since $\left(1-s^F\right)\left(q_F^F c_F^F\frac{dn_F}{ds^H} + \iota q_H^F c_H^F\frac{dn_H}{ds^H}\right) = \frac{dQ^F}{ds^H}(\sigma-1)$, it follows that this term is also zero.

Using these results to cancel terms, we are left with an expression that is a function of Home country factors alone (i.e. only unilateral considerations matter):

$$\begin{aligned}\left.\frac{d\Omega}{ds^H}\right|_{z^H=z^F=0} &= -\frac{1}{Q^H}\frac{dQ^H}{ds^H} - s^H\frac{dQ^H C_D^H}{ds^H} \\ &= -\frac{1}{Q^H}\frac{Q^H}{1-\sigma}\left(p_H^H c_H^H\frac{dn_H}{ds^H} + p_F^H c_F^H\frac{dn_F}{ds^H}\right) - s^H\left(qc_H^H\frac{dn_H}{ds^H} + \iota qc_F^H\frac{dn_F}{ds^H}\right) \\ &= \frac{1}{\sigma-1}\left(p_H^H c_H^H\frac{dn_H}{ds^H} + p_F^H c_F^H\frac{dn_F}{ds^H}\right) - \frac{s^H}{1-s^H}\left(p_H^H c_H^H\frac{dn_H}{ds^H} + p_F^H c_F^H\frac{dn_F}{ds^H}\right)\end{aligned}$$

Hence, when $s^H = 1/\sigma$, welfare is maximized.

5 Proof of Proposition 2

Proposition 2 *Suppose $\tau^H = \tau^F = e_H = e_F = 0$ and $s^H = s^F = 1/\sigma$. Suppose governments are free to choose any standards for local products and for imported products, without need for national treatment. Then, in the Nash equilibrium of the standard-setting game, either (i) $n_J = 0$ for some $J \in \{H, F\}$, or (ii) $\bar{a}_H^F \in \{a_{\min}, a_{\max}\}$ and $\bar{a}_F^H \in \{a_{\min}, a_{\max}\}$. The equilibrium level of global welfare is less than that attained under an NTA.*

Proof We look for the Nash equilibrium choices of product standards in an FTA without NT. By an FTA, we mean that the two governments are constrained to set $\tau^J = 0$, $e_J = 0$, and we also have $s^J = 1/\sigma$.[39]

Consider the outcome from free entry when $\bar{a}_H^F = a_{\min}$, $\bar{a}_F^H = a_{\max}$ and a_H^H and a_F^F are at their profit-maximizing levels in response to these extreme standards for imports. There are three possible outcomes: (i) $n_H > 0$ and $n_F > 0$; (ii) $n_H > 0$ and $n_F = 0$; (iii) $n_F > 0$ and $n_H = 0$.

Case (i): If $n_H > 0$ and $n_F > 0$ when $\bar{a}_H^F = a_{\min}$, $\bar{a}_F^H = a_{\max}$ and a_H^H and a_F^F are at their profit-maximizing levels in response to these extreme standards for imports, neither government can induce "complete delocation"; i.e., exit by all firms in the other country. As long as there are active firms in both countries, each government has an incentive to push its standard for import goods to the extreme, since doing so (given the other government's policy) always reduces the local price index by the arguments in Figure 1. Given the pair of extreme standards for import goods, the Nash response for each government is to set the standard for local products equal to the profit maximizing level.

Case (ii): Now the home government can induce complete delocation and it has an incentive to do so. It will set its standard for import products high enough to ensure $n_F = 0$. There will be a range of standards that achieve this, including $\bar{a}_F^H = a_{\max}$; all of them are best responses so any can be part of a Nash equilibrium (with the same consequences for other variables). But given that a_F^H is chosen such that $n_F = 0$, the incentives facing the foreign government are different. It does not use a_H^F to induce delocation, since such a strategy is bound to fail. Instead it "accepts" that all differentiated products will be imported and it trades off the desirability of the import products given local tastes and variety. By setting $a_H^F = \hat{a}^F$, the foreign government selects the optimal variant in the eyes of consumers in country F, considering both the direct effect on utility and the indirect effect on prices. By setting a_H^F at the profit maximizing level for home firms, it maximizes variety. It will choose a standard somewhere between these two. Arguing in this way, it is straightforward to establish that the best response for a_H^F is strictly between $\hat{a}^F$ and a_H^H. Similarly, the best response for a_H^H will be strictly between a_H^F and $\hat{a}^H$.

Case (iii) is similar.

On the interplay between better suitability and delocation. In the text following the statement of Proposition 2, we also discussed the interplay between the two motives for regulation—better suitability and delocation—featured by our model, and we claimed that when evaluated near the Nash equilibrium the delocation motive always operates on the margin. Here we expand on the interplay between better suitability and delocation in the context of standard-setting and establish this claim.

To this end, it is first helpful to express $\frac{dn_H}{da_F^H}$ and $\frac{dn_F}{da_F^H}$ evaluated at an arbitrary a_F^H. Following the same steps as in appendix section 2.2 but not requiring a_F^H to satisfy the first-order condition for profit maximization yields the following expressions for $\frac{dn_H}{da_F^H}$ and $\frac{dn_F}{da_F^H}$ evaluated at an arbitrary

[39] While the NTA could constrain consumption subsidies to their efficient levels $s^J = 1/\sigma$, by the result proved just above there is no need for such a constraint as long as national treatment is imposed on the application of consumption subsidies.

a_F^H:

$$\frac{dn_H}{da_F^H} = \frac{\left[\frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial n_F} + (1+\nu)\frac{\partial \tilde{c}_H^F}{\partial P^F}\frac{\partial P^F}{\partial n_F}\right]\left[\frac{N^H}{\sigma-1}(1+\nu)\frac{\partial \tilde{c}_F^H}{\partial a_F^H} - \Phi'\left(\left|a_F^H - a_F^F\right|\right)\right]}{\left(\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}\right)\left(\frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial \tilde{c}_F^F}{\partial P^F} - (1+\nu)^2\frac{\partial \tilde{c}_F^H}{\partial P^H}\frac{\partial \tilde{c}_H^F}{\partial P^F}\right)} - \frac{\frac{\partial P^H}{\partial a_F^H}\frac{\partial P^F}{\partial n_F}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}} \tag{49}$$

$$\frac{dn_F}{da_F^H} = \frac{-\left(\frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial n_F} + (1+\nu)\frac{\partial \tilde{c}_H^F}{\partial P^F}\frac{\partial P^F}{\partial n_F}\right)\left[\frac{N^H}{\sigma-1}(1+\nu)\frac{\partial \tilde{c}_F^H}{\partial a_F^H} - \Phi'\left(\left|a_F^H - a_F^F\right|\right)\right]}{\left(\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}\right)\left(\frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial \tilde{c}_F^F}{\partial P^F} - (1+\nu)^2\frac{\partial \tilde{c}_F^H}{\partial P^H}\frac{\partial \tilde{c}_H^F}{\partial P^F}\right)} + \frac{\frac{\partial P^H}{\partial a_F^H}\frac{\partial P^F}{\partial n_H}}{\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}} \tag{50}$$

