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JEL Codes: F02, F13, F15

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A Simple Theory of Deep Trade Integration^{*†}

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Abstract

Which countries should aim for regulatory cooperation, and to what extent should they pursue it? We develop an imperfectly competitive trade model that accounts for differences in technology and regulatory preferences regarding local consumption externalities across countries. Each country sets unique product standards, and firms incur costs when tailoring products to different markets. Trade occurs when the benefits of comparative advantages outweigh the desire for asymmetric regulations. Our findings indicate that regulatory cooperation, defined as the cooperative setting of standards, is most advantageous for countries with moderate differences in regulatory preferences. Shallow integration, however, falls short of achieving the optimal planner's solution. Countries with strong comparative advantages in distinct externality-generating goods can pursue deeper regulatory cooperation through mutual regulatory concessions. Additionally, when regulatory preferences are highly dispersed, international cooperation tends to form regulatory blocs.

JEL classifications: F02, F13, F15.

Keywords: deep economic integration, standards, trade policy, trade agreements.

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1 Introduction

In recent decades, the focus of trade policy has shifted from reducing tariffs to other areas of cooperation. Recent trade agreements such as the Comprehensive and Progressive Agreement for TransPacific Partnership (CPTPP) or the EU-Canada Comprehensive Economic Trade Agreement (CETA) involve countries whose tariffs are already low. Among these new areas of cooperation, those that run deepest in the popular debate are often linked to issues related to health or environmental protection when domestic regulations differ. Differences in domestic regulations may originate from pure protectionist motives, with the aim of creating a cost advantage for local firms. Reducing them in this case is positive from a social planner's perspective. They may also reflect countries' legitimate concerns for negative externalities, as recognized by Article XX of the General Agreement on Tariffs and Trade (GATT),¹ when those concerns vary across countries. Our paper provides a simple theory to analyze the complex welfare implications of regulatory convergence in the presence of externalities that different countries value differently.

We consider a simple trade model with two goods, where one of the goods generates a local consumption externality, for example, the local pollution emitted when driving cars (NO_x, noise, etc.).² All consumers buy one unit of the externality-generating good, and each country sets a product standard, which specifies the maximum level of externality that the consumption of a unit of the good can generate (*vertical* standards). For cars, these standards would, for example, correspond to maximum emissions of NO_x per km driven.³ We assume countries differ in their regulatory preferences, or "values",⁴ meaning the local consumption externality enters the utility function with a country-specific weight. Cross-country differences in regulatory preferences imply optimal standards in autarky are heterogeneous across countries. Countries in our model can choose their own standard in an open economy as long as they do not discriminate between imported and domestic goods. They can, for example, not set a NO_x emission limit of 80mg/km driven for domestically produced cars and 60mg/km for similar imported cars, because doing so would violate the "national treatment" obligation of the GATT (Article III).⁵

On the production side, each country has one national producer of the externality-generating good. The

¹Article XX specifies that the agreement does not prevent countries to adopt measures "necessary to protect human, animal or plant life or health" among others, as long as they do not constitute a disguised restriction on international trade.

²Cars generate a production externality (the pollution resulting from the production process) as well as a consumption externality (the pollution resulting from driving the car). Both externalities can be local (pollutants that have a limited geographic effect) or global (CO₂ emissions). We here consider the local consumption externality, and highlight how our results differ for a local production externality in section 2.2.

³We use "standards" and "regulations" interchangeably; that is, we do not think of standards as voluntary but as prescribed by the legislator.

⁴The term has been used repeatedly by the EU trade commissioner Cecilia Malmström; see for instance, <https://www.euractiv.com/section/trade-society/opinion/trade-is-not-just-about-economics-but-also-values/>. In that spirit, our setup also applies to countries' pure differences in preferences, such as different conceptions about animal welfare.

⁵We explore deviations from national treatment in section 3.4.

technology of each producer is characterized by two parameters. The first is a general efficiency level that governs whether a firm is relatively productive at any standard (Ricardian technology differences). The second is a core competence, defined as the standard imposed in the firm's domestic market in autarky.⁶ We assume producing a good at a more stringent standard is always more costly and that firms have a cost advantage in producing at a standard close to their core competence. Both countries also produce a good that generates no externality, under perfect competition and with the same productivity. This implies productivity differences in the externality-generating good immediately translate into comparative advantages. In an open economy, the producers of the externality-generating good compete à la Bertrand in each market. Our joint assumptions of Bertrand competition and inelastic demand imply we reach an efficient outcome in autarky with standards as the unique policy instrument, greatly simplifying the analysis. Our assumptions also allow us to isolate regulatory heterogeneity as the only source of inefficiency in an open economy.

When opening to trade, countries still have the option to produce domestically but may prefer importing the externality-generating good from a country with a more efficient technology. This usual Ricardian motive for trade is, however, dampened if countries have different perceptions of the externality, because the core competence of the exporting country may be far from the preferred standard of the importer. The benefits from trade thus depend positively on the strength of comparative advantage, but negatively on the heterogeneity in regulatory preferences. If this heterogeneity is large enough, it is better not to trade, even in the presence of comparative advantage.

Under Bertrand competition, the exporter captures the full surplus from trade, and the importing country has no incentive to adjust its standard when it is set non-cooperatively. The importer therefore does not take into account the costs borne by the exporter to produce at a different standard than its core competence (*cost-shifting externality*). A planner, maximizing world welfare, internalizes this when setting the importer's standard and chooses some degree of convergence in standards as long as trade occurs. In this setup, such a partial convergence raises world welfare the most if countries have moderate differences in regulatory preferences. For countries with similar regulatory preferences, standards are similar even without cooperation, so convergence only generates small welfare gains. If countries differ too much, on the other hand, even a deep integration does not make trade profitable, and converging in standards would be inefficient.

In our baseline setup, and in the absence of transfers, the planner's solution benefits the country exporting the externality-generating good, but harms its importer. We extend our setup to allow for many externality-generating goods and show an agreement with mutual concessions on standards can be Pareto improving. With intra-industry trade within the polluting industry, each country exports and imports some varieties of

⁶In practice, firms may have gathered experience producing at their autarky standard. This could be thought of as a short-run assumption, which we relax in section 4.2, where firms can freely choose their core competence.

the polluting good. The welfare loss from adjusting the standard on imported goods can now be—at least partially—balanced by the partner’s adjustment of its standard, raising profits on the export market. We show a mutual concession scheme guaranteeing the same welfare gain to both countries reaches a stronger convergence of standards when *intra*-industry differences in productivity are large between polluting varieties, but weaker with large *inter*-industry differences in productivity.

We then ask whether a convergence in standards requires explicitly coordinating on their level (*deep trade integration*) or whether more traditional instruments such as tariff reductions suffice (*shallow integration*). Introducing tariffs in our setup shows a non-trivial interaction with standards. Tariffs have a well-known distortionary effect, but in our setup, they also act as a way to partially internalize the cost-shifting externality, even in a non-cooperative setup. The rationale is that to raise more tariff revenue while maintaining the participation constraint of the exporting firm, an importing country will move its standard toward the core competence of the exporter. We show a shallow agreement does decrease tariffs compared with a non-cooperative world, but consequently incurs less cooperation in terms of standards. In that sense, a shallow agreement is not able to replicate the planner’s solution, and a full tariff liberalization is not optimal if not accompanied by a deep trade integration, even under non-violation mechanisms à la Bagwell and Staiger (2001), as we discuss in detail.

In a multi-country version of our setup, we show a planner would choose "regulatory blocs" around the most productive countries in the externality-generating good. These blocs are such that all countries with regulatory preferences in an interval around those of a productive exporter adjust their consumption standard toward that of the exporter. This implies some convergence in standards between countries located within the same bloc. The formation of trade blocs allows the social planner to reduce within-bloc heterogeneity, even if at the expense of allocating some of the worldwide production to countries that are not the most efficient.

Although highly stylized, our model fits well with a number of first-order features of recent trade-policy debates. Taken together, our results suggest deep trade integration should complement reductions in tariffs and take the form of regulatory blocs. The recent stalling of multilateral trade negotiations after decades of liberalization, and the concurrent expansion of bilateral and deeper agreements, echoes this insight.⁷ Our theory implies deep trade agreements should occur between countries that differ little in values and have substantial *intra*-industry trade in goods that generate consumption externalities. In fact, Mattoo et al. (2020) suggest trade agreements are deeper between developed countries, and less so between developing countries.

Our paper focuses on a single aspect of deep trade integration: solving local consumption externalities when perceptions differ internationally. We see these issues as playing an important role in agreements themselves and as shaping the popular debate around them. Consumer safety discussions on hormone-fed beef, chlorine-washed chicken, or the concentration of bacteria allowed in cheese can be interpreted through the lens of

⁷See Mattoo et al. (2020) for measures of the number and depth of preferential trade agreements over time.

our model,⁸ and ample evidence suggests perceptions, and consequently standards, differ across countries for such goods (see, e.g., Bradford (2020), chap. 6). Deep trade integration can, of course, serve other purposes, as argued in the literature (see below), and could also help tackle other types of externalities, such as local production externalities or more global externalities. Recent trade agreements do, in fact, address these issues, through provisions on environmental or labor issues. In this light, we develop a version of our model where the externality occurs at the production and not at the consumption stage, and show the results markedly differ from our baseline. In line with the extensive literature on pollution haven, we find differences in regulatory preferences can spur or dampen trade, depending on whether the country with a comparative advantage in the externality-generating good has a weak or strict regulatory preferences. In the presence of a production externality, all countries buy from the country with the highest productivity adjusted for regulatory preferences, and forming blocs is unnecessary.

Related Literature

Deep trade agreements and imperfectly competitive markets A burgeoning literature builds on the delocation model à la Venables (1987), which features a second and perfectly competitive sector (Grossman et al., 2021; Mei, 2023; Rebeyrol, 2023; Campolmi et al., 2021). In such models, the equilibrium number of firms is not optimal, due to the monopolistic distortion, and non-cooperative policies add a delocation externality (Ossa, 2011). The analysis of international regulatory cooperation in that framework relies on the set of policy instruments available to address or not these distortions (e.g., production subsidies, trade taxes) and a large chunk of the analysis focuses on the role of these instruments.⁹ Costinot (2008) considers a Cournot duopoly that features a trade-off similar to ours that is between a cost-shifting (akin to a profit-shifting) externality and a consumption externality. In contrast to all these papers, we seek to isolate the role of regulatory preferences on the gains from regulatory cooperation. This approach is made possible by our homogeneous-good model featuring Bertrand competition and unit quantities in which identical regulatory preferences across countries lead to the socially optimal outcome.¹⁰

Our model has two key features: different perceptions of externalities across countries and the fact that it is more costly to produce at standards that are more distant. Grossman et al. (2021) is to our knowledge the only

⁸Although food consumption may not necessarily create an externality on others, it can affect an agent's future self (an "internality" in the terminology of Griffith et al. (2018)). If agents do not fully take into account the long-term consequences of their current consumption, government intervention may be warranted.

⁹Other rationales behind consumption standards include coping with the excessive entry of low-quality firms (Macedoni and Weinberger, 2022) and asymmetric information (Disdier et al., 2023)

¹⁰Allowing for variable quantities as is standard in oligopolistic settings with profit-shifting externalities (Brander and Spencer, 1985; Costinot, 2008; Mrázová, 2021) would lead to an inefficient allocation of production between the numeraire and the imperfectly competitive sector, even when countries' preferences are aligned. In Appendix A.8, we show adding a consumption tax is enough to preserve our results in a setting with variable quantities.

paper in this strand of the literature which, in its last section, shares both features. Our first-best standards in fact have properties similar to theirs. Whereas Grossman et al. (2021) end their analysis with a characterization of those first-best standards and conclude deep integration is needed, we leverage the simplicity of our setting to ask a set of novel questions: Which countries should engage in international regulatory cooperation and to which extent? When can these gains be reaped without international transfers? Are regulatory blocs optimal in a many-country setting? Key to answering these questions is the interplay between countries' technology and their idiosyncratic regulatory preferences over domestic policies, an aspect that has not received much attention in the literature.

Deep integration and international coordination externalities The tension between country-level preferences and centralization is at the core of the fiscal federalism literature (Oates, 1972; Alesina et al., 2005). Our setup does not involve transboundary but local externalities only. Furthermore, the benefits of deep integration/centralization vary non-monotonically with preference heterogeneity in our setup, whereas the relationship is monotonic in the fiscal federalism literature.¹¹

Coordination externalities have also received a lot of attention in the trade literature (Ederington and Ruta, 2016). Regulatory-preference heterogeneity leads to additional costs that may fall on firms through adaptation (Toulemonde, 2013) or conversion costs (Gandal and Shy, 2001) and thereby foregone economies of scale (Grossman et al., 2021), but may also fall on consumers through asymmetric information (Toulemonde, 2013). Compatible products can also lead to welfare gains through network effects as considered in Gandal and Shy (2001), Costinot (2008), and Klimenko (2009). In our setup, tailoring a standard to the regulatory preference of each country is costly and consumers only value a product standard through its impact on firm pricing. The misalignment of the importing-country consumer surplus and the exporting-country producer surplus under different local regulatory preferences distorts the equilibrium standards relative to the first-best. Overall and with respect to that literature, our setup allows us to determine which country pairs—characterized by their technology and their regulatory preferences—select into deep trade integration.

Shallow vs. deep integration Considering a neoclassic environment, Bagwell and Staiger (2001) show a shallow trade agreement—understood as a commitment on tariffs and market access—may be enough to reach efficiency. Maggi and Ossa (2023) study the political economy of international regulatory cooperation in a neoclassic environment when shallow integration no longer suffices. They find different welfare implications of international cooperation on product versus process standards. Under imperfect competition, Grossman et al. (2021) find deep integration is required to reach the first-best when consumption triggers local externalities.

¹¹In that sense, our findings resonate with the conclusion of Loeper (2011) despite the large differences between both settings.

Relatedly, Mei (2023) calibrates a multi-country Krugman (1980) augmented with such externalities and finds significant welfare losses from the implementation of the WTO non-discriminatory principle relative to the first-best outcome. We extend our baseline model by introducing tariffs as a "shallow" trade-policy instrument. As is common in the literature on regulatory protectionism (Baldwin, 2000; Fischer and Serra, 2000), we find countries are less cooperative on non-tariff dimensions when tariffs are restricted through cooperative trade policy (Copeland, 1990). With respect to this literature, we show a shallow agreement does decrease tariffs, but leads to less cooperation in terms of standards. In that sense, a shallow agreement is not able to replicate the planner's solution, and a full tariff liberalization is not optimal if not accompanied by a deep trade integration.

Regulatory divergence as a non-tariff barrier Our paper also speaks to the empirical literature that investigates how the divergence in product standards or norms act as an impediment to trade flows. Fontagné et al. (2015) show SPS measures decrease trade flows both at the intensive and extensive margin. Conversely, several papers show deep trade integration involving standard harmonization increases trade flows (Disdier et al. (2015) and Schmidt and Steingress (2022)). These patterns are consistent with the view that regulatory heterogeneity can be modeled as a non-tariff barrier. Quantitative assessments of deep-trade-integration efforts (e.g. Egger et al. (2015) for TTIP or Dhingra et al. (2017) on Brexit) follow this strategy. Our simple model resonates with this intuition, where trade costs and regulatory divergence act in a similar fashion on the conditions for trade to happen. Specifically, large trade costs or large differences in regulatory preferences may outweigh the potential gains from trade. However, because standard heterogeneity remains even under a fully efficient, deep-integration scenario, a further reduction in standard heterogeneity would unambiguously decrease welfare, an implication at odds with the estimated impact of a reduction of non-tariff measures on welfare.¹²

The rest of the paper is structured as follows. Section 2 describes the baseline model with two countries and two goods and derives the necessary and sufficient conditions for trade to happen in equilibrium in a world with a non-cooperative and a cooperative standard setting. Section 3 extends the model to many varieties of polluting goods and shows under which conditions a trade agreement with mutual standard concessions is feasible. Section 4 provides a number of extensions of our baseline model, with many countries, endogenous core competence, or trade costs, as well as an extensive discussion of our setup. Section 5 concludes.

¹²This result echoes Berden and Francois (2015), who note that *"unlike trade taxes, regulatory barriers to trade are not generally targeted at trade as the primary policy objective. Rather, we are talking about (...) consumer safety, the stability of financial markets, and environmental protection (...). In this case, higher costs (...) most certainly reflect the balance between costs of regulation (including trade costs) and benefits linked to the primary policy objective. This point, while acknowledged in passing, is not given full due in quantitative analyses of NTM reductions. Where consumers (aka voters) in the US and EU place different values on such objectives, we need to be careful not to assume that identified barriers are not offset by benefits."* (p.3)

2 The baseline model

2.1 Setup

Consumer preferences. The world consists of 2 countries, indexed by $n \in \{0, 1\}$. Each country has a unit mass¹³ of identical agents with quasi-linear preferences over two goods. The first good, indexed by l , enters the utility linearly and has a price normalized to one. The second good, which is the focus of our study, is indivisible and generates utility V only for the first unit consumed.¹⁴ We assume throughout that consumers' willingness to pay V is high enough that all consumers buy it, but its consumption generates a negative externality. For simplicity, we henceforth refer to this good as the "externality-generating good" or short "good X." Consumer h in country n has utility

$$\mathcal{U}_h = x_{hl} + V - \kappa_n \int_{h' \in n} E_{h'} dh', \quad (1)$$

where x_{hl} represents the consumption of the numeraire good by individual h . The last term in the utility captures the externality, which depends on the consumption of good X by all agents in the country, with $E_{h'}$ denoting the externality generated by the consumption of agent h' . The externality is "local" in the sense that it only depends on the country's consumption of the good, and not on the world consumption. It is thus akin to a pollution that is localized in space (noise, emissions of nitrogen oxide, etc.). The cost of the externality in terms of utility depends on a country-specific parameter κ_n , which captures the degree to which individuals in n are concerned about the externality. This parameter can reflect pure differences in preferences, that is, different perceptions of how bad pollution is, but can also capture differences in the true effect of this pollution across countries, for example, due to differences in population density, climatic conditions, or the prevalence of some health conditions in the population. Regardless of the interpretation, we consider these κ 's as exogenously given in our model.¹⁵ The representative consumer's budget constraint in n is $x_{hl} + p_n = I_n$, where I_n is the income of a consumer in n and p_n is the price of good X. We assume $I_n > p_n$ to guarantee all individuals consume the numeraire good.

Government. The government in each country n sets a maximum externality E_n that good X can generate per unit consumed in its market.¹⁶ A lower E is thus equivalent to the imposition of stricter standards or

¹³Country-size asymmetries are analyzed in 4.2.

¹⁴The assumption of unit consumption is convenient to shut down inefficiencies arising from quantity choices and limit the number of policy instruments necessary to reach the first best. We relax this assumption in the robustness section 4.4.

¹⁵Our model is isomorphic to a setup where the externality is on the future self of an agent, that is, an internality. For example, if agents mistakenly do not (or insufficiently) take into account the negative effect of their current consumption on their future utility, governments have a more paternalistic reason for intervention and all our results go through under that alternative interpretation. If κ_n reflects this discounting gap between consumers and the government, consumers have utility $\mathcal{U}_h(E) = x_{h0} + V$, but paternalistic governments will act based on (1).

¹⁶We discuss other instruments, such as a Pigouvian tax, in section 4.3.3.

more stringent regulations. To simplify the notation and the interpretation, we assume the good can generate a maximum level of externality, called E^M . We define $e = E^M - E$ as the stringency of the standard, that is, the difference between the permitted externality and the maximum level of externality.

Production. Each agent in n inelastically supplies L_n units of labor and is freely mobile across sectors. Labor is the sole factor of production, and we normalize wages to one. Perfectly competitive firms produce the numeraire good using a linear production function, transforming one unit of labor into one unit of output.

A single firm exists that can produce the externality-generating good in each country. Each firm can produce the good at different standards, thereby tailoring its output to each market. Firm n (located in country n) has a core competence \bar{e}_n , that is, a standard at which it can produce relatively efficiently. The marginal costs of producing version e of the good is equal to the labor needed per unit produced:

$$l(e; c_n, \bar{e}_n) = c_n + \frac{1}{2}e^2 + \frac{\gamma}{2}(e - \bar{e}_n)^2. \quad (2)$$

The first term, c_n , is a country-specific (in)efficiency parameter. The second term, $\frac{1}{2}e^2$, captures the fact that producing a less polluting good is more costly. The last term implies deviating from the core competence comes with strictly positive costs, regardless of whether the standard is more or less stringent than the core competence. The underlying logic is that producing at a standard below or above the core competence requires an adjustment to the production process. In practice, this goal may come with switching to lower-/higher-quality inputs, cheaper/more expensive machines, or simply reorganizing production. If such re-optimization is costly, deviating from the core competence in any direction is costly.¹⁷

Note it does not mean reducing e below the core competence increases costs. In fact, we assume the second term always dominates and that producing a high e good is more expensive regardless of the firm's core competence, namely, that $\frac{\partial l(e; \bar{e}_n, c_n)}{\partial e} > 0$ for all admissible e and \bar{e}_n . Under this assumption, firms would thus never produce a good at a stricter standard than the government allows, rendering the consumption standard effectively binding. As we explain more clearly below, a sufficient condition for this, which we assume in the remaining analysis, is that $\kappa_n \in \left(\frac{\gamma}{1+\gamma}E^M, E^M \right]$ for all n . We stick to a very stylized production function in our baseline for simplicity but show in the Robustness section that our key results extend to more general

¹⁷We assume deviating from its core competence is costly for the firm, regardless of whether it produces a good with a higher or lower e (the symmetry around the core competence is not required, as shown in the robustness section). Equivalently, we assume producing a good with a given e is cheaper for firms with a core competence in low e goods. Think of the production of cars designed to accommodate a filter to limit exhaust emissions, such as the ADblue technology. To save on costs, the manufacturer would not install the filter if standards are weak (second term: costs decrease with e). But the car without filter would have been cheaper to produce had it not been designed to accommodate a filter (third term: deviation from core competence). Similarly, a manufacturer with a low core competence producing at a high standard would bear the costs of raising the standard (second term), as well as any additional costs from adjusting away from its core competence (third term).

production functions.

Autarky and core competence. In autarky, the government in country n first sets the minimum e_n allowed in its market, which is the standard at which the firm produces under the assumptions above. Faced with this standard, the monopolist in n acquires a core competence in autarky¹⁸ $\bar{e}_n = e_n$ and sets its price to maximize profits. Solving by backward induction, the monopoly in n charges the highest possible price for which consumers decide to buy the goods. It extracts the full surplus of the consumer from the consumption of the polluting good, setting: $p_n = V$. We assume $V > c_n + \frac{1}{2}(E^M)^2$, which guarantees the firm wants to produce in autarky.

Welfare in country n in autarky is given by

$$I_n - p_n + V - \kappa_n(E^M - e_n) = I_n - \kappa_n(E^M - e_n),$$

where I_n consists of labor income L_n and profits, given by $V - c_n - \frac{1}{2}e_n^2$, redistributed to the representative agent¹⁹. In our setup, consumers pay a high price in autarky but get it back through profits, without creating any distortion due to the unit-consumption assumption. In autarky, the government maximizes

$$\max_{e_n} \underbrace{L_n + V - \kappa_n E^M + \frac{1}{2}\kappa_n^2 - c_n}_{\mathcal{V}_n} - \frac{1}{2}(e_n - \kappa_n)^2,$$

and chooses to set $e_n = \kappa_n$. Countries with a higher κ set more stringent limits on the maximum externality permitted on their market, and the maximized welfare of country n in autarky is equal to

$$\mathcal{W}_n^A = \mathcal{V}_n - c_n. \quad (3)$$

Hereafter, we assume in our baseline model that the core competence of firms is fixed at their autarky level $\bar{e}_n = \kappa_n$. Although this assumption can be thought of as a short-run one, it captures the well-known difficulty of adjusting inputs and technology to a different standard when trade liberalization is not anticipated. In section 4.2, we show our results would still hold if the firm could adjust its core competence.

¹⁸Two alternative but isomorphic interpretations are possible. One is that the firm develops a core competence by simply being exposed to the autarky standard. The other is that the firm chooses its core competence given the autarky standard and sets it at that level to minimize costs.

¹⁹A sufficient condition for $I_n > p_n$, which ensures a positive consumption of the numeraire, is that $L_n > c_n + \frac{1}{2}(E^M)^2$.

2.2 Open economy

We now assume goods can be traded costlessly across borders and that the numeraire good is produced in each country, pinning down wages to one. Because both countries have the same productivity in the numeraire good, an absolute advantage in good X implies a comparative advantage in good X .

In a first stage, countries simultaneously set the minimum permissible e_n on their market. The two producers of good X (one firm from each country) then engage in head-to-head competition à la Bertrand on each market. Due to the Bertrand structure of competition, the firm with the lowest cost of selling on market n is the only seller and charges a price equal to the costs of the second cheapest firm.²⁰ Consumers in country n pay a price $p(e_n)$ equal to the highest marginal costs among the two firms at standard e_n :

$$p(e_n) = \max \{l_0(e_n), l_1(e_n)\},$$

where $l_n(e) \equiv l(e; c_n, \kappa_n)$. The firm from country 0 thus makes the following profits in market n :

$$\pi_{0n}(e_n) = \max \{l_1(e_n) - l_0(e_n), 0\} \quad (4)$$

because consumers in country n buy from the cheapest source and pay the price of the second cheapest. The welfare of country 0 is given by

$$\mathcal{W}_0(e_0, e_1) = V - \kappa_0 E^M + \kappa_0 e_0 + L_0 - p(e_0) + \pi_{00}(e_0) + \pi_{01}(e_0) = \mathcal{V}_0 - c_0 - \frac{1 + \gamma}{2} (e_0 - \kappa_0)^2 + \pi_{01}(e_1). \quad (5)$$

Country 0's welfare decreases in the mismatch between e_0 and κ_0 through two channels. One, $(e_0 - \kappa_0)^2/2$, captures the direct effect of the externality, which is not properly internalized if a discrepancy exists between the standard and the preference of country 0. The second, $\gamma(e_0 - \kappa_0)^2/2$, comes through a cost effect: deviating from the core competence, which is equal to κ_0 , comes at a cost that depends on the distance between the standard e_0 and κ_0 . The final term, $\pi_{01}(e_1)$, shows the profits that the firm from country 0 makes in country 1. The above formulas easily extend to country 1. Note that importing good X in this framework does not generate any surplus,²¹ because the full surplus from trade is captured by the exporter in Bertrand competition.

²⁰See section 4.4 for a discussion of the market structure.

²¹Note $-p(e_0) + \pi_{00}(e_0) = -l_0(e_0) = -\frac{1}{2}e_0^2 - \frac{\gamma}{2}(e_0 - \kappa_0)^2$, which is independent of which firm sells in country 0. If country 0 imports good X from country 1, $\pi_{00} = 0$, and $p_0(e_0) = l_0(e_0)$, whereas if it does not import, $p_0(e_0) = l_1(e_0)$ and $\pi_{00}(e_0) = l_1(e_0) - l_0(e_0)$. Importing or not thus shifts the surplus between consumers and firms within country 0 but does not affect their sum.

Non-cooperative equilibrium. It is immediate from (5) and its counterpart for country 1 that the optimal choice of standard by each country is to set, as in autarky,

$$e_n^* = \kappa_n. \quad (6)$$

The reason is that a country's consumption standard only affects its domestic surplus and not the profits it makes on foreign markets.

We assume for ease of exposition and without loss of generality that $c_0 < c_1$, that is, that country 0 has a comparative advantage in good X . In equilibrium, firm 0 always supplies its home market. It also exports to country 1 if and only if it is the cheapest producer in country 1, that is, if

$$c_1 - c_0 > \frac{\gamma}{2} \Delta\kappa^2, \quad (7)$$

where $\Delta\kappa^2 \equiv (\kappa_1 - \kappa_0)^2$ is the distance between the κ 's of the two countries. The cost difference measures the strength of country 0's comparative advantage in good X ,²² and is related to the efficiency gains from trade. Because both countries have different perceptions of the externality, the exporter produces at different standards for both countries, which raises the costs of production. These costs, which depend on the parameter γ , are increasing in the distance between the two countries' κ 's and make international trade less likely to happen. Importantly, the consumption externality per se is not what constitutes a barrier to trade: in fact, the externality is irrelevant as soon as countries' perception of the externality are aligned. We summarize these insights in the following proposition.

Proposition 1. *Countries trade in equilibrium if the strength of comparative advantage more than compensates for the differences in their regulatory preferences.*

Planner. We now consider a utilitarian world planner, who chooses the pair $\{e_0, e_1\}$ to maximize the sum of both countries' welfare:

$$\max_{e_0, e_1} \mathcal{W}_0(e_0, e_1) + \mathcal{W}_1(e_1, e_0).$$

Contrary to the non-cooperative case, the planner internalizes the effect of the consumption standard in the destination country on the source country's profits. The planner's solution features exports from country 0 to country 1 if and only if

$$c_1 - c_0 > \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta\kappa^2, \quad (8)$$

²²Due to the equal productivity of both countries in the numeraire good, a higher $c_1 - c_0$ is equivalent to a stronger comparative advantage for country 0.

and the planner's choice of standards is

$$e_0^{*P} = \kappa_0 \quad \text{and} \quad e_1^{*P} = \begin{cases} \frac{\kappa_1 + \gamma \kappa_0}{1 + \gamma} & \text{if: } c_1 - c_0 > \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta \kappa^2 \\ \kappa_1 & \text{otherwise.} \end{cases} \quad (9)$$

If the comparative advantage of country 0 is strong enough relative to the difference in perceptions ($\Delta \kappa^2$), the planner's solution features exports from country 0 to country 1, and country 1 adjusts its standard toward κ_0 , thereby decreasing firm 0's costs of producing away from its core competence. The key difference between the planner's solution and the non-cooperative equilibrium is that the importing country 1 now adjusts its standard to decrease firm 0's costs of producing at two standards. The following proposition compares our results under the planner and under a non-cooperative solution.