It is clear that the term $\left(\frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial P^H}{\partial n_F} + (1+\nu)\frac{\partial \tilde{c}_H^F}{\partial P^F}\frac{\partial P^F}{\partial n_F}\right)$ is negative, whereas the terms $\left(\frac{\partial P^H}{\partial n_H}\frac{\partial P^F}{\partial n_F} - \frac{\partial P^H}{\partial n_F}\frac{\partial P^F}{\partial n_H}\right)$ and $\left(\frac{\partial \tilde{c}_H^H}{\partial P^H}\frac{\partial \tilde{c}_F^F}{\partial P^F} - (1+\nu)^2\frac{\partial \tilde{c}_F^H}{\partial P^H}\frac{\partial \tilde{c}_H^F}{\partial P^F}\right)$ are positive, so the sign of the first term in (49) will be opposite the sign of $\left[\frac{N^H}{\sigma-1}(1+\nu)\frac{\partial \tilde{c}_F^H}{\partial a_F^H} - \Phi'\left(\left|a_F^H - a_F^F\right|\right)\right]$ while the sign of the first term in (50) will be the same as the sign of $\left[\frac{N^H}{\sigma-1}(1+\nu)\frac{\partial \tilde{c}_F^H}{\partial a_F^H} - \Phi'\left(\left|a_F^H - a_F^F\right|\right)\right]$. And, as Lemma 3 confirms, the sign of the second term in (49) is negative while the sign of the second term in (50) is positive.

Evaluated at the profit-maximizing choice of a_F^H, the associated first-order condition assures that

$$\frac{N^H}{\sigma-1}(1+\nu)\frac{\partial \tilde{c}_F^H}{\partial a_F^H} - \Phi'\left(\left|a_F^H - a_F^F\right|\right) = 0$$

and so the first term in each of the expressions (49) and (50) is zero, and the expressions collapse to those given in (31) and (32) respectively. But when these expressions are evaluated at a level of a_F^H above the profit-maximizing choice, we have $\frac{N^H}{\sigma-1}(1+\nu)\frac{\partial \tilde{c}_F^H}{\partial a_F^H} - \Phi'\left(\left|a_F^H - a_F^F\right|\right) < 0$ making the first term in (49) positive and therefore working to overturn the second term in (49), and making the first term in (50) negative and therefore working to overturn the second term in (50). And when these expressions are evaluated at a level of a_F^H below the profit-maximizing choice, we have $\frac{N^H}{\sigma-1}(1+\nu)\frac{\partial \tilde{c}_F^H}{\partial a_F^H} - \Phi'\left(\left|a_F^H - a_F^F\right|\right) > 0$ making the first term in (49) negative and therefore working to reinforce the second term in (49), and making the first term in (50) positive and therefore working to reinforce the second term in (50).

Now consider Figure 2, which depicts n_H and n_F as a function of a_F^H. To draw the n_H and n_F curves, we use expressions (49) and (50). The point in the figure labeled a_F^{H1} is where n_F takes its maximum value, and the point in the figure labeled a_F^{H2} is where n_H takes its minimum value. According to (49) and (50) evaluated at the profit maximizing levels of a_F^F and a_H^F, $a_F^{H1} < a_F^{H2}$ as depicted. Also depicted in the figure is the local ideal $\hat{a}^H$. And finally, as noted in the figure, P^H falls as we move away from the profit-maximizing level a_F^H in either direction.

Several observations follow from Figure 2. Moving left from the profit maximizing level a_F^H, P^H falls due to the delocation associated with the fall in a_F^H, with n_F falling and n_H rising as foreign firms are delocated to the home-country market. So the incentive for the home country to

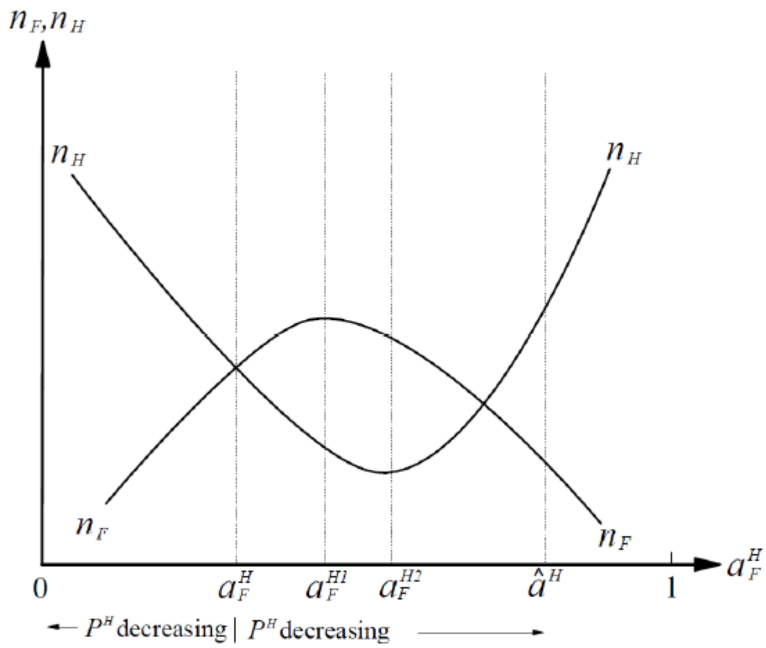

Figure 2: Number of Firms as Function of a_F^H

defect toward the left from the efficient profit maximizing a_F^H is due to delocation. But moving right from the profit maximizing level a_F^H, P^H falls despite the fact that initially n_F is rising and n_H is falling. So the incentive to defect toward the right from the efficient profit maximizing a_F^H is initially – in the interval (a_F^H, a_F^{H1}) – *not* due to delocation; it is due instead to the direct impact on P^H of having imports adopt a characteristic that is a little closer to the Home ideal $\hat{a}^H$, and this direct impact dominates the (anti-) delocation effects here. Once we move into the interval (a_F^{H1}, a_F^{H2}), *both* n_H and n_F are falling with further increases in a_F^H, so again the incentive for the home country to keep raising a_F^H in this interval to lower P^H is not due to delocation, but must still be due to the domination of the direct impact on P^H of having imports adopt a characteristic that is a little closer to the Home ideal $\hat{a}^H$. In the interval $(a_F^{H2}, \hat{a}^H)$, we now have delocation *and* the direct impact described above both helping to push P^H lower. But for the interval $(\hat{a}^H, a_{\max})$, the direct effect is now going the wrong way so it is the delocation effect that dominates at this point and keeps P^H falling.

Finally, notice that Figure 2 shows the number of foreign firms as being still positive at $\hat{a}^H$, which, if a general property, would mean that *only* the delocation motive operates in the neighborhood of the case (ii) Nash equilibrium. On the other hand, if n_F hits zero at a standard smaller than $\hat{a}^H$, then the "last little bit of standard" could provide benefits both via delocation and via product suitability. It can be shown that both possibilities can arise. Hence the product suitability motive may or may not be operative on the margin in the Nash equilibrium, but the delocation motive *always* is operative.