Proposition 2.

1. *The planner's solution features (partial) regulatory convergence. Consumption standards are more similar between countries, and international trade takes place under a larger set of parameters than in the non-cooperative equilibrium.*
2. *The difference in world welfare between the planner's solution and the non-cooperative equilibrium is non-monotonic in the distance between countries' regulatory preferences. The gains from cooperation are lower for country pairs that have either small or large differences in their regulatory preferences.*

The first part of the Proposition immediately obtains by comparing (6) and (9), as well as (7) and (8), and we show in section 4.4 that the convergence result also holds with much more general production functions. Our model makes explicit the scope for an international cooperation on standards, which raises welfare as long as the efficiency gains from trade are large enough (strong comparative advantage) relative to the differences in the perception about the externality. The second part of the Proposition compares different pairs of countries that differ in $\Delta \kappa^2$. It relies on computing $\Delta \mathcal{W}$, the difference between $\mathcal{W}_0(e_0^{*P}, e_1^{*P}) + \mathcal{W}_1(e_1^{*P}, e_0^{*P})$ and $\mathcal{W}_0(e_0^*, e_1^*) + \mathcal{W}_1(e_1^*, e_0^*)$. We show the solution graphically in Figure 1. If both countries have the same concern for the externality, they naturally choose the same and optimal standard from the world perspective, and cooperation does not generate any gain. If both countries have very different perceptions of the externality, on the other hand, coordinating standards is too costly in terms of welfare, and not trading good X is optimal. We discuss the robustness of these insights to alternative market structures in section 4.4. For instance, introducing additional firms in the exporting country may reduce the gains from cooperation depending on the technological gap between the most productive exporter and its domestic competitors.

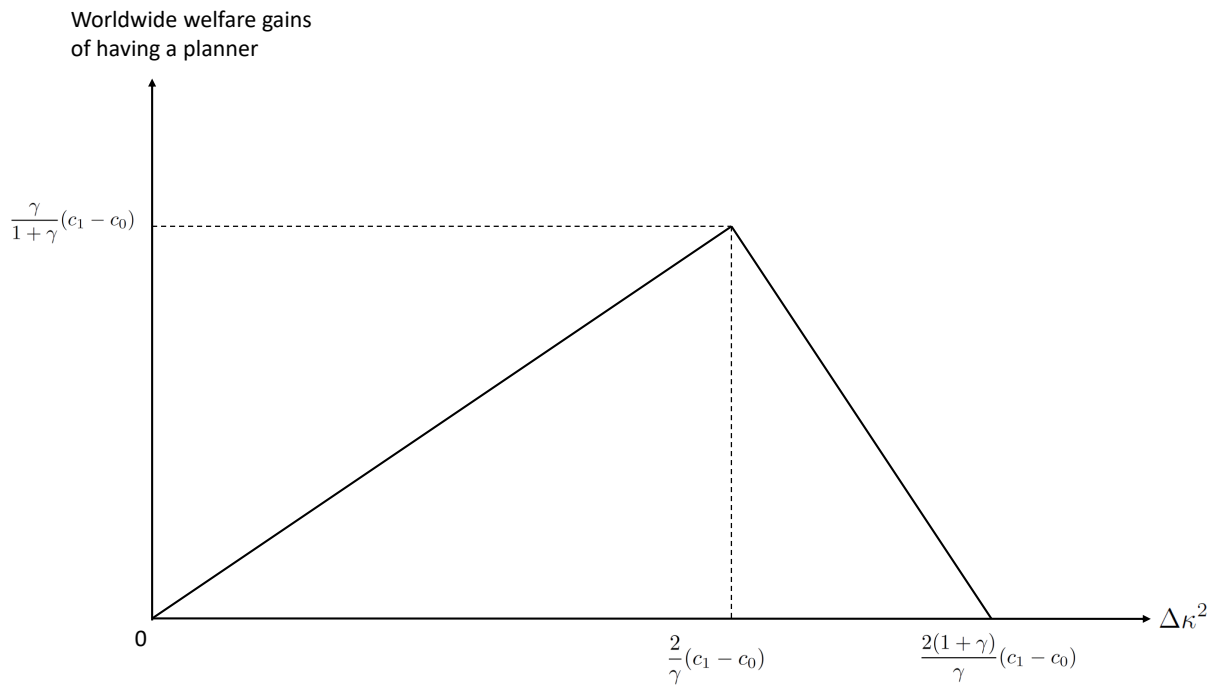


Figure 1: Welfare gains of coordination

The vertical axis shows the difference in the worldwide welfare between the planner's and the non-cooperative solution. It plots $\Delta\mathcal{W} = \mathcal{W}_0(e_0^{*P}, e_1^{*P}) + \mathcal{W}_1(e_1^{*P}, e_0^{*P}) - \mathcal{W}_0(e_0^*, e_1^*) - \mathcal{W}_1(e_1^*, e_0^*)$. The top of the curve obtains where the exporter is indifferent between selling or not under a non-cooperative solution. The decreasing part is the parameters space for which trade occurs in the planner's but not the non-cooperative solution.

Production vs. consumption externality. Production externalities have been extensively studied in the literature on trade and the environment starting with the seminal contribution of Copeland and Taylor (1994). Although the difference between a consumption and a production externality is immaterial in a closed economy, an open economy allows high- κ countries to offshore polluting activities to low- κ countries. Thus, regulatory divergence per se can be a source of comparative advantage. A combination of low costs of production and low concerns for the production externality strengthens a country's comparative advantage and the total gains from trade. A negative correlation between κ and c weakens them (see Appendix A.1 for a full-fledged derivation of our setup with production externalities). This finding is consistent with the North-South pattern of trade in polluting goods and echoes the pollution-haven hypothesis in the literature linking trade and the environment. Instead, in our setup with consumption externalities, regulatory divergence necessarily (weakly) dampens comparative advantage. Despite these rather different implications, note our setup allows for an interpretation of the externality term that goes beyond a consumption externality: our setup allows for any rationales consistent with a government objective function that puts a negative weight on consumption. Hence, even when the externality *occurs* where production takes place, our setup encompasses the case of an importing country with preferences over foreign production externalities.

3 Trade integration with many varieties

We now extend our baseline model to allow for the existence of a continuum of varieties that generate an externality. This extension serves three main purposes. First, and in line with Dornbusch et al. (1977)'s extension of the standard Ricardian model, it makes our main results "smoother." The extensive margin—whether trade occurs—now enters continuously through the mass of traded varieties. Second, it sets the stage for a trade agreement when international lump-sum transfers are not available. Specifically, for countries to make mutual concessions on standards, we need more than one externality-generating variety. Third, it allows us to introduce tariffs and discuss the link between shallow and deep integration in a non-trivial way.

3.1 Model with a continuum of varieties

A mass one of externality-generating varieties exists, indexed by $\omega \in [0; 1]$. A country n has the same perception of the externality regardless of which good generates it (κ_n does not depend on ω), but can set a minimum standard $e_n(\omega)$ specific to each good. This structure preserves the results of our baseline setup, because the government sets a standard independently for each good. Each consumer h in country n buys a single unit of

all externality-generating varieties, each generating a utility V , such that

$$\mathcal{U}_h = x_{hl} + V - \kappa_n \int_0^1 \left(\int_{h' \in n} E_{h'}(\omega) dh' \right) d\omega.$$

We order varieties such that country 1 has a relatively better technology for varieties with a higher index. Formally, we define $A(\omega) = c_0(\omega) - c_1(\omega)$, with $A'(\omega) > 0$. We also assume $A(0) < 0 < A(1)$ to guarantee each country has a comparative advantage (compared to the numeraire) in at least some of the externality generating varieties. As in our baseline, each country has one producer of each good, which compete à la Bertrand in an open economy. All firms from n producing an externality-generating good have κ_n as core competence, and the results of our baseline immediately apply good by good. In line with our earlier analysis, the condition for a firm in 0 to sell in n is that $\pi_{0n}(e_n)$, as defined in (4), is positive. Country 0 exports to country 1 all varieties such that

$$\pi_{01}(\omega, e_1(\omega)) = -A(\omega) + \frac{\gamma}{2}(e_1(\omega) - \kappa_1)^2 - \frac{\gamma}{2}(e_1(\omega) - \kappa_0)^2 = -A(\omega) - \frac{\gamma}{2}\Delta\kappa^2 + \gamma(\kappa_1 - \kappa_0)(\kappa_1 - e_1(\omega)) \geq 0, \quad (10)$$

whereas country 1 exports to 0 all varieties with

$$\pi_{10}(\omega, e_0(\omega)) = A(\omega) + \frac{\gamma}{2}(e_0(\omega) - \kappa_0)^2 - \frac{\gamma}{2}(e_0(\omega) - \kappa_1)^2 = A(\omega) - \frac{\gamma}{2}\Delta\kappa^2 + \gamma(\kappa_1 - \kappa_0)(e_0(\omega) - \kappa_0) \geq 0. \quad (11)$$

In the *non-cooperative case*, countries choose standard $e_n(\omega) = \kappa_n$, as in our baseline. With this choice of standard, country 0 exports all varieties $\omega \in [0, \omega_0^{NC}]$, where $-A(\omega_0^{NC}) = \frac{\gamma}{2}\Delta\kappa^2$ defines the variety for which country 0 is indifferent between exporting or not, in line with (7). Similarly, country 1 exports all varieties $\omega \in [1 - \omega_1^{NC}, 1]$, with $A(1 - \omega_1^{NC}) = \frac{\gamma}{2}\Delta\kappa^2$.

Consistent with our baseline, the *planner's solution* is characterized by a step function: country 0 sets $e_0(\omega) = \kappa_0$ for all varieties that it does not import and $e_0(\omega) = \frac{\kappa_0 + \gamma\kappa_1}{1 + \gamma}$ for the varieties that it imports. It exports all varieties $[0, \omega_0^P]$, where ω_0^P is defined by $-A(\omega_0^P) = \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta\kappa^2$ (consistent with (9)). A similar result holds for country 1. We illustrate this pattern in Figure 2, where the standard schedules under the planner are in bold and the schedules in the non-cooperative solution are horizontal lines at κ_n .

3.2 Mutual regulatory concessions

Concessions. In our baseline case with one externality-generating good, implementing the planner's solution would require that concessions be forced on the importer for the exporter to gain profits. A mutually beneficial agreement would therefore require international transfers. Instead, in a setting with intra-industry trade (think

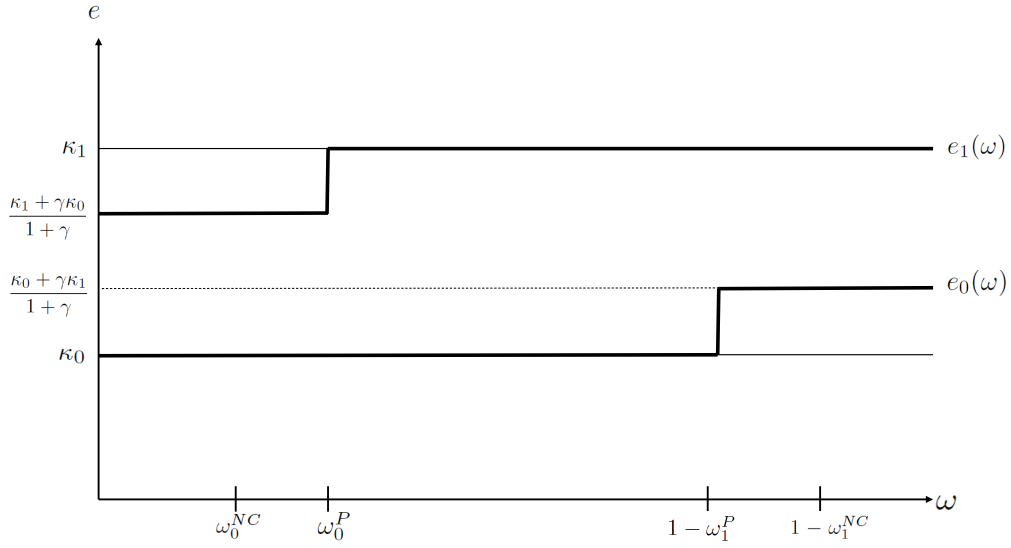


Figure 2: Standards in non-cooperative and planner's case

of externality-generating varieties as part of one industry), a trade agreement through mutual concessions may be feasible without transfers. In the following, we assume without loss of generality that $\kappa_0 < \kappa_1$. The welfare that both countries obtain from good ω is

$$\mathcal{W}_0(\omega) = \mathcal{V}_0 - \frac{1+\gamma}{2}(e_0(\omega) - \kappa_0)^2 + \max\{\pi_{01}(\omega, e_1(\omega)), 0\} \quad (12)$$

$$\mathcal{W}_1(\omega) = \mathcal{V}_1 - \frac{1+\gamma}{2}(e_1(\omega) - \kappa_1)^2 + \max\{\pi_{10}(\omega, e_0(\omega)), 0\}. \quad (13)$$

Setting $\kappa_1 - e_1(\omega) > 0$ imposes a cost on country 1, because it deviates from its optimal standard and raises the welfare of country 0 by increasing its profits. We denote such a change in standard that moves a country's standard away from its preferred level as a concession. To guarantee a given level of welfare to country 0, we now characterize the schedule $e_1(\omega)$ that minimizes the welfare loss from the perspective of country 1. Equations (12) and (13) show that, for each variety, the costs of granting a concession are quadratic. The gains for the receiving country, which benefits from higher profits, are linear conditional on trade occurring. This finding implies that for any two varieties ω and ω' that it imports from country 0, country 1 should set $e_1(\omega) = e_1(\omega')$ and set $e_1(\omega) = \kappa_1$ otherwise. This implies country 1 sets standards according to the following schedule:

$$e_1(\omega) = \begin{cases} e_1 & \text{if } \omega < \omega_0 \\ \kappa_1 & \text{otherwise,} \end{cases} \quad (14)$$

where e_1 and ω_0 are such that $\pi_{01}(\omega, e_1) \geq 0$ for $\omega \geq \omega_0$. Country 1 chooses its e_1 and ω_0 in the most efficient way to transfer a given welfare to country 0; that is, it minimizes its costs of guaranteeing a given level of profits μ for the exporter:

$$\min_{e_1, \omega_0} \frac{1 + \gamma}{2} \int_0^{\omega_0} (\kappa_1 - e_1)^2 d\omega \quad s.t. \quad \int_0^{\omega_0} \pi_{01}(\omega, e_1) d\omega \geq \mu.$$

Taking the ratio of the first-order conditions shows country 1 chooses ω_0 and e_1 to fulfill the following condition for any μ , defining an implicit function $\omega_0(e_1)$ ²³:

$$-A(\omega_0) - \frac{\gamma}{2} \Delta \kappa^2 + \frac{\gamma}{2} (\kappa_1 - \kappa_0) (\kappa_1 - e_1) = 0. \quad (15)$$

Equations (14) and (15) summarize the shape of the most efficient schedule of $e_1(\omega)$ for country 1 to make a given concession to country 0. A similar reasoning shows that, from the perspective of country 0,

$$e_0(\omega) = \begin{cases} e_0 & \text{if } \omega > 1 - \omega_1(e_0) \\ \kappa_0 & \text{otherwise} \end{cases} \quad (16)$$

where $\omega_1(e_0)$ is implicitly defined by

$$A(1 - \omega_1) - \frac{\gamma}{2} \Delta \kappa^2 + \frac{\gamma}{2} (\kappa_1 - \kappa_0) (e_0 - \kappa_0) = 0. \quad (17)$$

Definition 1. We define the productivity schedule $A(\omega)$ as symmetric if $A(\omega) + A(1 - \omega) = 0$ for all ω . Country 0's productivity dominates country 1's productivity if $A(\omega) + A(1 - \omega) < 0$ for all ω .

If both countries stick to their non-cooperative standards or make symmetric adjustments to their standards compared to autarky ($\kappa_1 - e_1 = e_0 - \kappa_0$), equations (15) and (17) imply that $A(1 - \omega_1) + A(\omega_0) = 0$. Under a symmetric productivity schedule, this equation holds if both countries export the same mass of varieties, $\omega_0 = \omega_1$. If country 0's productivity dominates, however, setting $\omega_0 = \omega_1$ would imply that $A(1 - \omega_1) - A(\omega_0) < 0$, and be inconsistent with a symmetric adjustment of standards. In that case, $\omega_0 > \omega_1$ and country 0 exports more varieties to country 1 than the converse. For trade to be balanced at the aggregate level, it implies that country 1 is a net exporter of the numeraire good.

Pareto-improving coordination without transfers: intra vs. inter-industry trade. When choosing the level of standard e_n in (14), country n affects its own welfare as well as that of its partner. We denote the

²³Note that the non-cooperative and the planner's solutions are nested in this condition: $\omega_0 = \omega_0^{NC}$ when $e_1 = \kappa_1$, and $\omega_0 = \omega_0^P$ when $e_1 = \frac{\kappa_1 + \gamma \kappa_0}{1 + \gamma}$.

change in welfare of each country relative to the non-cooperative scenario as $\Delta\mathcal{W}_n(e_0, e_1) \equiv \mathcal{W}_n(e_0, e_1) - \mathcal{W}_n(\kappa_0, \kappa_1)$. For country 0, it is given by

$$\Delta\mathcal{W}_0(e_0, e_1) = -\frac{1+\gamma}{2}(e_0 - \kappa_0)^2\omega_1(e_0) + \gamma\omega_0(\kappa_1)(\kappa_1 - \kappa_0)(\kappa_1 - e_1) - \int_{\omega_0(\kappa_1)}^{\omega_0(e_1)} \pi_{01}(\omega, e_1)d\omega. \quad (18)$$

The first term captures the negative effect for country 0 of moving its standard away from κ_0 , an adjustment that applies to the mass $\omega_1(e_0)$ of varieties that it imports. The second term is the gain in profits for country 0 provided by country 1's concession on its standard at the intensive margin, that is, for varieties that it already exports in the non-cooperative situation. The third term captures the gains from e_1 's adjustment for country 0's profits at the extensive margin, that is, for varieties that it starts exporting. We define a pair of e_0 and e_1 as compatible with mutual concessions if $\Delta\mathcal{W}_0(e_0, e_1) = \Delta\mathcal{W}_1(e_0, e_1)$, i.e. if both countries have the same welfare change compared to the non-cooperative benchmark. As can readily be seen from (18), a given adjustment to the level of standards (e.g., the nominal $\kappa_1 - e_1$) is not a proper measure of the strength of a concession, because it does not reflect how many varieties the adjustment applies. Defining mutual concessions in terms of changes in welfare automatically gives more weight to a change in standards if it applies to more varieties. In an agreement with mutual concessions, both countries choose e_0 and e_1 to maximize total welfare $\Delta\mathcal{W}_0(e_0, e_1) + \Delta\mathcal{W}_1(e_0, e_1)$ subject to the constraint $\Delta\mathcal{W}_0(e_0, e_1) = \Delta\mathcal{W}_1(e_0, e_1)$. We show the following properties of a mutual-concession equilibrium in the appendix.

Proposition 3. *A Pareto-improving coordination of standards through mutual concessions is such that*

1. *it replicates the planner's solution if the productivity schedule is symmetric.*
2. *if country 0's productivity dominates country 1's productivity, country 0 adjusts its standard too much from the planner's perspective, but country 1 does not adjust enough.*

Proof: see Appendix 3.

Mutual concessions allow both countries' welfare to improve as long as they both export and import at least some varieties (i.e., as long as $A(0) < 0 < A(1)$). When the productivity schedule is symmetric, implying strong intra-industry trade in the externality generating good, these mutual concessions can replicate the planner's solution. The stronger the productivity asymmetry, the lower the intra-industry trade and the lower countries' ability to improve welfare through mutual concessions.

3.3 Shallow vs. deep trade integration

The analysis above assumes tariffs have been set to zero and that an agreement can only take the form of cooperation in standards (deep integration). This choice stems from the very low levels of tariffs on average

for many countries and varieties, making them less central in policy discussions. Introducing tariffs in our setup is, however, useful to illustrate their complex interplay with standards and to relate to a large chunk of the literature comparing shallow and deep trade agreements. We now ask whether the optimal degree of convergence of standards can be reached through a "shallow" trade integration, that is, without contracting on the level of standards.

We assume country n can set a tariff per unit imported of a good. We consider that the continuum of varieties belong to the same tariff line so that the tariff is the same across all varieties.²⁴ From a modeling perspective, this assumption restores a distortive effect of tariffs when quantities are fixed, because tariffs affect the number of varieties traded. Turning to standards, we assume each country must set the same e for all varieties within a tariff line. Indeed, assuming standards are variety-specific would make them more flexible than tariffs, providing a mechanical rationale for deep integration.²⁵ To sum up, national treatment now applies across different varieties within the same tariff line.

To simplify the exposition as much as possible, we assume $A(\omega) = \omega - \frac{1}{2}$. Throughout this section, we also assume the following regularity condition holds for the problem to be concave:

$$\frac{\gamma^2}{1 + \gamma} \Delta \kappa^2 < 1, \quad (19)$$

and we relegate most derivations to Appendix A.3.

In the presence of tariffs, a variety ω is now imported if $\pi_{01}(\omega, e_1) \geq t_1$, where π_{01} is defined in (10). Under the functional-form assumption for $A(\omega)$, this condition defines a cutoff:

$$\omega_0 = \max \left\{ \min \left\{ \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 + \gamma(\kappa_1 - \kappa_0)(\kappa_1 - e_1) - t_1, 1 \right\}, 0 \right\}. \quad (20)$$

Everything else equal, a higher tariff reduces the set of varieties imported by country 1 if ω_0 is interior.

Non-cooperative. We first consider the non-cooperative case, where country 1 chooses a uniform t_1 and a uniform e_1 without taking country 0's profits into account, but realizing that setting a tariff brings tariff revenues. Country 1 maximizes

$$\tilde{\mathcal{W}}^{NC} := -\frac{1 + \gamma}{2} (e_1 - \kappa_1)^2 + t_1 \omega_0. \quad (21)$$

²⁴This assumption is without loss of generality. The analysis below can be generalized to any—non negligible—subset of varieties $[0, \underline{\omega}]$ with $\underline{\omega} < 1$; see Appendix A.3.

²⁵The resolution of this case is available upon request.

If ω_0 is interior, the first-order condition for e_1 leads to

$$\tilde{e}_1^{NC} = \kappa_1 - \frac{\gamma}{1+\gamma}(\kappa_1 - \kappa_0)t_1. \quad (22)$$

If tariffs are zero, $e_1 = \kappa_1$, as we showed in our baseline. With positive import tariffs, however, country 1 realizes it can extract more tariff revenue by relaxing the participation constraint of the exporter through a change in standards. Tariffs effectively make country 1 appropriate part of the exporter's profits, leading it to adjust its standard toward the exporter's core competence. In that sense, tariffs are a tool to partially resolve the cost-shifting externality in our setup. Solving for the optimal unilateral tariff of country 1, we get

$$\tilde{t}_1^{NC} = \tilde{\omega}_0^{NC} = \frac{\frac{1}{2} - \frac{\gamma}{2}\Delta\kappa^2}{2 - \frac{\gamma^2}{1+\gamma}\Delta\kappa^2}. \quad (23)$$

Planner (deep integration). We then turn to the problem of the planner. Because a planner decides cooperatively on both standards and tariffs, we refer to this case as deep integration. As illustrated in our baseline model, the exporter's profits are undistorted conditional on the importer's policies. The problem of the planner boils down to choosing e_1 and t_1 to maximize the importing country's welfare augmented by the exporter's profits. The planner maximizes

$$\tilde{W}^P := -\frac{1+\gamma}{2}(e_1 - \kappa_1)^2 - \int_0^{\omega_0} \omega d\omega + \left(\frac{1}{2} - \frac{\gamma}{2}\Delta\kappa^2 + \gamma(\kappa_1 - \kappa_0)(\kappa_1 - e_1)\right)\omega_0. \quad (24)$$

The first term is the welfare cost of adjusting the standard for country 1. The last two terms are the profits of the exporter excluding the cost of the tariff, because it constitutes a transfer to country 1.

As shown in Appendix A.3, the planner sets

$$\tilde{t}_1^P = 0, \quad \tilde{\omega}_0^P = \min \left\{ \frac{\frac{1}{2} - \frac{\gamma}{2}\Delta\kappa^2}{1 - \frac{\gamma^2}{1+\gamma}\Delta\kappa^2}, 1 \right\}, \quad \tilde{e}_1^P = \kappa_1 - \frac{\gamma}{1+\gamma}(\kappa_1 - \kappa_0)\tilde{\omega}_0^P. \quad (25)$$

The planner's solution features no tariffs. Note that from our baseline model, we know the unconstrained planner—that would set standards independently for each good—would set $e_1 = \frac{\kappa_1 + \gamma\kappa_0}{1+\gamma}$ on imported varieties and $e_1 = \kappa_1$ on the others. Instead, the constrained planner makes a weighted average of these two choices.

Shallow integration: tariffs. We then turn to the case of shallow integration and assume countries cooperatively set their tariffs in the first stage and non-cooperatively set their standards in the second stage. This assumption implies country 1 sets a standard according to (22) in the second stage. Country 1 chooses its tariff in the first stage to maximize (24), the planner's objective, knowing the choice of t_1 will affect e_1 in the second

stage. Under the parameter restrictions above, we show in the appendix that countries set positive tariffs (\tilde{t}_1^{SH}) in a shallow agreement, though lower than their non-cooperative level. This reduces the distortive effect of tariffs and raises the number of varieties traded relative to the non-cooperative situation ($\tilde{\omega}_0^P \geq \tilde{\omega}_0^{SH} > \tilde{\omega}_0^{NC}$). Depending on the parameter constellation, shallow integration may yield the same set of traded varieties as the planner (if it is equal to the upper bound in both cases) or a strictly lower one. In terms of standards, we show $\tilde{e}_1^P < \tilde{e}_1^{NC} < \tilde{e}_1^{SH}$. Under a shallow agreement, the importer adjusts its standard less toward the core competence of the exporter than in the planner (deep integration), but also less than in the non-cooperative situation. A shallow agreement, by reducing tariffs relative to non-cooperation, also reduces the incentives for country 1 to take into account country 0's core competence. The above analysis provides two interesting conclusions. First, it shows cooperating on tariffs only induced countries to be less cooperative in terms of standards. This observation is in line with the empirical evidence that as tariffs have decreased over time, non-tariff barriers have become more widespread. Cooperating on tariffs but not on standards is thus insufficient, calling for deep integration at least in some cases. Second, a shallow integration that consists only of decreasing tariffs should not set them to zero. Decreasing tariffs does reduce their distortive effect but provides less incentives for countries to internalize the cost-shifting externality. In this case, decreasing tariffs to zero should not happen if not accompanied by commitments on standards (deep integration).

Shallow integration: non-violation. Shallow integration may entail more than committing to a tariff level. The literature has identified "non-violation complaints" as one important provision that can be used to make shallow integration work. This provision prevents countries from nullifying or impairing concessions by using measures that limit market access ex post (Article XXIII of the GATT). In the spirit of Bagwell and Staiger (2001), we think of a first stage where countries choose a maximum level of tariff cooperatively. Evaluated at the *initial* standard, these drops in tariffs define a concession in terms of market access. In a second stage, countries set their tariffs and standards non-cooperatively subject to two constraints: (i) Tariffs must stay below the bound set in the first stage, and (ii) implied market-access concessions cannot be impaired.²⁶ Whether we consider as an initial standard the autarkic one ($e_1 = \kappa_1$) or the non-cooperative standard with tariffs (\tilde{e}_1^{NC}), decreasing the bound tariff to zero would not generate enough market access from the planner's perspective, because the importer should also adjust its standard.²⁷ In the second stage, the country would stick to a zero tariff and the initial standard, being unable to reach the planner's solution. The starting point of our baseline

²⁶Defining market access is generally not simple, in particular, under vertical differentiation or in the presence of externalities (see Grossman et al. (2021)). In our highly stylized model, and as long as ω_0 is interior, it is equivalent to defining market access in terms of a mass of imported varieties or in terms of the profits of the exporter, which is the quantity of interest in terms of the exporter's welfare.

²⁷This is in line with Proposition 3 of Bagwell and Staiger (2001). They argue that if the WTO would leave more freedom to countries to renegotiate their tariff bounds, they could first set lower tariffs than optimal, to generate higher market access concessions, and would choose in a second stage to raise tariffs and be more cooperative on standards to reach the optimum. In our case, where efficient tariffs are zero, this renegotiation would require negative bound tariffs in the first place, which is highly unlikely.

case could be thus thought of as the result of a shallow integration with a non-violation constraint, where initial standards are at their autarky level. Our baseline would thus be about the deep integration that should be implemented from that starting point.