6 Regulatory Convergence: FTA versus NTA

As argued in the text, when Nash standards are set at their extreme limits, a transition from an FTA to an NTA will involve regulatory convergence. To see this is also true for an FTA that involves complete delocation, suppose that $n_F = 0$. This implies:

$$\left(P^H\right)^{\sigma-1} = \frac{\left(p_H^H\right)^{\sigma-1}}{n_H \left(A_H^H\right)^{\sigma}}$$

$$\left(P^F\right)^{\sigma-1} = \frac{\left(p_H^F\right)^{\sigma-1}}{n_H \left(A_H^F\right)^{\sigma}}$$

Since firms are only active in the home country, solving the zero profit condition gives:

$$n_H = \frac{N^H + N^F}{(\sigma-1)\Phi(a_H^H - a_H^F)}$$

The choice of standard in each location will attempt to minimize the relevant local price index. Substituting n_H into the relevant price index and minimizing with respect to the local standard generates the following best response functions:

$$\frac{\Phi'\left(\bar{a}_H^H - \bar{a}_H^F\right)}{\Phi\left(\bar{a}_H^H - \bar{a}_H^F\right)} \frac{d(\bar{a}_H^H - \bar{a}_H^F)}{d\bar{a}_H^J} = \sigma \frac{A_a\left(\bar{a}_H^J, \gamma_H^J\right)}{A\left(\bar{a}_H^J, \gamma_H^J\right)} + (1-\sigma)\,\eta\left(\bar{a}_H^J\right), \quad J = H, F. \tag{51}$$

The Nash equilibrium is the pair of standards that satisfy these two equations.

Regulatory convergence is confirmed by comparing the first-order conditions in (51) that characterize the Nash standards to those generated by profit-maximization, and therefore the globally efficient standards. For the representative home firm, the optimal choices of $\tilde{a}_H^H$ and $\tilde{a}_H^F$ when $\mathbf{z} = 0$ and $\mathbf{s} = 1/\sigma$ satisfy

$$\frac{\Phi'\left(\tilde{a}_H^H - \tilde{a}_H^F\right)}{\Phi\left(\tilde{a}_H^H - \tilde{a}_H^F\right)} \frac{d\left(\tilde{a}_H^H - \tilde{a}_H^F\right)}{d\tilde{a}_H^J} = \Lambda_H^J\left(\tilde{a}_H^H, \tilde{a}_H^F\right)\left[\sigma \frac{A_a\left(\tilde{a}_H^J, \gamma^J\right)}{A\left(\tilde{a}_H^J, \gamma^J\right)} + (1-\sigma)\,\eta\left(\tilde{a}_H^J\right)\right], \quad J = H, F, \tag{52}$$

where $\Lambda_H^J\left(\tilde{a}_H^H, \tilde{a}_H^F\right)$ is the fraction of its global operating profits that the representative home firm earns in market J. But with $\Lambda_H^J\left(\tilde{a}_H^H, \tilde{a}_H^F\right) < 1$ for $J = H, F$, it follows from (51) and (52) that $\left|\tilde{a}_H^H - \tilde{a}_H^F\right| < \left|\bar{a}_H^H - \bar{a}_H^F\right|$; and thus an efficient NTA delivers regulatory convergence.

7 A Smarter OTA without National Treatment

We now show that the countries often can achieve higher joint welfare by using an OTA that departs from free trade. However, a "smarter OTA"—one with offsetting tariffs and export subsidies—can never be designed so as to deliver the first best.

To illustrate the possibility of a smarter OTA, let us take an initial equilibrium under the

FTA with active firms in both countries and with $\bar{a}_F^H = a_{\max}$ and $\bar{a}_H^F = a_{\min}$. Suppose we were to depict the zero-profit lines for home and foreign firms when all firms are free to choose their profit-maximizing characteristics for sales in their local market but are subject to these extreme regulations in their export markets. In such circumstances, each zero-profit would be downward sloping, just as in Figure 1. Moreover, it will often be the case that the $\pi_H = 0$ line would have a (negative) slope greater than one in absolute value, and the $\pi_F = 0$ line would have a (negative) slope less than one in absolute value, just as in the earlier figure.

Now suppose that we contemplate a trade agreement with zero *net* tariffs, just as with an FTA, but now with $\tau^H = \tau^F = -e_H = -e_F \equiv \tau > 0$. As we know, equilibrium prices and quantities depend only on net trade taxes and so are independent of τ. Home welfare in these circumstances would be given by

$$\Omega^H = L_H + \tau\left(\frac{\sigma}{\sigma-1}\right)\left(\tilde{M}^H - \tilde{E}_H\right) - N^H \log\left(P^H\right) - N^H \frac{1}{\sigma-1} \ ,$$

where aggregate home imports are

$$\tilde{M}^H = N^H n_F \lambda_F^H \left(A_F^H\right)^\sigma \left(p_F^H\right)^{-\sigma} \left(P^H\right)^{\sigma-1}$$

and aggregate home exports are

$$\tilde{E}_H = N^F n_H \lambda_H^F \left(A_H^F\right)^\sigma \left(p_H^F\right)^{-\sigma} \left(P^F\right)^{\sigma-1} \ .$$

Would the home government still wish to apply the extreme standard of $\bar{a}_F^H = 1$ in such circumstances, as it would with free trade? Recall that under the FTA, the delocation motive operates on the margin. Were the home country to slightly ease its regulation of imports to something a bit less than $\bar{a}_F^H = a_{\max}$, it would induce entry by foreign firms and exit by home firms; i.e., it would reverse the last bit of delocation. The increase in n_F would contribute to greater imports. Also, since $\bar{a}_F^H$ now is closer to $\hat{a}^H$, import products would be more attractive which also contributes to greater imports. Finally, the shift of $\bar{a}_F^H$ away from the level that minimizes the local price index P^H eases competition in the home market, which further contributes to a rise in imports. Overall, the easing of standards causes imports to rise. Meanwhile, the fall in the number of home firms and the fall in the foreign price index spell a reduction in home exports. The expansion in home imports and the contraction of home exports generate an increase in home tax revenues, as tariff collections rise and export subsidy outlays fall.

The net effect on home welfare combines the adverse effect of the cut in $\bar{a}_F^H$ on the home price index and the favorable effect on total tax revenues. Note, however, that the marginal welfare loss from an increase in P^H is independent of τ, whereas the marginal gain from the increased tax revenues rises linearly with τ. It follows that there must exist a τ large enough that the positive effect dominates.[40] In short, when τ is sufficiently large, the home government's best response to

[40] Since $\widetilde{M}^H$ and $\widetilde{E}_H$ depend only on net trade taxes and thus are independent of τ, the gain in tax revenues

any set of foreign standards will be to choose a standard for imports strictly less than one. By analogous arguments, the foreign government will choose an import standard $\bar{a}_H^F$ that is strictly greater than zero. In other words, the positive tariffs and offsetting export subsidies induce both governments to moderate their regulation of imports. Finally, if the home and foreign zero profit lines under an FTA are, respectively, steeper and flatter than a line with slope minus one, global welfare will be higher under a smart trade agreement with $\boldsymbol{\tau} > 0$ than under an FTA with $\boldsymbol{\tau} = 0$.