3.4 Harmonization, national treatment, and mutual recognition

Discriminatory regulations. We have assumed up to now that national treatment holds—either at the good or the tariff-line level—meaning governments cannot impose a different standard on foreign or domestic producers. Defining e_{nm} as the standard at which firms from n sell in m , we now relax our assumption that $e_{1m}(\omega) = e_{0m}(\omega)$ and allow firms to face different standards in country m . For simplicity, we drop the index ω in the following, but all expressions are specific to a good. When selling in a foreign country, firms make profits:

$$\pi_{01}(e_{01}, e_{11}) = \max\{l_1(e_{11}) - l_0(e_{01}), 0\}, \quad \pi_{10}(e_{00}, e_{10}) = \max\{l_0(e_{00}) - l_1(e_{10}), 0\}. \quad (26)$$

The welfare associated with a variety in country 1 is given by

$$\mathcal{W}_1 = \mathcal{V}_1 - \frac{1}{2}\kappa_1^2 - l_1(e_{11}) + \max\{\pi_{10}, 0\} + \begin{cases} \kappa_1 e_{11} & \text{if } \pi_{01} < 0 \\ \kappa_1 e_{01} & \text{if } \pi_{01} > 0, \end{cases} \quad (27)$$

and a similar expression holds for welfare in country 0. The standard that country 1 applies to its domestic firm (e_{11}) matters for the price that firm 0 can charge in 1, whereas e_{01} is the standard that matters in terms of externality if country 1 imports. Country 1 wants to set the lowest possible e_{11} ($\frac{\gamma}{1+\gamma}E^M$), while setting the highest possible e_{10} (E^M), to extract as much surplus as possible from country 0. If, at those values, firm 0 would make negative profits, the participation constraint of the exporter must be binding in equilibrium and country 1 sets

$$e_{10} = \frac{\kappa_1 + \gamma\kappa_0}{1 + \gamma},$$

and finds it profitable to import under the same condition as the planner in our baseline model (8). For those varieties where the importer captures all the profits (those where comparative advantages are not too strong), it has an incentive to set a standard that takes into account the core competence of the exporter, thereby solving the externality. *Relaxing* the national treatment would here mimic the allocation of the planner for those varieties where the importer captures the full surplus, that is, when comparative advantages are not too strong and the participation constraint of the exporter is binding. This surprising result relies on the fact that exporters are passive in our baseline. If exporters were to make a choice based on their profits, the fact that the importer

appropriates all profits would bias the exporter's decisions. For example, when firms choose their core competence as in our extension in section 4.2, discriminatory standards would distort the choice of core competence by the exporter and still result in an inefficiency even with no national treatment.

Mutual Recognition. Another potential framework for deep integration is the use of mutual recognition, as is common in the EU. Under mutual recognition, member states cannot prohibit the sale of goods "which are lawfully produced and/or marketed in another Member State." We follow Costinot (2008)'s perspective and model mutual recognition such that destination country n imposes a standard $\check{e}_{jn}(\omega)$ on firm j producing ω , but that firm j can apply $e_{jn}(\omega) = \min\{\check{e}_{j0}(\omega), \check{e}_{j1}(\omega)\}$. Each firm now sells in both markets at the lowest standard that it faces. This approach results in some stark differences in the chosen standards and in the patterns of trade relative to our baseline setup. We provide here an intuitive account of the main features and relegate the formal analysis to Appendix A.4. Because standards are the same across markets for each firm, it is immediate from (26) that $\pi_{01} = -\pi_{10}$, implying each variety is traded.²⁸ Mutual recognition also gives countries an incentive to set lower standards than in our baseline. Conditional on importing, a country has no incentives to set high standards, neither on the importer nor on its domestic producer: a lower standard on its domestic producer reduces the maximum price that the importer can charge, and the standard on the importer is irrelevant as long as it is higher than the one set by the exporting country on its exporter. When a country exports a variety, it sets a lower home standard than its core competence. Under mutual recognition, setting lower standards at home means selling at lower standards abroad, thereby generating higher profits. As a consequence, varieties are sold in both markets at a lower standard than the country's core competence, an inefficient outcome. Mutual recognition thus comes with too much trade and inefficiently low standards.

Harmonization. One avenue in the design of trade agreements is to harmonize standards or to refer to international standards. As is evident from Figure 2, the optimal standards in our setup are consistent with a partial harmonization, only for traded varieties. A full harmonization of standards would go too far in our setup, even for traded varieties. The differences in perceptions of the externality, and the fact that the costs of producing a standard increase in the distance from the core competence, are strong forces preventing a full harmonization. For non-traded varieties, standards should stay at their autarky level because harmonization would be damageable. Interestingly, a full harmonization of standards would maximize trade and ensure all varieties are traded. With the same standards in both markets, if a firm is cheaper in country 0, it is necessarily also cheapest in country 1 with no transport costs. Full harmonization would thus generate too much trade from a planner's perspective.

²⁸In our baseline, firms face different standards in both markets. Firm 0 can then be a cheaper provider in country 0 if e_0 is closer to its core competence, whereas the opposite may hold for firm 1 in country 1, in which case, the variety is not traded.

4 Extensions and discussion

4.1 A multi-country model

We now turn back to our baseline model with two goods but consider an open economy with many countries and still assume one potential producer of good X in each country. To keep the analysis tractable, we now assume firms need to pay a fixed cost of export F , which can be arbitrarily small, before competing in prices in a foreign market. Because it is a fixed cost of exporting, domestic firms do not need to pay it and we define

$$F_{ni} = \begin{cases} F & \text{if } n \neq i \\ 0 & \text{if } n = i. \end{cases}$$

At the Bertrand competition stage, a firm from n will sell in market i if it has the lowest marginal costs of selling among all firms from $n' \neq i$ that paid the fixed cost and firm i . All other firms make zero profits in that market and would not find it profitable to pay the fixed cost of exporting in the first place. The fixed cost therefore simplifies competition at the price-competition stage by leaving only the domestic firm and one foreign firm if it is sufficiently productive. A firm from n only sells in i if

$$c_n + \frac{\gamma}{2}(e_i - \kappa_n)^2 + F_{ni} = \min_{n'} \left\{ c_{n'} + \frac{\gamma}{2}(e_i - \kappa_{n'})^2 + F_{n'i} \right\}. \quad (28)$$

We define the indicator $\mathbb{1}_{ni}$ as taking a value of 1 if firm n exports to i , that is, if (28) holds. The maximum price that firm n can charge in $i \neq n$ is the marginal cost of the domestic firm, $l_i(e_i)$. If the domestic firm has the lowest costs of production, it can charge a price of V , as in autarky, because it has no competitor at the price-competition stage. If a firm n exports to $i \neq n$, it makes profits

$$\pi_{ni} = \mathbb{1}_{ni} \times (l_i(e_i) - l_n(e_i) - F).$$

Similarly to the baseline case (equation (5)), the welfare of country n is given by

$$\mathcal{W}_n = \mathcal{V}_n - \frac{1}{2}(e_n - \kappa_n)^2 - p(e_n) + \pi_{nn}(e_n) + \sum_{i \neq n} \pi_{ni}(e_i) = \mathcal{V}_n - \frac{1 + \gamma}{2}(e_n - \kappa_n)^2 + \sum_{i \neq n} \mathbb{1}_{ni} \times (l_i(e_i) - l_n(e_i) - F), \quad (29)$$

where, as in our baseline model, $-p(e_n) + \pi_{nn}(e_n) = -\gamma(e_n - \kappa_n)^2/2$ regardless of whether country n imports. The only difference relative to the two-country case is that a firm from n can sell to many foreign countries.

Non-cooperative equilibrium. In the non-cooperative equilibrium, country n maximizes (29) and sets the following, as in autarky²⁹:

$$e_n^* = \kappa_n. \quad (30)$$

Plugging back in (28) shows that in the non-cooperative equilibrium, the firm from country n sells good X in i if and only if

$$c_n + \frac{\gamma}{2} \Delta \kappa_{ni}^2 + F_{ni} = \min_{n'} \left\{ c_{n'} + \frac{\gamma}{2} \Delta \kappa_{n'i}^2 + F_{n'i} \right\}, \quad (31)$$

where we define $\Delta \kappa_{ni}^2 \equiv (\kappa_n - \kappa_i)^2$. This expression extends the insights of Proposition 1 to a multicountry setup. It is immediate from equation (31) that if country n has a higher efficiency (lower c_n), it sells to a weakly larger set of countries, and it is more likely to sell to country i if κ_n and κ_i are not too far. Under the additional assumption that f is small enough, we obtain the following lemma:

Lemma 1. *For F small enough, if country n produces the externality-generating good, it sells it to all countries within an interval of κ .*

Proof: See Appendix 1.

Planner. The planner seeks to maximize world welfare, given by

$$\sum_i \left[\mathcal{V}_i - c_i - \frac{1}{2} (e_i - \kappa_i)^2 - \min_n \left\{ c_n + \frac{\gamma}{2} (e_i - \kappa_n)^2 + F_{ni} \right\} \right]. \quad (32)$$

Given an assignment where country n sells to country i , the planner will choose, as in the baseline case,

$$e_i^{*P} = \frac{\kappa_i + \gamma \kappa_n}{1 + \gamma}. \quad (33)$$

The planner again takes into account that any country that buys from i has an impact on n 's profits when setting its consumption standard. Plugging back in (32) shows that in the planner's solution, country i buys from country n if and only if

$$c_n + \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta \kappa_{ni}^2 + F_{ni} = \min_{n'} \left\{ c_{n'} + \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta \kappa_{n'i}^2 + F_{n'i} \right\}. \quad (34)$$

The proof of Lemma 1 readily extends to the planner's solution, in which an exporter also sells to all countries within a given κ interval. As long as sufficient dispersion exists in κ 's and in c across countries, (31) and (34)

²⁹The fixed cost avoids that, if country i imports from the cheapest exporter n , it moves its standard towards those of the second cheapest exporter n' to decrease the maximum price that n can charge. We do not see this as particularly realistic and switch it off through a fixed cost. Introducing a fixed cost of exporting in the baseline model changes none of the insights, but makes expressions slightly more cumbersome.

further imply more than one exporter exists, which is the case we concentrate on in the following. Using (31), (33), and (34), we can derive the following results:

Proposition 4. *In a cooperative equilibrium,*

1. *the most productive countries export more altogether;*
2. *the worldwide distribution of standards is more concentrated around the regulatory preferences of the exporters: "regulatory blocs" emerge.*

The first part of the proposition immediately obtains from comparing (31) and (34). These equations only differ by the coefficient on $\Delta\kappa_{ni}$, with the planner's solution putting a smaller weight on differences in κ 's. Differences in c 's consequently play a larger role in the planner's solution, making the relatively more efficient producers sell to a weakly larger set of destination countries. Another way of expressing this first property is to define the share of destinations to which a country sells as a function of its c as $T(c)$. The first statement of Proposition 4 is that $T(c)$ in the non-cooperative case first-order stochastically dominates $T(c)$ in the planner's case.

For the second part of the Proposition, we note that in the non-cooperative situation, the distribution of standards across countries is equal to that of κ , which immediately obtains from (30). In the planner's solution, (33) shows all countries importing from a given exporter set a standard that is a weighted average of their own κ_i and that of the exporter κ_n . This finding implies the difference in standards between any two countries that import from the same exporter is smaller in the planner's solution than in autarky. On the other hand, if two countries, 1 and 2 such that $\kappa_1 < \kappa_2$, import respectively from country 0 with $\kappa_0 < \kappa_1$ and from country 3 with $\kappa_3 > \kappa_2$, the difference between the standards of countries 1 and 2 is larger under the planner than under the non-cooperative equilibrium. In this sense, we talk of the formation of regulatory blocs, centered around the most productive countries.

These results echo the literature on regional and bilateral trade agreements. Krugman (1991) and Frankel et al. (1995) notably consider the case of "natural" regional trade agreements based on geography. The argument is that if some countries are geographically close together but relatively remote from the rest of the world, forming a regional trade agreement between them will create trade and not divert much. This set of countries is a natural one to make a welfare-improving trade agreement. In our case, natural groups of countries to make an agreement consist of countries that are close in terms of their perceptions of the externalities, rather than close in geographical terms.

4.2 Endogenous core competence

In our baseline model, we assume firms choose their core competence in autarky but cannot adjust it once trade opens up. We now assume firms can also adjust their core competence after opening to trade, which can be thought of as a "long-run" extension of our baseline case. The purpose of this section is twofold: First, we show our baseline results still hold; second, we make use of this extension to analyze the impact of country-size asymmetry on equilibrium standards.

We assume that in a first stage, both countries set their consumption standards, e_0 and e_1 . In the second stage, firm 0 and firm 1 choose their core competence. Last, firms compete in prices in both markets. As in the baseline model, the firm with the lowest marginal costs in market n , that is, with the lowest $l(e_n; c, \bar{e})$ is the only seller in n . When choosing its core competence, a firm needs to consider whether it will sell to one or two markets. If it sells in market n only, a firm will choose as core competence $\bar{e} = e_n$ to minimize its costs of production. If it sells in both markets, 0 and 1, it chooses its technology \bar{e} to minimize $l(e_0; c, \bar{e}) + l(e_1; c, \bar{e})$, and sets

$$\bar{e} = \frac{e_0 + e_1}{2}.$$

The marginal cost of producing good X at standard $e \in \{e_0, e_1\}$ if the firm produces at both standards thus boils down to

$$l\left(e; c, \frac{e_0 + e_1}{2}\right) = c + \frac{1}{2}e^2 + \frac{\gamma}{8}(e_1 - e_0)^2.$$

In the long run, the extra costs of tailoring products to different standards is thus a simple quadratic distance between the standards offered in the two markets, as in Grossman et al. (2021). Assuming without loss of generality that $c_0 < c_1$, firm 0 is the only firm that can profitably sell in both markets in equilibrium. It can charge at most a price $c_1 + \frac{1}{2}e_1^2$ in market 1, equal to the marginal costs of firm 1 if it chooses $\bar{e}_1 = e_1$. Firm 0 finds it profitable to export if it has higher profits when doing so, that is, if its profits in market 1 more than compensate the increased marginal costs it faces in 0 due to it producing at two standards. We denote the difference in profits of firm 0 when it exports relative to when it does not as

$$\Delta\pi(e_0, e_1) \equiv c_1 - c_0 - \frac{\gamma}{4}(e_1 - e_0)^2.$$

Firm 0 will only sell in both markets if $\Delta\pi(e_0, e_1) > 0$, which captures the trade-off between diseconomies of scope and market access. From the perspective of country 1, and as in our baseline case, welfare in the open economy is equal to welfare in autarky, because the exporter can extract the whole surplus, due to Bertrand

competition. This finding implies that whether it imports or not, country 1 has welfare

$$\mathcal{W}_1 = \mathcal{V}_1 - c_1 - \frac{1}{2}(e_1 - \kappa_1)^2$$

and sets again its standard at the autarky level $e_1^{*C} = \kappa_1$. The firm from 0 only exports if it makes profits in country 1, and country 0 chooses the e_0 that maximizes

$$\mathcal{W}_0(e_0, e_1) = \mathcal{V}_0 - c_0 - \frac{1}{2}(e_0 - \kappa_0)^2 + \max\{0, \Delta\pi(e_0, e_1)\}. \quad (35)$$

If it exports, firm 0 sets

$$e_0^{*C} = \frac{\kappa_0 + \frac{\gamma}{2}\kappa_1}{1 + \frac{\gamma}{2}} \quad (36)$$

and internalizes the impact of its consumption standard on the profits that its firm obtains in country 1. To decrease the cost of producing goods at different e 's, it sets its consumption standard to reflect both its own perception of the externality, as well as that of the importing country. This approach reduces country 0's domestic welfare relative to autarky, because its consumption standard is less in line with its perception of the externality but allows country 0 to reap higher profits in market 1. If firm 0 sells to country 1, the welfare of country 0 is given by

$$\mathcal{W}_0(e_0^{*C}, \kappa_1) = \mathcal{V}_0 - c_0 + c_1 - c_0 - \frac{1}{2} \frac{\frac{\gamma}{2}}{1 + \frac{\gamma}{2}} \Delta\kappa^2.$$

Country 0 only sets e_0 if exporting to country 1 is preferable to selling only domestically, that is, under the condition that its welfare is higher than in autarky. If not, country 0 sets $e_0 = \kappa_0$ and no trade takes place between the countries.³⁰ When the core competence is endogenous, country 0 exports to country 1 if and only if

$$c_1 - c_0 > \frac{1}{2} \frac{\frac{\gamma}{2}}{1 + \frac{\gamma}{2}} \Delta\kappa^2,$$

which is the counterpart to (7) when the core competence is fixed at its autarky level. By adjusting its consumption standard and its core competence, the exporter makes selling at the two different standards less costly and makes trade more likely.

Even with endogenous core competence, note the planner's solution differs from the non-cooperative outcome. As in our baseline case, the planner would still require the importer to adjust its standard toward the κ

³⁰The objectives of the firm in 0 and of country 0 are different: the firm only maximizes its profits, whereas the country also takes into account the impact of a mismatch between e_0 and κ_0 as reflected in (35). Country 0 sets $e_0 = e_0^{*C}$ only if, at this standard, its welfare is higher than in autarky, that is, if $-\frac{1}{2}(e_0^{*C} - \kappa_0)^2 + \Delta\pi(e_0^{*C}, \kappa_1) > 0$, which implies that at e_0^{*C} , the firm would also be willing to export. If country 0 chooses a standard $e_0 = \kappa_0$, on the other hand, the implication is that it does not want to export. It is immediate from (35) that if the country does not want to export at $e_0 = \kappa_0$, the firm also does not want to export.

of the exporter and to set

$$e_0^{*CP} = \frac{(1 + \frac{\gamma}{2}) \kappa_0 + \frac{\gamma}{2} \kappa_1}{1 + \gamma} \quad e_1^{*CP} = \frac{(1 + \frac{\gamma}{2}) \kappa_1 + \frac{\gamma}{2} \kappa_0}{1 + \gamma},$$

and international trade is preferable to autarky when

$$c_1 - c_0 > \frac{1}{4} \frac{\gamma}{1 + \gamma} \Delta \kappa^2.$$

Propositions 1 and 2 thus readily extend to the case of endogenous core competences.

Country-size asymmetries. We now consider a small variation of the setup with endogenous core competence, where we allow countries to differ in size, with M_n being the mass of consumers in country n . Although we can also introduce such asymmetries in the baseline model, they generate particularly useful insights with an endogenous core competence.

If country 0 sells in both countries, it chooses \bar{e}_0 to minimize its costs of production, given by $M_0 l(e_0; c_0, \bar{e}_0) + M_1 l(e_1; c_0, \bar{e}_0)$, and picks

$$\bar{e}_0 = \frac{M_1 e_1 + M_0 e_0}{M_1 + M_0},$$

; that is, it chooses as the core competence a weighted average of the two countries standards, with weights reflecting their relative size. The change in profits if the firm exports versus not becomes

$$\Delta \pi(e_0, e_1) = M_1(c_1 - c_0) - \frac{\gamma}{2} \frac{M_0 M_1}{M_1 + M_0} (e_1 - e_0)^2,$$

and the per-capita welfare of country 0 if it exports is

$$\mathcal{V}_0 - c_0 - \frac{1}{2} (e_0 - \kappa_0)^2 + \max \left\{ 0, \frac{\Delta \pi(e_0, e_1)}{M_0} \right\},$$

which implies

$$e_0^{*C} = \frac{\kappa_0 + \gamma \frac{M_1}{M_0 + M_1} \kappa_1}{1 + \gamma \frac{M_1}{M_0 + M_1}}. \quad (37)$$

Country 0 sets e_0 at the above level, and international trade takes place only if the country's welfare is higher than in autarky, that is, if

$$c_1 - c_0 > \frac{1}{2} \frac{\gamma \frac{M_0}{M_0 + M_1}}{1 + \gamma \frac{M_1}{M_0 + M_1}} \Delta \kappa^2. \quad (38)$$

If the above condition does not hold, no trade occurs in the non-cooperative equilibrium, and country 0 sets its standard at the autarky level $e_0 = \kappa_0$. Equations (37) and (38) yield some interesting results. If the foreign

market is large (high M_1), country 0 finds it more beneficial to export to country 1. If it does export, it sets its consumption standard closer to that of country 1. This captures the fact that exporters are more willing to adjust their standard to match those of large markets (affecting the "core competence" in our setup), thereby affecting the choice of consumption standard in their own country (see, e.g., Bradford (2020) for illustrations).

The planner's solution, if it gives each country a weight that is proportional to its size, is such that

$$e_0^{*CP} = \frac{\left(1 + \frac{\gamma M_0}{M_0 + M_1}\right) \kappa_0 + \frac{\gamma M_1}{M_0 + M_1} \kappa_1}{1 + \gamma} \quad e_1^{*CP} = \frac{\left(1 + \frac{\gamma M_1}{M_0 + M_1}\right) \kappa_1 + \frac{\gamma M_0}{M_0 + M_1} \kappa_0}{1 + \gamma}, \quad (39)$$

and the condition for trade to be optimal under the planner becomes

$$c_1 - c_0 > \frac{\gamma}{2} \frac{M_0}{M_0 + M_1} \frac{\Delta \kappa^2}{1 + \gamma}. \quad (40)$$

Comparing (38) and (40) and using (39) immediately shows Propositions 1 and 2 also hold with asymmetric sizes.

4.3 Discussion

4.3.1 Transport costs

We now extend our baseline model to allow for transport costs, which we think of as given when countries choose their standards. From the perspective of the firm from n , it implies paying an additional cost t_{ni} to ship a unit of the good to country i , with $t_{nn} = 0$. The profits of firm 0 on market 1 become (the counterpart to equation (4))

$$\pi_{01}(e_1) = \max\{l_1(e_1) - l_0(e_1) - t_{01}, 0\}.$$

The welfare of country 0 is still given by equation (5), where $\pi_{01}(e_1)$ now contains the additional costs of selling abroad. Because the local producer in country 1 is not affected by transport costs, the maximum price that firm 0 can charge remains the same, but it faces higher costs of selling the good in 1. Country 0 still sets a standard $e_0 = \kappa_0$, as in our baseline. We present here our main results and relegate the detailed proofs to Appendix A.6. In contrast to the analysis in section 3.3, t_{01} is not associated with any additional revenue from the perspective of country 1.³¹ Country 1's welfare when it imports is the same as in our baseline analysis:

$$\mathcal{W}_1 = \mathcal{V}_1 - c_1 - \frac{1 + \gamma}{2} (e_1 - \kappa_1)^2,$$

³¹This feature would also be true of the "red tape" barriers that Maggi et al. (2021) emphasize.

and the optimal policy choice in a non-cooperative environment remains to set $e_1 = \kappa_1$. Trade only happens if the exporter from 0 makes positive profits, that is, if

$$c_1 - c_0 > t_{01} + \frac{\gamma}{2} \Delta \kappa^2. \quad (41)$$

This condition is more stringent than the condition with no costs of trade. The additional cost of trading requires a stronger cost advantage for trade to happen, but the insights of Proposition 1 remain unchanged. Turning to the planner's case, the condition for trade to take place (8) is again modified to include the costs of trade and becomes

$$c_1 - c_0 > t_{01} + \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta \kappa^2.$$

The standards the planner chooses are the same as in our baseline (equation (9)), with the condition for trade being replaced by the above equation. It is immediate that Proposition 2 extends to the case of trade costs, and the difference in standards across countries in the planner's solution is given by

$$e_0^{*P} - e_1^{*P} = \begin{cases} \kappa_0 - \kappa_1 & \text{if } c_1 - c_0 - t_{01} < \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta \kappa^2 \\ \frac{\kappa_0 - \kappa_1}{1 + \gamma} & \text{otherwise.} \end{cases} \quad (42)$$

As transport costs decrease, the planner's solution goes from one without trade to one with trade and a convergence of standards. As shown in Appendix A.6, the difference in global welfare between the planner and the non-cooperative equilibrium ($\Delta \mathcal{W}$) is weakly decreasing in transport costs, making the gains from cooperation on standards increase when transport costs decrease.³² Equation (41) shows differences in regulatory preferences ($\Delta \kappa^2$)—equal to differences in standards in the non-cooperative equilibrium—enter in a manner akin to transport costs. This is consistent with the way the literature quantifies non-tariff barriers using a tariff equivalent. In fact, our model suggests differences in standards are too high in a non-cooperative equilibrium, and reducing them is equivalent to reducing transport costs. However, equation (42) makes explicit that the optimal difference in standards is not zero and that a full convergence would not maximize welfare. Going too far would become similar to raising transport costs again. Quantifying the welfare effects of a convergence in standards using a tariff equivalent should not rely on the premise that a full harmonization corresponds to the optimum (see also the statement of Berden and Francois (2015) mentioned in the introduction).

³²This result extends to a world with a continuum of varieties, making the result more "continuous."

4.3.2 Externality vs. preferences.

A key ingredient of our setup is that consumption generates externalities over which countries have heterogeneous perceptions. To stress the importance of externalities in our model, we consider an alternative version of our baseline where E is a quality parameter, perceived and internalized by consumers. Consumers prefer to buy a low- E good, and κ_n denotes the weight that they put on quality. When deciding on which version of the good to buy, consumers in i pick the one produced by the firm from n if it has the lowest-quality adjusted price, that is, if $p_{ni} - \kappa_i e_{ni} = \min_{n'} \{p_{n'i} - \kappa_i e_{n'i}\}$, with p_{ni} , the price charged by firm n in i , and e_{ni} , the market-specific quality that firm n chooses in i . If it sells to consumers in i , firm n with $\bar{e}_n = \kappa_n$ maximizes $p_{ni} - l_n(e_{ni})$. It chooses $e_{ni} = \frac{\kappa_i + \gamma \kappa_n}{1 + \gamma}$, which minimizes its marginal costs net of $\kappa_i e_{ni}$. If country 0 sells in country 1, it thus charges a price that makes consumers indifferent between buying its good or that of firm 1, that is, $p_{0i} = l_1(e_{1i}) - \kappa_i e_{1i} + \kappa_i e_{0i}$. Firm 0 exports to market 1 whenever its profits, given by $c_1 - c_0 - \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta \kappa^2$, are positive. This choice is also the one a planner would make and is equivalent to the planner's condition for international trade in our baseline model with externality, as derived in (8). The quality at which firm 0 sells in country 1 is also equivalent to the choice of standard in country e_1^{*P} by the planner in (9). Because it does not call for national regulations, a model with quality does not generate the cross-country externality that is key to our model.

4.3.3 Minimum standard vs. Pigouvian tax

In our setup, governments address the externality arising from the consumption of good X through a minimum standard. Although we consider this modeling choice more realistic, we now modify our setup to allow for the imposition of a Pigouvian tax instead. Assume a country can set a tax $t \times (E^M - e)$ per unit sold, that is, a tax that depends on the level of the externality. As in our baseline, consumers buy the cheapest good on offer, because they do not internalize the externality. Firms consequently choose to produce at an e that minimizes the costs of producing the good, including the tax. A firm from n with a core competence \bar{e}_n and wanting to sell in market i with tax t_i will produce a good at standard e_{ni} that minimizes $l(e_{ni}; c_n, \bar{e}_n) + t_i(E^M - e_{ni})$, that is,

$$e_{ni} = \frac{t_i + \gamma \bar{e}_n}{1 + \gamma}. \quad (43)$$

In autarky, when choosing its core competence, the firm from n chooses $\bar{e}_n = t_n$ to minimize its costs of production and would therefore set $e_{nn} = t_n$. Country n 's welfare in autarky boils down to³³

$$V - \kappa_n(E^M - t_n) - c_n - \frac{1}{2}t_n^2,$$

and country n sets, in autarky, $t_n = \kappa_n$. This outcome mirrors our baseline model in autarky, where the core competence and the standard are equal to κ_n , with welfare \mathcal{W}_n^A as defined in (3).