Although countries may be able to design a smarter OTA that improves upon an FTA, there are no values of $\tau^H = -e_F$ and $\tau^F = -e_H$ that would permit an OTA without national treatment to deliver the first-best level of global welfare. To see this, begin at the profit-maximizing standards illustrated in Figure 1. Suppose first that τ^H and τ^F are set to be positive and consider the welfare effects of a small increase in $\bar{a}_F^H$. By Lemma 2 foreign firms would enter and home firms would exit. By Lemma 3, there would be no first-order change in either price index. Meanwhile, the increase in $\bar{a}_F^H$ from the level that is profit-maximizing for foreign firms makes the import product more attractive to home consumers. Together, the increases in n_F and A_H^F imply that imports $\widetilde{M}^H$ would rise, which would generate a gain in tariff revenues. Meanwhile, the exit by home firms reduces home exports $\tilde{E}_H$, so home outlays for export subsidies would fall. In combination, the home country's tax revenues grow, with no first-order effect on its price index. This combination represents a gain in welfare for the home country and hence we have that no positive τ^H and τ^F exist to discourage deviation from the first-best standards. Suppose instead that the countries set τ^H and τ^F to be negative. In that case, the home government could deviate by reducing its standard $\bar{a}_F^H$ slightly below the efficient level and raise domestic welfare with an increase in trade tax revenues and no first-order effect on the home price index.[41] So, negative tariffs (with positive export taxes) also do not discourage deviations in standard setting. Evidently, a smarter OTA, no matter how smart, cannot deliver the first best.

8 Nash Standards with National Treatment

As in section 3.3 suppose that the countries have concluded an FTA that mandates free trade and subsidies that counteract markup pricing; i.e., we take $\tau^J = e_J = 0$ and $s^J = 1/\sigma$ for $J = H, F$. The agreement also includes a mandate for national treatment in regulatory policy. We ask, What characteristics , $\bar{a}^H$ and $\bar{a}^F$ will the two governments choose in a Nash equilibrium of standard setting, if there are no further constraints on their choices?

When all brands sold in country J bear the same characteristic, $\bar{a}^J$, the demand shifters take the common value $\bar{A}^J \equiv A\left(\bar{a}^J, \gamma^J\right)$. Then we can write the price index for country J simply as

$$P^J = \left(\bar{A}^J\right)^{\frac{\sigma}{1-\sigma}} \left[n_J \left(p_J^J\right)^{1-\sigma} + n_K \left(p_K^J\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \text{ for } J = H, F.$$

generated by a reduction in $\bar{a}_F^H$ grows linearly with τ, without bound.

[41] When $\bar{a}_F^H$ is reduced below the profit-maximizing level for foreign firms, n_F falls, A_F^H falls, and n_H rises. So imports fall, exports rise, and the sum of outlays for import subsidies and proceeds from export taxes will rise. Meanwhile, the home price index is unaffected to first order, so the deviation must be beneficial to the home country.

Solving this pair of equations for the number of firms in each country gives

$$n_J = \frac{\left(\bar{A}^K\right)^{\sigma}\left(p_K^K\right)^{1-\sigma}\left(P^J\right)^{1-\sigma} - \left(\bar{A}^J\right)^{\sigma}\left(p_K^J\right)^{1-\sigma}\left(P^K\right)^{1-\sigma}}{\left(\bar{A}^H\right)^{\sigma}\left(\bar{A}^F\right)^{\sigma}\left[\left(p_H^H\right)^{1-\sigma}\left(p_F^F\right)^{1-\sigma} - \left(p_F^H\right)^{1-\sigma}\left(p_H^F\right)^{1-\sigma}\right]}, \tag{53}$$

provided that the solution yields non-negative values for both n_H and n_F.

The denominator of (53) is always positive. It follows that firms are active in both countries if and only if the numerators are positive for both $J = H$ and $J = F$. Using the pricing equations (8)-(10), this is equivalent to $\left(\bar{A}^H/\bar{A}^F\right)^{\sigma}\left(\bar{\lambda}^H/\bar{\lambda}^F\right)^{1-\sigma}(1+\nu)^{\sigma-1} > \left(P^H/P^F\right)^{1-\sigma}$ $> \left(\bar{A}^H/\bar{A}^F\right)^{\sigma}\left(\bar{\lambda}^H/\bar{\lambda}^F\right)^{1-\sigma}(1+\nu)^{1-\sigma}$, where $\bar{\lambda}^J \equiv \lambda\left(\bar{a}^J\right)$.

Assuming for the moment that firms are active in both countries, we can use the two zero-profit conditions to solve for the equilibrium price indices. We find

$$\left(P^J\right)^{\sigma-1} = \frac{\sigma\left[\Phi\left(\left|\bar{a}^H - \bar{a}^F\right|\right)\right]}{N^J\left(\bar{A}^J\right)^{\sigma}\left(\bar{\lambda}^J\right)^{1-\sigma}\left[1+(1+\nu)^{1-\sigma}\right]}, \quad J = H, F. \tag{54}$$

Then, in a Nash equilibrium, each government chooses its standard to minimize its price index, given the standard of the other. The best-response functions that follow from the first-order conditions imply

$$\frac{\Phi'\left(\bar{a}^H - \bar{a}^F\right)}{\Phi\left(\bar{a}^H - \bar{a}^F\right)}\frac{d(\bar{a}^H - \bar{a}^F)}{d\bar{a}^J} = \sigma\frac{A_a\left(\bar{a}^J, \gamma^J\right)}{A\left(\bar{a}^J, \gamma^J\right)} + (1-\sigma)\,\eta\left(\bar{a}^J\right), \quad J = H, F. \tag{55}$$

9 Nash Standards under MR when Adaptation Costs are Large

If adaptation costs a large, each firm will choose only one characteristic and invoke mutual recognition to serve the export market. A firm then chooses a to maximize

$$A^J\left(a_J\right)^{\sigma}\lambda\left(a_J\right)^{1-\sigma}N^J\left(P^J\right)^{\sigma-1} + A^K\left(a_J\right)^{\sigma}\lambda\left(a_J\right)^{1-\sigma}(1+\nu)^{1-\sigma}N^K\left(P^K\right)^{\sigma-1}.$$

The first order condition implies:

$$A^J\left(a_J\right)^{\sigma}\lambda\left(a_J\right)^{1-\sigma}N^J\left(P^J\right)^{\sigma-1}\left[\sigma\frac{\partial\log\left(A^J(a_J)\right)}{\partial a_J} + (1-\sigma)\frac{\partial\log\left(\lambda(a_J)\right)}{\partial a_J}\right]$$
$$+ A^K\left(a_J\right)^{\sigma}\lambda\left(a_J\right)^{1-\sigma}(1+\nu)^{1-\sigma}N^K\left(P^K\right)^{\sigma-1}\left[\sigma\frac{\partial\log\left(A^K(a_J)\right)}{\partial a_J} + (1-\sigma)\frac{\partial\log\left(\lambda(a_J)\right)}{\partial a_J}\right] = 0.$$

Thus

$$\left(A_H^H\right)^{\sigma} N^H \left(P^H\right)^{\sigma-1} \left[\sigma \frac{\partial \log\left(A^H(a_H)\right)}{\partial a_H} + (1-\sigma) \frac{\partial \log\left(\lambda(a_H)\right)}{\partial a_H}\right] + \left(A_H^F\right)^{\sigma} (1+\nu)^{1-\sigma} N^F \left(P^F\right)^{\sigma-1} \left[\sigma \frac{\partial \log\left(A^F(a_H)\right)}{\partial a_H} + (1-\sigma) \frac{\partial \log\left(\lambda(a_H)\right)}{\partial a_H}\right] = 0 \quad (56)$$

and

$$\left(A_F^F\right)^{\sigma} N^F \left(P^F\right)^{\sigma-1} \left[\sigma \frac{\partial \log\left(A^F(a_F)\right)}{\partial a_F} + (1-\sigma) \frac{\partial \log\left(\lambda(a_F)\right)}{\partial a_F}\right] + A\left(a_F^H\right)^{\sigma} (1+\nu)^{1-\sigma} N^H \left(P^H\right)^{\sigma-1} \left[\sigma \frac{\partial \log\left(A^H(a_F)\right)}{\partial a_F} + (1-\sigma) \frac{\partial \log\left(\lambda(a_F)\right)}{\partial a_F}\right] = 0. \quad (57)$$

In addition, the two zero profit conditions imply:

$$N^H \left(P^H\right)^{\sigma-1} = \frac{\left[\left(A_F^F\right)^{\sigma} \lambda_F^{1-\sigma} - (1+\nu)^{1-\sigma} \left(A_H^F\right)^{\sigma} \lambda_H^{1-\sigma}\right] \sigma\nu(0)}{\lambda_H^{1-\sigma}\lambda_F^{1-\sigma}\left[\left(A_H^H\right)\left(A_F^F\right)^{\sigma} - (1+\nu)^{1-\sigma}\left(A_F^H\right)^{\sigma}(1+\nu)^{1-\sigma}\left(A_F^F\right)^{\sigma}\right]} \quad (58)$$

and

$$N^F \left(P^F\right)^{\sigma-1} = \frac{\left[\left(A_H^H\right)^{\sigma} \lambda_H^{1-\sigma} - (1+\nu)^{1-\sigma} \left(A_F^H\right)^{\sigma} \lambda_F^{1-\sigma}\right] \sigma\nu(0)}{\lambda_H^{1-\sigma}\lambda_F^{1-\sigma}\left[\left(A_H^H\right)\left(A_F^F\right)^{\sigma} - (1+\nu)^{1-\sigma}\left(A_F^H\right)^{\sigma}(1+\nu)^{1-\sigma}\left(A_F^F\right)^{\sigma}\right]}. \quad (59)$$

Substituting into (56) and (57) gives:

$$\left(A_H^H\right)^{\sigma}\left[\left(A_F^F\right)^{\sigma}\lambda_F^{1-\sigma} - (1+\nu)^{1-\sigma}\left(A_H^F\right)^{\sigma}\lambda_H^{1-\sigma}\right]\left[\sigma \frac{\partial \log\left(A^H(a_H)\right)}{\partial a_H} + (1-\sigma) \frac{\partial \log\left(\lambda(a_H)\right)}{\partial a_H}\right] + (1+\nu)^{1-\sigma}\left(A_H^F\right)^{\sigma}\left[\left(A_H^H\right)^{\sigma}\lambda_H^{1-\sigma} - (1+\nu)^{1-\sigma}\left(A_F^H\right)^{\sigma}\lambda_F^{1-\sigma}\right]\left[\sigma \frac{\partial \log\left(A^F(a_H)\right)}{\partial a_H} + (1-\sigma) \frac{\partial \log\left(\lambda(a_H)\right)}{\partial a_H}\right] = 0$$

and

$$\left(A_F^F\right)^{\sigma}\left[\left(A_H^H\right)^{\sigma}\lambda_H^{1-\sigma} - (1+\nu)^{1-\sigma}\left(A_F^H\right)^{\sigma}\lambda_F^{1-\sigma}\right]\left[\sigma \frac{\partial \log\left(A^F(a_F)\right)}{\partial a_F} + (1-\sigma) \frac{\partial \log\left(\lambda(a_F)\right)}{\partial a_F}\right] + (1+\nu)^{1-\sigma}\left(A_F^H\right)^{\sigma}\left[\left(A_F^F\right)^{\sigma}\lambda_F^{1-\sigma} - (1+\nu)^{1-\sigma}\left(A_H^F\right)^{\sigma}\lambda_H^{1-\sigma}\right]\left[\sigma \frac{\partial \log\left(A^H(a_F)\right)}{\partial a_F} + (1-\sigma) \frac{\partial \log\left(\lambda(a_F)\right)}{\partial a_F}\right] = 0.$$

The Nash equilibrium with MR is the solution of these two equations for a_H and a_F.

10 Derivation of Demands in the Presence of Consumption Externalities

Here we derive an explicit expression in the presence of a consumption externality ($\xi < 1$) for the industry-level price index $\mathcal{P}^J$ that enters (2) and (3).

As in the body of the paper, for ease of notation, we define

$$A_i^J \equiv (1-\xi)\, A^{*J} + \xi A\left(a_i^J, \gamma^J\right); \quad \mathcal{A}_i^J \equiv A\left(a_i^J, \gamma^J\right)$$

and hence, by (1) and (4), per-capita utility in country J for $\xi \leq 1$ is given by

$$U^J = 1 + C_Y^J + \log\left(\left\{\sum_{i\in\Theta^H} A_i^J \left(c_i^J\right)^\beta + (1-\xi)\left[\mathcal{A}_i^J - A^{*J}\right]\left(c_{i\mu}^J\right)^\beta\right\}^{\frac{1}{\beta}}\right).$$

The first-order conditions for the utility-maximizing choice of c_i^J imply

$$(C_D^J)^{-\beta} A_i^J (c_i^J)^\beta = p_i^J c_i^J.$$

Summing over i yields

$$(C_D^J)^{-\beta} \sum_i A_i^J (c_i^J)^\beta = \sum_i p_i^J c_i^J.$$

We define $\mathcal{P}^J$ so that

$$\mathcal{P}^J C_D^J = \sum_i p_i^J c_i^J.$$

Then

$$\mathcal{P}^J = (C_D^J)^{-\beta-1} \sum_i A_i^J (c_i^J)^\beta.$$

Also, from the first-order conditions,

$$\begin{aligned} c_i^J &= (p_i^J)^{\frac{1}{\beta-1}} (A_i^J)^{\frac{-1}{\beta-1}} (C_D^J)^{\frac{\beta}{\beta-1}} \\ (c_i^J)^\beta &= (p_i^J)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-\beta}{\beta-1}} (C_D^J)^{\frac{\beta}{\beta-1}} \\ A_i^J (c_i^J)^\beta &= (p_i^J)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-1}{\beta-1}} (C_D^J)^{\frac{\beta}{\beta-1}}. \end{aligned}$$

Hence we have

$$\mathcal{P}^J = (C_D^J)^{-\beta-1} (p_i^J)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-1}{\beta-1}} (C_D^J)^{\frac{\beta}{\beta-1}} = (C_D^J)^{\frac{1}{\beta-1}} (p_i^J)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-1}{\beta-1}}.$$

Note that with $c_i^J = c_{i\mu}^J$ we can write

$$C_D^J = \left[\sum_i \mathcal{A}_i^J \left(c_i^J\right)^\beta\right]^{\frac{1}{\beta}} = (C_D^J)^{\frac{\beta}{\beta-1}} \left[\sum_i \mathcal{A}_i^J (p_i^J)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-\beta}{\beta-1}}\right]^{\frac{1}{\beta}},$$

and therefore

$$(C_D^J)^{\frac{-1}{\beta-1}} = \left[\sum_i \mathcal{A}_i^J (p_i^J)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-\beta}{\beta-1}}\right]^{\frac{1}{\beta}},$$

which implies

$$C_D^J = \left[\sum_i^J \mathcal{A}_i^J (p_i^J)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-\beta}{\beta-1}}\right]^{\frac{-(\beta-1)}{\beta}}.$$

Substituting yields

$$\mathcal{P}^J = \left[\sum_i \mathcal{A}_i^J (p_i^H)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-\beta}{\beta-1}}\right]^{\frac{-1}{\beta}} (p_i^J)^{\frac{\beta}{\beta-1}} (A_i^J)^{\frac{-1}{\beta-1}}$$

or finally using $\sigma \equiv \frac{1}{1-\beta}$

$$\mathcal{P}^J = \frac{\sum_i (p_i^J)^{1-\sigma} (A_i^J)^\sigma}{\left[\sum_i \mathcal{A}_i^J (p_i^J)^{1-\sigma} (A_i^J)^{\sigma-1}\right]^{\frac{\sigma}{\sigma-1}}} = \left[\frac{\sum_i \left(A_i^J\right)^\sigma \left(p_i^J\right)^{1-\sigma}}{\sum_i \left(\frac{\mathcal{A}_i^J}{A_i^J}\right) \left(A_i^J\right)^\sigma \left(p_i^J\right)^{1-\sigma}}\right]^{\frac{\sigma}{\sigma-1}} P^J,$$

where the second equality follows from the expression for P^J given in (5).