In the open economy, we take again the core competence as given by its autarky level ($\bar{e}_n = \kappa_n$). If it sells in country 1, firm 0 charges a price that makes consumers indifferent between buying the good from itself or from the other firm. If it sells in 1, it sets a consumer price equal to $l_1(e_{11}) + t_1(E^M - e_{11})$ and makes profits

$$\pi_{01} = \max \left\{ c_1 - c_0 + \frac{1}{2}e_{11}^2 - \frac{1}{2}e_{01}^2 + \frac{\gamma}{2}(e_{11} - \kappa_1)^2 - \frac{\gamma}{2}(e_{01} - \kappa_0)^2 - t_1(e_{11} - e_{01}), 0 \right\}, \quad (44)$$

where e_{ni} is given by (43). If country 0 exports to 1, the respective welfare of each country is

$$\mathcal{W}_0 = V - c_0 - \frac{1}{2}e_{00}^2 - \frac{\gamma}{2}(e_{00} - \kappa_0)^2 - \kappa_0(E^M - e_{00}) + \pi_{01} \quad (45)$$

$$\mathcal{W}_1 = \mathcal{W}_1^A + (t_1 - \kappa_1)(e_{11} - e_{01}) - \frac{1 + \gamma}{2}(e_{11} - \kappa_1)^2. \quad (46)$$

In the non-cooperative case, country 0 sets $t_0 = \kappa_0$, such that $e_{00} = \kappa_0$, as in autarky and as in our baseline with minimum standards. From the perspective of country 1, a given level of policy t_1 will now be associated with different levels of standards for the two potential producers, as should be clear from (43). Equation (46) thus differs from its counterpart in the baseline by including a term $(t_1 - \kappa_1)(e_{11} - e_{01})$. In contrast to the baseline case, the importer can now capture part of the surplus from trade. If $\kappa_1 > \kappa_0$ ($e_{11} > e_{01}$), a higher tax reduces the price difference between the good produced by firm 1 and the one produced by firm 0. By manipulating the relative costs of both firms in Bertrand competition, country 1 can thus appropriate part of the surplus. If it wants to import, country 1 chooses t_1 to maximize (46) under the condition that firm 0 does not make a loss. We define the tax for which firm 0 makes zero profits on market 1 as

$$\tilde{t}_1 = \frac{\kappa_0 + \kappa_1}{2} + \frac{1 + \gamma}{\gamma} \frac{c_1 - c_0}{\kappa_1 - \kappa_0}.$$

Firm 0 makes positive profits in country 1 if $t_1 < \tilde{t}_1$ when $\kappa_1 > \kappa_0$ or if $t_1 > \tilde{t}_1$ when $\kappa_1 < \kappa_0$. Knowing the

³³Note the taxes paid on the externality generate an equivalent revenue for the country and only enter welfare through their effect on the behavior of firms.

participation constraint of the firm from 0, country 1 sets a tax:

$$t_1 = \begin{cases} \kappa_1 & \text{if } c_1 - c_0 < \frac{1}{2} \frac{\gamma}{1+\gamma} \Delta \kappa^2 \\ \tilde{t}_1 & \text{if } \frac{1}{2} \frac{\gamma}{1+\gamma} \Delta \kappa^2 \leq c_1 - c_0 < \frac{\gamma}{1+\gamma} \left(\gamma + \frac{1}{2}\right) \Delta \kappa^2 \\ \kappa_1 + \gamma(\kappa_1 - \kappa_0) & \text{if } \frac{\gamma}{1+\gamma} \left(\gamma + \frac{1}{2}\right) \Delta \kappa^2 \leq c_1 - c_0. \end{cases} \quad (47)$$

The first line above corresponds to the case where no trade occurs in equilibrium and country 1 picks its tax as in autarky. The second line is the case where trade generates a surplus that country 1 can fully appropriate through a manipulation of the Pigouvian tax. Plugging \tilde{t}_1 into e_{01} shows firm 0 produces at a standard κ_0 and κ_1 , generating some adjustment of standards toward the planner's solution. As we show in Appendix A.7, however, this adjustment is weaker than what the planner would choose in our baseline (e_1^P). In the third line, firm 0 produces at $e_{01} = \kappa_1$ for country 1, and both countries have some benefit from trade.

Note the condition for trade to happen with a Pigouvian tax is the same as that of the planner in our baseline (8). Because country 1 can appropriate some of the surplus from trade, it designs its tax in such a way that trade happens as soon as trade brings benefits from a world perspective. However, country 1 does not mimic the choice of the planner, which would pick $e_{01} = \frac{\kappa_1 + \gamma \kappa_0}{1 + \gamma}$ and take into account the effect of the Pigouvian tax on the profits of country 0. As in the baseline, the importer does not internalize the effects of its choice of standard on the profits of the exporter and sets a standard that is too close to its autarky standard relative to what is optimal from a planner's perspective.

Seen from the perspective of country 1, we show in Appendix A.7 that a tax generates a higher welfare than a minimum standard as long as $c_1 - c_0 > \frac{1}{2} \frac{\gamma}{1+\gamma} \Delta \kappa^2$. The reason is similar to our result on relaxing the national treatment in section 3.4: a tax effectively implies a different choice of standard by the two firms, and country 1 can use this additional flexibility to appropriate some of the profits from the exporter. From a world welfare perspective, a non-cooperative tax only weakly dominates a non-cooperative minimum standard. In the range $\frac{1}{2} \frac{\gamma}{1+\gamma} \Delta \kappa^2 < c_1 - c_0 < \frac{\gamma}{1+\gamma} \left(\gamma + \frac{1}{2}\right) \Delta \kappa^2$, country 1 sets a tax such that firm 0 can produce a bit closer to its core competence, raising global welfare. If $c_1 - c_0$ is higher, however, $e_{01} = \kappa_1$, as in the non-cooperative minimum standard, and global welfare is the same under both instruments.

4.4 Robustness

Our setup consists of an international Bertrand duopoly with inelastic demand. We discuss here the role of alternative assumptions:

Variable quantities Under a more standard demand schedule and assuming a linear pollution function in quantities, a single instrument is no longer enough to restore efficiency. The consumption standard is chosen to mitigate both the monopolistic distortion over the social marginal cost of production and the externality. Assuming governments can now also use a consumption tax, we prove in Appendix A.8 that the results of our baseline model continue to hold: the gains from cooperation are maximized for modest differences in regulatory preferences. In contrast to Figure 1, the gains from deep integration are now shaped by the curvature of demand.

Domestic duopoly The inefficiency of the non-cooperative equilibrium relies on the importer's consumption standard having an impact on the welfare of the exporting country. In our setup, it comes down to the existence of positive profits in the equilibrium on which the importer's consumption standard has *some* incidence. The need for deep integration thus results from a cost-shifting externality. Instead, a market structure featuring Bertrand competition *within* each country could restore efficiency of the non-cooperative equilibrium. Consider a case where the exporting firm also has a domestic competitor—a firm with the same core competence but a higher cost parameter c . Bertrand competition implies profits are completely inelastic to a "small" change in the importer's standards as long as the firm with the second lowest marginal costs is the domestic one. Thus, the tailoring costs to the importing-country's standard are entirely passed onto the final consumer price. The importing country internalizes these costs and chooses the optimal consumption standard. Even in this case, for larger changes in the standard, our setup implies that at some level, the firm in the importing country becomes the second-lowest marginal cost producer, restoring the mechanism at play in the baseline model. Note, however, that the gains from cooperation are smaller in this case. Overall, the benefit from a trade agreement will be larger when the exporting firm holds a larger technological lead over its competitors, at home and abroad.

Cournot vs. Bertrand Assumptions on the market structure are known to be key in analyzing optimal trade policy. In our framework, however, isolating the role played by the mode of competition would require changing the set of policy instruments that governments are endowed with. Our assumption of Bertrand competition with unit consumption aims at isolating the role played by heterogeneous regulatory preferences: when countries share the same regulatory preferences, the outcome of the market is first-best and a trade agreement becomes irrelevant. This scenario would not be the case under variable quantities with Cournot competition, which would lead to under-production. Efficiency may be restored if the government is endowed with sufficient policy—potentially discriminatory—instruments. In this scenario, the main purpose of deep integration would remain the internalization of the cost-shifting externality. By contrast, without these additional instruments, the

gains from deep integration would depend non-trivially on the competitive effects stemming from international competition.

More general cost functions Our baseline model uses a very stylized cost function to keep the exposition simple, but our key results extend to a more general setup. Consider a cost function given by ³⁴

$$l_n(e) = c_n + \varphi(e, \bar{e}_n),$$

with the following regularity conditions: $\varphi_e \equiv \partial\varphi/\partial e > 0$ and $\varphi_{ee} \equiv \partial^2\varphi/\partial e^2 > 0$. The chosen standard (e) and the core competence (\bar{e}_n) now enter in a flexible form. We define $\tilde{\varphi}(e) = \varphi(e, e)$ as the cost function, such that the core competence would always be equal to the chosen standard e , neutralizing the effect of the core competence ($\tilde{\varphi}(e) = e^2/2$ in our baseline). $\tilde{\varphi}_e$ is such that a small change in e comes mechanically with the same change in core competence and we have $\tilde{\varphi}_e > 0$, and $\tilde{\varphi}_{ee} > 0$. We assume the following property of φ for a core competence to make sense:

$$\varphi_e(e, \bar{e}) - \tilde{\varphi}_e(e) \geq 0 \text{ if } e \geq \bar{e}; \quad (48)$$

that is, changes in standards away from the core competence raise the marginal costs of production relative to a world with no core competence. Similarly, we assume $\varphi_{\bar{e}}(e, \bar{e}) \geq 0$ if $\bar{e} \geq e$, such that fixing e , moving \bar{e} away raises costs. We replicate the results of Proposition 2 for this more general cost function, starting with the fact that standards converge in the planner's solution relative to the non-cooperative equilibrium. In autarky, the core competence is such that

$$\kappa_n = \tilde{\varphi}_e(\bar{e}_n).$$

A country with a higher κ chooses a higher core competence \bar{e} . When countries trade, they still set $e_n = \bar{e}_n$ in a non-cooperative situation for the same reason as in our baseline setup, and they will trade if firm 0 (we assume $c_0 < c_1$) makes positive profits, that is, if

$$c_1 - c_0 + \varphi(\bar{e}_1, \bar{e}_1) - \varphi(\bar{e}_1, \bar{e}_0) > 0.$$

³⁴The separability between the cost term c and the part that depends on standards φ is key to generating tractable results. An interaction between the two parts would generate additional effects, because countries would now have different comparative advantages for different standards, blurring the distinction between technological efficiency and standards. Results, available upon request, show most of our intuitions would carry over in an expected sense under meaningful assumptions of the correlation between κ and c across countries.

The planner, on the other hand, maximizes world welfare, which is equivalent to maximizing

$$\kappa_1 e_1 - \varphi(e_1, \bar{e}_1) + \underbrace{\max\{c_1 - c_0 + \varphi(e_1, \bar{e}_1) - \varphi(e_1, \bar{e}_0), 0\}}_{\text{Profits of 0 on market 1}} + \kappa_0 e_0 - \varphi(e_0, \bar{e}_0).$$

If trade occurs, it sets $e_0^P = \bar{e}_0$ and e_1^P such that $\varphi_e(e_1^P, \bar{e}_0) = \kappa_1$, or $\varphi_e(e_1^P, \bar{e}_0) - \tilde{\varphi}_e(\bar{e}_1) = 0$. If the planner were to set $e_1^P = \bar{e}_1$, by the definition of the core competence, the condition would be positive for $\bar{e}_1 > \bar{e}_0$ and negative for $\bar{e}_1 < \bar{e}_0$. Because $\varphi_{ee} > 0$, the implication is that e_1^P must move away from \bar{e}_1 toward \bar{e}_0 , which generalizes part 1 of Proposition 2. At a basic level, convergence obtains because the planner internalizes the effect of the importer's standards on the exporters' profits. Starting from a Nash equilibrium in which both countries set a standard equal to their core competence, condition (48) ensures moving the importer's standards toward the exporters's core competence raises the exporter's profits. The condition for trade to occur in the planner's solution is

$$c_1 - c_0 + \varphi(e_1^P, \bar{e}_1) - \varphi(\bar{e}_1^P, \bar{e}_0) > 0,$$

which is a weaker condition than in the non-cooperative case, as in our baseline. We show in Appendix A.9 that the second part of Proposition 2 still obtains with this more general cost function.

5 Conclusion

This paper develops an imperfectly competitive trade model with Ricardian technological differences, where the consumption of goods generates local externalities. Countries vary in their regulatory preferences regarding these externalities and impose more or less stringent product standards accordingly. Tailoring products to different standards is costly for firms, and trade is only beneficial if the gains from comparative advantages outweigh the asymmetric concerns over these externalities.

In this context, we derive several properties regarding the feasibility and nature of regulatory cooperation. We first show that regulatory convergence is advantageous when countries have small to moderate differences in regulatory preferences. In a multi-country world, this implies the optimality of regulatory blocs, wherein countries with similar regulatory preferences converge on standards. With the many caveats inherent to a simple model, our framework contributes to the regionalism versus multilateralism debate in trade. Our analysis suggests that the recent wave of deep trade agreements may indeed be an efficient outcome in a world with low tariffs among countries with different but sufficiently similar regulatory preferences. However, we emphasize that regulatory cooperation should not be an end in itself, especially when countries have differing views on local externalities.

Our model also reveals a complementarity between shallow and deep integration: if tariffs are already low but positive, further reductions may not be beneficial without accompanying deep integration. This perspective helps explain the stalling of multilateral tariff negotiations since the Doha round began in 2001, reflecting the difficulty and potential inefficiency of combining further tariff reductions with deep integration on a global scale.

Our results should not be seen as a critique of multilateralism in trade; we assume low tariffs, and acknowledge the GATT/WTO's role in achieving this. However, if regulatory convergence is the next step in trade integration, striving for worldwide convergence may not be optimal due to heterogeneous regulatory preferences across countries. Even when efficient, achieving the right level of regulatory convergence can be challenging. We show that when each country has a comparative advantage in certain varieties of externality-generating goods (intra-industry trade), mutual regulatory concessions can help countries approach an efficient level of convergence. Such symmetry is less likely between developed and developing countries, making regulatory convergence harder to implement, even if it would be efficient.

From an environmental perspective, the relationship between developed and developing countries has often been analyzed concerning local *production* externalities. Our results contrast with these models. With a production externality, importers tend to source from countries less concerned with these externalities, leading to trade with countries that have different regulatory preferences. However, we have not considered the possibility of a government's preference reflecting a genuine concern for import-driven production externalities. For example, the availability of consumption-based accounting of CO2 emissions might shape the social welfare function of countries importing "dirty" goods (Davis and Caldeira, 2010). In this case, our model with consumption externalities aligns with a model where governments are concerned with production externalities generated abroad. An increase in concern for these externalities by an importing country could lead to the formation of trade blocs contrary to Ricardian trade patterns. Endogenizing such shifts in the social welfare function is a task for future research. Additionally, we have abstracted from politically motivated governments whose objectives may be influenced by lobbying pressure (Maggi and Ossa, 2020; Maggi and Mrázová, 2023; Rebeyrol, 2023). This constitutes another avenue for future research where regulatory "preferences" could be endogenized.

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A Appendix

A.1 Production externalities

Here, we consider the case of an externality that arises through production and not through consumption. Our setup is otherwise unchanged, with different perceptions of the externality across countries, indexed by κ , and minimum production standards as policy options. In autarky, because production equals consumption, this change is immaterial and the optimal policy in each country remains to set $e_n = \kappa_n$. In an open economy, however, producing for the export market is now associated with a higher externality. Everything else being equal, *offshoring* the externality provides a direct gain for the importer.