11 Proof of Proposition 6

Proposition 6 *Suppose consumption of differentiated products confers externalities, as reflected in (17). Then global efficiency requires $z^H > 0$ and $s^H > 1/\sigma$ for all forms of product differentiation that satisfy Assumption 1. It requires $z^F > 0$ and, $s^F > 1/\sigma$ if versions of a brand are horizontally differentiated, but $z^F < 0$ and, $s^F < 1/\sigma$ if versions of a brand are vertically differentiated. Regulation is needed to ensure efficient product designs. The optimal standards induce firms to design products closer to the ideal in each destination markets compared to their profit-maximizing choices.*

Proof In the text we derived the following expressions which implicitly define the efficient prices for $\xi \in [0,1]$:

$$p_J^{JE}(\xi) = p_J^{JE}(1) \left[\left(\frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}\right) \left(\frac{P^{JE}(\xi)}{\mathcal{P}^{JE}}\right)^{\left(\frac{\sigma-1}{\sigma}\right)}\right]$$

and

$$p_K^{JE}(\xi) = p_K^{JE}(1) \left[\left(\frac{A_K^{JE}(\xi)}{\mathcal{A}_K^{JE}}\right) \left(\frac{P^{JE}(\xi)}{\mathcal{P}^{JE}}\right)^{\left(\frac{\sigma-1}{\sigma}\right)}\right]$$

where $\mathcal{P}^{JE}$ is the efficient industry-level (and brand-level) price index in country J when $\xi = 1$. We claimed that for $\xi < 1$, $p_H^{HE}(\xi) < p_H^{HE}(1)$, $p_F^{HE}(\xi) > p_F^{HE}(1)$, and that the relationship between $p_J^{FE}(\xi)$ and $p_J^{FE}(1)$ depends on the form of product differentiation; if different versions of a brand are horizontally differentiated, $p_F^{FE}(\xi) < p_F^{FE}(1)$ and $p_F^{HE}(\xi) > p_F^{HE}(1)$, whereas if they are vertically differentiated, $p_F^{FE}(\xi) > p_F^{FE}(1)$ and $p_F^{HE}(\xi) < p_F^{HE}(1)$.

Efficient pricing can be implemented with a combination of efficient net trade taxes and efficiency consumption subsidies, namely

$$\tau^{JE}(\xi) + e_{KE}(\xi) = (1+\nu)\left[\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}} - 1\right],\ J = H, F.$$

and

$$s^{JE}(\xi) = \frac{1}{\sigma} + \left(\frac{\sigma-1}{\sigma}\right)\left[1 - \left(\frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}\right)\left(\frac{P^{JE}(\xi)}{\mathcal{P}^{JE}}\right)^{\frac{\sigma-1}{\sigma}}\right],\ \ J = H, F,$$

We claimed that $\tau^{HE}(\xi) + e_{FE}(\xi) > 0$ and $s^{HE}(\xi) > 1/\sigma$ for all demand shifters that satisfy Assumption 1. In the foreign country, $\tau^{FE}(\xi) + e_{HE}(\xi) > 0$ and $s^{FE}(\xi) > 1/\sigma$ if versions of brand i are horizontally differentiated, whereas $\tau^{FE}(\xi) + e_{HE}(\xi) < 0$ and $s^{FE}(\xi) < 1/\sigma$ if they are vertically differentiated. To establish these claims, we need to examine

$$sgn\left[\left(\frac{A_J^{KE}(\xi)}{\mathcal{A}_J^{KE}}\right)\left(\frac{P^{KE}(\xi)}{\mathcal{P}^{KE}}\right)^{\frac{\sigma-1}{\sigma}} - 1\right]$$

for $J = H, F$.

First we prove another claim made in the text, namely, that under the efficient consumption subsidies and net trade taxes and the implied vector of efficient prices (which we denoted by $\mathbf{p}^E(\xi)$), and in combination with the vector of efficient product characteristics (which we denoted by $\mathbf{a}^E$), we have

$$\mathcal{P}^{JE}(\xi) = \mathcal{P}^{JE} = P^{JE} \text{ for } J = H, F,$$

where $\mathcal{P}^{JE}(\xi)$ is defined by (18) using $\mathbf{a}^E$ and $\mathbf{p}^E(\xi)$ and $\mathcal{P}^{JE} = \mathcal{P}^{JE}(1)$. To show that $\mathcal{P}^{HE}(\xi) = \mathcal{P}^{HE}$ (the steps to show $\mathcal{P}^{FE}(\xi) = \mathcal{P}^{FE}$ are analogous), we first write $\mathcal{P}^{HE}$ as

$$\mathcal{P}^{HE} = \left[n_H(\mathcal{A}_H^{HE})^{\sigma}(p_H^{HE}(1))^{1-\sigma} + n_F(\mathcal{A}_F^{HE})^{\sigma}(p_F^{HE}(1))^{1-\sigma}\right]^{\frac{-1}{\sigma-1}},$$

where we have used $A_H^{HE}(\xi = 1) = \mathcal{A}_H^{HE}$ and $A_F^{HE}(\xi = 1) = \mathcal{A}_F^{HE}$. Then, using the definition of P^H and the relationship between P^H and $\mathcal{P}^H$, we have

$$\mathcal{P}^{HE}(\xi) = \frac{\left[P^{HE}(\xi)\right]^{-(\sigma-1)}}{\left[n_H\frac{\mathcal{A}_H^{HE}}{A_H^{HE}(\xi)}(A_H^{HE}(\xi))^{\sigma}(p_H^{HE}(\xi))^{1-\sigma} + n_F\frac{\mathcal{A}_F^{HE}}{A_F^{HE}(\xi)}(A_F^{HE}(\xi))^{\sigma}(p_F^{HE}(\xi))^{1-\sigma}\right]^{\frac{\sigma}{\sigma-1}}}.$$

Plugging the expressions for $p_H^{HE}(\xi)$ and $p_F^{HE}(\xi)$ into the denominator of the above expression and simplifying then yields

$$\begin{aligned}
& \frac{\left[P^{HE}(\xi)\right]^{-(\sigma-1)}}{\left[n_H \frac{\mathcal{A}_H^{HE}}{A_H^{HE}(\xi)}(A_H^{HE}(\xi))^{\sigma}(p_H^{HE}(\xi))^{1-\sigma} + n_F \frac{\mathcal{A}_F^{HE}}{A_F^{HE}(\xi)}(A_F^{HE}(\xi))^{\sigma}(p_F^{HE}(\xi))^{1-\sigma}\right]^{\frac{\sigma}{\sigma-1}}} \\
= & \frac{\left(\mathcal{P}^{HE}\right)^{-(\sigma-1)}}{\left[n_H \frac{\mathcal{A}_H^{HE}}{A_H^{HE}(\xi)}(A_H^{HE}(\xi))^{\sigma}(p_H^{HE}(1))^{1-\sigma}\left(\frac{A_H^{HE}(\xi)}{\mathcal{A}_H^{HE}}\right)^{1-\sigma} + n_F \frac{\mathcal{A}_F^{HE}}{A_F^{HE}(\xi)}(A_F^{HE}(\xi))^{\sigma}(p_F^{HE}(1))^{1-\sigma}\left(\frac{A_F^{HE}(\xi)}{\mathcal{A}_F^{HE}}\right)^{1-\sigma}\right]^{\frac{\sigma}{\sigma-1}}} \\
= & \left[n_H(\mathcal{A}_H^{HE})^{\sigma}(p_H^{HE}(1))^{1-\sigma} + n_F(\mathcal{A}_F^{HE})^{\sigma}(p_F^{HE}(1))^{1-\sigma}\right]^{\frac{-1}{\sigma-1}} \\
= & \mathcal{P}^{HE}.
\end{aligned}$$

Having established that $\mathcal{P}^{HE}(\xi) = \mathcal{P}^{HE}$, we turn to examine

$$sgn\left[\left(\frac{A_H^{HE}(\xi)}{\mathcal{A}_H^{HE}}\right)\left(\frac{P^{HE}(\xi)}{\mathcal{P}^{HE}}\right)^{\left(\frac{\sigma-1}{\sigma}\right)} - 1\right]$$

Using $\mathcal{P}^{HE}(\xi) = \mathcal{P}^{HE}$ and the relationship between P^H and $\mathcal{P}^H$, we have

$$\begin{aligned}
& \left(\frac{A_H^{HE}(\xi)}{\mathcal{A}_H^{HE}}\right)\left(\frac{P^{HE}(\xi)}{\mathcal{P}^{HE}}\right)^{\left(\frac{\sigma-1}{\sigma}\right)} = \left(\frac{A_H^{HE}(\xi)}{\mathcal{A}_H^{HE}}\right)\left(\frac{P^{HE}(\xi)}{\mathcal{P}^{HE}(\xi)}\right)^{\left(\frac{\sigma-1}{\sigma}\right)} \\
= & \left(\frac{A_H^{HE}(\xi)}{\mathcal{A}_H^{HE}}\right)\left[\frac{n_H \frac{\mathcal{A}_H^{HE}}{A_H^{HE}(\xi)}(A_H^{HE}(\xi))^{\sigma}(p_H^{HE}(\xi))^{1-\sigma} + n_F \frac{\mathcal{A}_F^{HE}}{A_F^{HE}(\xi)}(A_F^{HE}(\xi))^{\sigma}(p_F^{HE}(\xi))^{1-\sigma}}{n_H(A_H^{HE}(\xi))^{\sigma}(p_H^{HE}(\xi))^{1-\sigma} + n_F(A_F^{HE}(\xi))^{\sigma}(p_F^{HE}(\xi))^{1-\sigma}}\right] \\
= & \frac{n_H(A_H^{HE}(\xi))^{\sigma}(p_H^{HE}(\xi))^{1-\sigma} + n_F\left[\frac{A_H^{HE}(\xi)/\mathcal{A}_H^{HE}}{A_F^{HE}(\xi)/\mathcal{A}_F^{HE}}\right]\left[A_F^{HE}(\xi)\right])^{\sigma}(\left[p_F^{HE}(\xi)\right]^{1-\sigma}}{n_H(A_H^{HE}(\xi))^{\sigma}(p_H^{HE}(\xi))^{1-\sigma} + n_F(A_F^{HE}(\xi))^{\sigma}(p_F^{HE}(\xi))^{1-\sigma}} \\
< & 1
\end{aligned}$$

where the inequality follows for $\xi < 1$ from the ranking of efficient product characteristics, i.e., $a_H^{HE} > a_F^{HE} \Rightarrow A_H^{HE}(\xi)/\mathcal{A}_H^{HE} < A_F^{HE}(\xi)/\mathcal{A}_F^{HE}$. An analogous argument establishes that

$$\left[\frac{A_F^{HE}(\xi)}{\mathcal{A}_F^{HE}}\right]\left[\frac{P^{HE}(\xi)}{\mathcal{P}^{HE}}\right]^{\frac{\sigma-1}{\sigma}} > 1.$$

Similarly, in the foreign country, we have

$$\left[\frac{A_F^{FE}(\xi)}{\mathcal{A}_F^{FE}}\right]\left[\frac{P^{FE}(\xi)}{\mathcal{P}^{FE}}\right]^{\frac{\sigma-1}{\sigma}} < 1$$

and

$$\left[\frac{A_H^{FE}(\xi)}{\mathcal{A}_H^{FE}}\right]\left[\frac{P^{FE}(\xi)}{\mathcal{P}^{FE}}\right]^{\frac{\sigma-1}{\sigma}} > 1$$

for the case of horizontal differentiation, because then $a_F^{FE} < a_H^{FE} \Rightarrow A_F^{FE}(\xi)/\mathcal{A}_F^{FE} < A_H^{FE}(\xi)/\mathcal{A}_H^{FE}$. However, with vertical differentiation, $a_F^{FE} < a_H^{FE} \Rightarrow A_F^{FE}(\xi)/\mathcal{A}_F^{FE} > A_H^{FE}(\xi)/\mathcal{A}_H^{FE}$, so the two inequalities are reversed.

Finally, in the text we also claimed that the additional consumption subsidies and net trade taxes implied by efficient intervention in the presence of the consumption externality are revenue neutral, implying that global welfare under the efficient policies when $\xi < 1$ is given by

$$\begin{aligned}\Omega(\xi) &= \sum_J L^J - \sum_J N^J \log \mathcal{P}^{JE}(\boldsymbol{\xi}) - \sum_J N^J \frac{1}{\sigma-1} \\ &= \sum_J L^J - \sum_J N^J \log \mathcal{P}^{JE} - \sum_J N^J \frac{1}{\sigma-1}.\end{aligned}$$

the same level of global welfare that is reached under efficient policies when $\xi = 1$.

To confirm that the additional consumption subsidies and net trade taxes implied by efficient intervention in the presence of the consumption externality are revenue neutral, note that the trade tax revenue goes from zero under the efficient policies when $\xi = 1$ to the amount

$$\sum_J N^J \frac{\sigma}{\sigma-1}(1+\nu)\left[\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}} - 1\right]\left[n_{KE}\tilde{c}_K^{JE}\right] \tag{60}$$

under the efficient policies when $\xi < 1$: the change in trade tax revenue is therefore given by (60). The increase in consumption subsidy payments is given by

$$\sum_J \left\{ N^J \frac{\sigma}{\sigma-1}\left(\frac{1}{\sigma} + \frac{\sigma-1}{\sigma}\left[1 - \left(\frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}\right)\left(\frac{P^J(p_J^{JE}(\xi), p_K^{JE}(\xi); \mathbf{n}_E, a_J^{JE}, a_K^{JE})}{\mathcal{P}^{JE}}\right)^{\frac{\sigma-1}{\sigma}}\right]\right) \right.$$
$$\left. \times \left[n_{JE}\tilde{c}_J^{JE} + n_{KE}(1+\nu+\tau^{JE}(\xi) + e_{KE}(\xi))\tilde{c}_K^{JE}\right] - N^J \frac{1}{\sigma-1}\left[n_{JE}\tilde{c}_J^{JE} + n_{KE}(1+\nu)\tilde{c}_K^{JE}\right] \right\}$$

which can be simplified to

$$\sum_J \left\{ -N^J \frac{1}{\sigma-1} n_{KE}(1+\nu)\tilde{c}_K^{JE} + N^J n_{JE}\tilde{c}_J^{JE} + N^J \frac{\sigma}{\sigma-1} n_{KE}(1+\nu)\frac{\left[\frac{A_K^{JE}(\xi)}{\mathcal{A}_K^{JE}}\right]}{\left[\frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}\right]}\tilde{c}_K^{JE} \right.$$
$$\left. -N^J \left[\frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}\right]\left(\frac{P^J(p_J^{JE}(\xi), p_K^{JE}(\xi); \mathbf{n}_E, a_J^{JE}, a_K^{JE})}{\mathcal{P}^{JE}}\right)^{\frac{\sigma-1}{\sigma}}\left[n_{JE}\tilde{c}_J^{JE} + n_{KE}(1+\nu)\frac{\left[A_K^{JE}(\xi)/\mathcal{A}_K^{JE}\right]}{\left[A_J^{JE}(\xi)/\mathcal{A}_J^{JE}\right]}\tilde{c}_K^{JE}\right] \right\}.$$

Hence, in going from $\xi = 1$ to $\xi < 1$ the change in revenue implied by the efficient trade taxes and consumption subsidies is given by

$$\Delta Rev = \sum_J \{ N^J \left(\frac{\sigma}{\sigma-1}\right)(1+\nu)\left[\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}} - 1\right][n_{KE}\tilde{c}_K^{JE}] + N^J \left(\frac{1}{\sigma-1}\right) n_{KE}(1+\nu)\tilde{c}_K^{JE}$$

$$- N^J n_{JE}\tilde{c}_J^{JE} - N^J \left(\frac{\sigma}{\sigma-1}\right) n_{KE}(1+\nu)\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}}\tilde{c}_K^{JE}$$

$$+ N^J \frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}\left[\frac{P^J(p_J^{JE}(\xi), p_K^{JE}(\xi); \mathbf{n}_E, a_J^{JE}, a_K^{JE})}{\mathcal{P}^{JE}}\right]^{\frac{\sigma-1}{\sigma}}\left[n_{JE}\tilde{c}_J^{JE} + n_{KE}(1+\nu)\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}}\tilde{c}_K^{JE}\right],$$

which simplifies to

$$\Delta Rev = \sum_J N^J \left\{ n_{KE}(1+\nu)\tilde{c}_K^{JE}\left\{\frac{A_K^{JE}(\xi)}{\mathcal{A}_K^{JE}}\left[\frac{P^J(p_J^{JE}(\xi), p_K^{JE}(\xi); \mathbf{n}_E, a_J^{JE}, a_K^{JE})}{\mathcal{P}^{JE}}\right]^{\frac{\sigma-1}{\sigma}} - 1\right\}\right.$$

$$\left. + n_{JE}\tilde{c}_J^{JE}\left\{\frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}\left[\frac{P^J(p_J^{JE}(\xi), p_K^{JE}(\xi); \mathbf{n}_E, a_J^{JE}, a_K^{JE})}{\mathcal{P}^{JE}}\right]^{\frac{\sigma-1}{\sigma}} - 1\right\}\right\}.$$

Using $\mathcal{P}^H(\mathbf{a}^E, \mathbf{p}^E(\xi)) = \mathcal{P}^{HE}$ and the relationship between P^H and $\mathcal{P}^H$, we then have

$$\Delta Rev = \sum_J \frac{N^J}{n_H(A_H^{HE}(\xi))^\sigma (p_H^{HE}(\xi))^{1-\sigma} + n_F(A_F^{HE}(\xi))^\sigma (p_F^{HE}(\xi))^{1-\sigma}}$$

$$\times \left\{ n_{KE}(1+\nu)\tilde{c}_K^{JE}\cdot\left[n_{JE}\left[\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}} - 1\right](\left[A_J^{JE}(\xi)\right]^\sigma (p_J^{JE}(\xi))^{1-\sigma}\right]\right.$$

$$\left. + n_{JE}\tilde{c}_J^{JE}\cdot\left[n_{KE}\left[\frac{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}}{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}} - 1\right]\left[A_K^{JE}(\xi)\right]^\sigma \left[p_K^{JE}(\xi)\right]^{1-\sigma}\right]\right\},$$

which can be rewritten as

$$\Delta Rev = \sum_J \frac{N^J}{n_H(A_H^{HE}(\xi))^\sigma (p_H^{HE}(\xi))^{1-\sigma} + n_F(A_F^{HE}(\xi))^\sigma (p_F^{HE}(\xi))^{1-\sigma}} n_{KE}n_{JE}$$

$$\times \frac{\tilde{c}_J^{JE}\tilde{c}_K^{JE}}{(P^J(p_J^{JE}(\xi), p_K^{JE}(\xi); \mathbf{n}_E, a_J^{JE}, a_K^{JE}))^{\sigma-1}}\left\{(1+\nu)\frac{p_J^{JE}(\xi)}{\lambda_J^{JE}(\xi)}\left[\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}} - 1\right] + \frac{p_K^{JE}(\xi)}{\lambda_K^{JE}(\xi)}\left[\frac{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}}{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}} - 1\right]\right\}$$

which implies $\Delta Rev = 0$ if and only if

$$(1+\nu)\frac{p_J^{JE}(\xi)}{\lambda_J^{JE}(\xi)}\left[\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}} - 1\right] + \frac{p_K^{JE}(\xi)}{\lambda_K^{JE}(\xi)}\left[\frac{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}}{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}} - 1\right] = 0.$$

But substituting in the expressions for $p_J^{JE}(\xi)$ and $p_K^{JE}(\xi)$ yields

$$
\begin{aligned}
&(1+\nu)\frac{p_J^{JE}(\xi)}{\lambda_J^{JE}(\xi)}\left[\frac{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}}-1\right]+\frac{p_K^{JE}(\xi)}{\lambda_K^{JE}(\xi)}\left[\frac{A_J^{JE}(\xi)/\mathcal{A}_J^{JE}}{A_K^{JE}(\xi)/\mathcal{A}_K^{JE}}-1\right] \\
&=(1+\nu)\left[\frac{P^J(p_J^{JE}(\xi),p_K^{JE}(\xi);\mathbf{n}^E,a_J^{JE},a_K^{JE})}{\mathcal{P}^{JE}}\right]^{\frac{\sigma-1}{\sigma}}\left[\frac{A_K^{JE}(\xi)}{\mathcal{A}_K^{JE}}-\frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}+\frac{A_J^{JE}(\xi)}{\mathcal{A}_J^{JE}}-\frac{A_K^{JE}(\xi)}{\mathcal{A}_K^{JE}}\right]\} \\
&=0.
\end{aligned}
$$

QED