The firm from 0 now finds it profitable to export to country 1 when $l_1(e_1) - l_0(e_0) > 0$. Equation (4) differs in that the marginal costs of the two firms are now evaluated at different standards, namely, the production standards. A higher production standard in country 0 would raise the costs of production for firm 0 relative to firm 1, thereby decreasing its cost advantage. A higher standard in country 1 raises the costs of firm 0's competitor, allowing firm 0 to charge a higher price in country 1. The welfare of country 0 if it exports becomes

$$\mathcal{V}_0 - c_0 - \frac{1 + \gamma}{2}(e_0 - \kappa_0)^2 - \kappa_0(E^M - e_0) + l_1(e_1) - l_0(e_0).$$

Compared with (5), country 0 suffers from an additional externality, due to the production for the foreign market $\kappa_0(E^M - e_0)$, and its profits are modified as explained above. The optimal policy from the perspective of country 0 if it exports remains to set $e_0 = \kappa_0$, as with a consumption externality. The profits of firm 0 in market 1 are positive as long as $l_1(e_1) - l_0(\kappa_0) > 0$. However, no direct alignment exists between the profits of the firm in country 0 and the welfare of country 0. With a production externality, the firm does not consider the externality it imposes on its origin country when producing, and the condition for exporting to be beneficial for country 0 is that $\kappa_0(E^M - \kappa_0) + l_1(e_1) - l_0(\kappa_0) > 0$. Whether the actual condition for trade to occur is the one of firm 0 or of country 0 depends on whether country 0 has additional instruments to control the behavior of its national producer, to guarantee exports are beneficial for the country as a whole. We assume this case holds and that after the choice of standards, countries can forbid their national firm from exporting if they deem the prohibition beneficial.³⁵

Country 1 has welfare $L_1 + V - l_1(e_1)$ if it imports, and the condition for country 1 to benefit from importing

³⁵In the case of consumption externalities, as is apparent in equation (5), no misalignment exists between the firm and the country's objectives. For a given standard, a country wants its firm to export if it makes positive profits abroad. This case does not hold with a production externality, because the externality happens in the producing country. To keep the setup simple and comparable, we thus give the means for countries to choose whether their firm can export or not after the choice of standard. Without such an instrument, countries would be tempted to use the production standard to influence the export decision of their firms, and no pure strategy Nash equilibrium would exist in the choice of production standards. The proof is available upon request.

is

$$\frac{1}{2}e_1^2 + \frac{\gamma}{2}(e_1 - \kappa_1)^2 - \frac{1}{2}\kappa_1^2 < \kappa_1 E^M - \kappa_1^2.$$

When importing, country 1 avoids the production externality (right-hand side [RHS]) and may face a change in price relative to autarky (left-hand side [LHS]). This change in price is largely influenced by country 1: when choosing e_1 , country 1 affects the costs of production of its domestic firm and thereby the price that firm 0 can charge. If it wants to import, country 1 sets a production standard that minimizes its costs of production, conditional on the participation constraint of country 0. Combining the conditions for country 0 to export and country 1 to benefit from exporting shows country 0 exports to 1 as long as

$$c_1 + \frac{1}{2}\kappa_1^2 + \kappa_1 (E^M - \kappa_1) > c_0 + \frac{1}{2}\kappa_0^2 + \kappa_0 (E^M - \kappa_0). \quad (\text{A.1})$$

This condition now states that the autarky production costs in country 0, including the utility cost of the production externality, should be lower than in country 1. This formulation simply extends comparative advantages by including the utility costs of the externality on top of the technological costs. The terms on each side of the externality are symmetric; that is, if the inequality is reversed, patterns of trade switch and country 1 exports good X to country 0. As long as (A.1) does not hold with equality, some trade takes place in equilibrium along the lines of those extended comparative advantages. This difference stands in stark contrast to our baseline model and the condition for trade in (7), where the difference in regulatory preferences per se matters and generates a range of parameters with no trade. With a production externality, a combination of low costs of production and low concerns for the production externality strengthens a country's comparative advantage and the total gains from trade. A negative correlation between κ and c weakens them.

Also note that with production standards, the non-cooperative solution is the same as the planner's solution in the presence of minimum standards. The planner also chooses the country with the lowest $c_n + \frac{1}{2}\kappa_n^2 + \kappa_n (E^M - \kappa_n)$ as the exporter and sets $e_n = \kappa_n$ for the exporter, as in the non-cooperative case.

A.2 Proof of Proposition 3

Starting from equation (18) and its equivalent for country 1,

$$\Delta \mathcal{W}_0(e_0, e_1) = -\frac{1+\gamma}{2}(e_0 - \kappa_0)^2 \omega_1(e_0) + \gamma \omega_0(e_1)(\kappa_1 - \kappa_0)(\kappa_1 - e_1) - \int_{\omega_0(\kappa_1)}^{\omega_0(e_1)} \left(A(\omega) + \frac{\gamma}{2} \Delta \kappa^2 \right) d\omega \quad (\text{A.2})$$

$$\Delta \mathcal{W}_1(e_0, e_1) = -\frac{1+\gamma}{2}(e_1 - \kappa_1)^2 \omega_0(e_1) + \gamma \omega_1(e_0)(\kappa_1 - \kappa_0)(e_0 - \kappa_0) + \int_{1-\omega_1(e_0)}^{1-\omega_1(\kappa_0)} \left(A(\omega) - \frac{\gamma}{2} \Delta \kappa^2 \right) d\omega \quad (\text{A.3})$$

Integrating by substitution and using (15) gives

$$\int_{\omega_0(\kappa_1)}^{\omega_0(e_1)} \left(A(\omega) + \frac{\gamma}{2} \Delta \kappa^2 \right) d\omega = \int_{\kappa_1}^{e_1} \left(A(\omega_0(e)) + \frac{\gamma}{2} \Delta \kappa^2 \right) \omega_0'(e) de = \int_{\kappa_1}^{e_1} \frac{\gamma}{2} (\kappa_1 - \kappa_0) (\kappa_1 - e) \omega_0'(e) de.$$

After integrating by parts, the above becomes

$$\int_{\omega_0(\kappa_1)}^{\omega_0(e_1)} \left(A(\omega) + \frac{\gamma}{2} \Delta \kappa^2 \right) d\omega = \frac{\gamma}{2} (\kappa_1 - \kappa_0) (\kappa_1 - e_1) \omega_0(e_1) - \int_{e_1}^{\kappa_1} \frac{\gamma}{2} (\kappa_1 - \kappa_0) \omega_0(e) de$$

Following a similar reasoning for country 1, and plugging back in (A.2) and (A.3), gives

$$\Delta \mathcal{W}_0(e_0, e_1) = -\frac{1+\gamma}{2} (e_0 - \kappa_0)^2 \omega_1(e_0) + \frac{\gamma}{2} \omega_0(e_1) (\kappa_1 - \kappa_0) (\kappa_1 - e_1) + \frac{\gamma}{2} (\kappa_1 - \kappa_0) \int_{e_1}^{\kappa_1} \omega_0(e) de \quad (\text{A.4})$$

$$\Delta \mathcal{W}_1(e_0, e_1) = -\frac{1+\gamma}{2} (e_1 - \kappa_1)^2 \omega_0(e_1) + \frac{\gamma}{2} \omega_1(e_0) (\kappa_1 - \kappa_0) (e_0 - \kappa_0) + \frac{\gamma}{2} (\kappa_1 - \kappa_0) \int_{\kappa_0}^{e_0} \omega_1(e) de \quad (\text{A.5})$$

- Proof of Part 1

The planner's solution requires symmetric adjustment to standards, that is, $\kappa_1 - e_1^P = e_0^P - \kappa_0$. With a symmetric productivity schedule, this implies $\omega_0(e_1^P) = \omega_1(e_0^P)$, and it immediately follows that

$$\Delta \mathcal{W}_0(e_0^P, e_1^P) - \Delta \mathcal{W}_0(e_0^P, e_1^P) = \frac{\gamma}{2} (\kappa_1 - \kappa_0) \left[\int_{e_1^P}^{\kappa_1} \omega_0(e) de - \int_{\kappa_0}^{e_0^P} \omega_1(e) de \right] = 0$$

where the second equality uses that, for each $\kappa_1 - e = e - \kappa_0$, $\omega_0(e) = \omega_1(e)$ (this can be seen more formally by changing the variable of integration from e to $\kappa_1 - e$ in the first place and from e to $e - \kappa_0$ in the second). This proves that the planner's solution can be reached under mutual concessions. When maximizing the sum of welfare, requiring that $\Delta \mathcal{W}_0(e_0, e_1) = \Delta \mathcal{W}_1(e_0, e_1)$ does not impose an additional constraint on the problem, and both countries reach the planner's solution through a Pareto-improving mutual concession.

- Proof of Part 2

We now consider the case where country 0's productivity dominates that of country 1; that is, $A(\omega) + A(1 - \omega) < 0$ for all ω . Consider a pair of standards $e_0 \geq \kappa_0$ and $e_1 \leq \kappa_1$ such that $e_0 - \kappa_0 = \kappa_1 - e_1$. Equations (15) and (17) imply $\omega_0(e_1) > \omega_1(e_0)$, which, from (A.4) and (A.5), means $\Delta \mathcal{W}_0(e_0, e_1) > \Delta \mathcal{W}_1(e_0, e_1)$. The reason is that country 0 exports relatively more to country 1 and benefits more from a given level of adjustment in standard by its partner.

We also note

$$\frac{\partial \Delta \mathcal{W}_0}{\partial e_1} = \frac{\gamma}{2}(\kappa_1 - \kappa_0)(\kappa_1 - e_1)\omega'_0(e_1) - \gamma\omega_0(e_1)(\kappa_1 - \kappa_0) \quad (\text{A.6})$$

$$\frac{\partial \Delta \mathcal{W}_1}{\partial e_0} = \frac{\gamma}{2}(\kappa_1 - \kappa_0)(e_0 - \kappa_0)\omega'_1(e_0) + \gamma\omega_1(e_0)(\kappa_1 - \kappa_0) \quad (\text{A.7})$$

$$\frac{\partial \Delta \mathcal{W}_0}{\partial e_0} = -(1 + \gamma)(e_0 - \kappa_0)\omega_1(e_0) - \frac{1 + \gamma}{2}(e_0 - \kappa_0)^2\omega'_1(e_0) \quad (\text{A.8})$$

$$\frac{\partial \Delta \mathcal{W}_1}{\partial e_1} = -(1 + \gamma)(e_1 - \kappa_1)\omega_0(e_1) - \frac{1 + \gamma}{2}(e_1 - \kappa_1)^2\omega'_0(e_1), \quad (\text{A.9})$$

where we know from the total differentiation of (15) and (17) that

$$\omega'_0(e_1) = -\frac{1}{2} \frac{\gamma(\kappa_1 - \kappa_0)}{A'(\omega_0)} < 0; \quad \omega'_1(e_0) = \frac{1}{2} \frac{\gamma(\kappa_1 - \kappa_0)}{A'(1 - \omega_1)} > 0. \quad (\text{A.10})$$

This implies $\frac{\partial \Delta \mathcal{W}_0}{\partial e_1} < 0$ and $\frac{\partial \Delta \mathcal{W}_0}{\partial e_0} < 0$. Country 0 loses from adjusting its own standard but benefits from concessions by its partner (a lowering of e_1). A similar reasoning shows $\frac{\partial \Delta \mathcal{W}_1}{\partial e_0} > 0$ and that $\frac{\partial \Delta \mathcal{W}_1}{\partial e_1} > 0$. Combining with the fact that $\Delta \mathcal{W}_0(e_0, e_1) > \Delta \mathcal{W}_1(e_0, e_1)$ for $e_0 - \kappa_0 = \kappa_1 - e_1$, it implies a pair of standards can only be compatible with mutual concessions if $e_0 - \kappa_0 > \kappa_1 - e_1$, that is, if the country with the productivity advantage makes a larger nominal adjustment to its standard.

To show country 0 goes beyond the standard chosen by the planner, we start from a situation that is compatible with mutual concessions and where $e_0 = e_0^P$, implying $e_1 > e_1^P$. At these standards,

$$\left. \frac{\partial \Delta \mathcal{W}_0}{\partial e_0} \right|_{e_0=e_0^P} = -\gamma(\kappa_1 - \kappa_0)\omega_1(e_0^P) - \frac{\gamma^2 \Delta \kappa^2}{2(1 + \gamma)}\omega'_1(e_0^P) = - \left. \frac{\partial \Delta \mathcal{W}_1}{\partial e_0} \right|_{e_0=e_0^P}.$$

A marginal change in e_0 from e_0^P is zero sum: it raises country 1's welfare by the same amount as it harms country 0. This transfer of welfare to country 1 would allow it to make additional concessions, that is, to decrease e_1 . We note

$$\frac{\partial \Delta \mathcal{W}_0}{\partial e_1} + \frac{\partial \Delta \mathcal{W}_1}{\partial e_1} = \left[(\kappa_1 - e_1) \frac{\omega'_0(e_1)}{2} - \omega_0(e_1) \right] [\gamma(\kappa_1 - \kappa_0) - (1 + \gamma)(\kappa_1 - e_1)],$$

which is negative for $e_1 > e_1^P$. Country 0 benefits from a decrease in e_1 to a greater degree than country 1 loses. This finding implies that with mutual concessions, country 0 sets $e_0 > e_0^P$ to induce country 1 to adjust its e_1 toward e_1^P .

A.3 Shallow vs. deep integration

We assume throughout that $\frac{1}{2} - \frac{\gamma}{2}\Delta\kappa^2 > 0$, that is, that some trade would take place at autarky standard with zero tariffs. Generalizing the model in the main text, we consider a tariff line consisting of a subset of goods $[0, \underline{\omega}]$ with $\underline{\omega} < 1$. Results from the main text are readily obtained by assessing the expressions below at $\underline{\omega} = 1$.

Planner. The planner maximizes (24) with respect to t_1 and e_1 given the definition of ω_0 in (20). If ω_0 is interior, the first-order conditions are

$$\frac{\partial \tilde{\mathcal{W}}^P}{\partial e_1} = -(1 + \gamma)(e_1 - \kappa_1)\underline{\omega} - \gamma(\kappa_1 - \kappa_0)\omega_0 + \frac{\partial \omega_0}{\partial e_1}t_1 = 0 \quad (\text{A.11})$$

$$\frac{\partial \tilde{\mathcal{W}}^P}{\partial t_1} = \frac{\partial \omega_0}{\partial t_1}t_1 = 0, \quad (\text{A.12})$$

where $\partial \omega_0 / \partial e_1 = -\gamma(\kappa_1 - \kappa_0)$ and $\partial \omega_0 / \partial t_1 = -1$. Whether ω_0 is interior or not, we obtain

$$\kappa_1 - \tilde{e}_1^P = \frac{\gamma}{1 + \gamma}(\kappa_1 - \kappa_0)\frac{\tilde{\omega}_0^P}{\underline{\omega}}.$$

We also obtain

$$\frac{\partial^2 \tilde{\mathcal{W}}^P}{\partial e_1^2} = -(1 + \gamma)\underline{\omega} + \gamma^2\Delta\kappa^2, \quad \frac{\partial^2 \tilde{\mathcal{W}}^P}{\partial t_1^2} = -1, \quad \frac{\partial^2 \tilde{\mathcal{W}}^P}{\partial e_1 \partial t_1} = 0$$

calling for the regularity condition (19). To determine $\tilde{\omega}_0^P$, we plug \tilde{e}_1^P into the definition of ω_0 and obtain (25).

We can easily show $\tilde{\omega}_0^P = \underline{\omega}$ if and only if

$$\underline{\omega} < \frac{1}{2} - \frac{\gamma}{2}\Delta\kappa^2 + \frac{\gamma^2}{1 + \gamma}\Delta\kappa^2. \quad (\text{A.13})$$

Non-cooperative. In a non-cooperative setting, country 1 maximizes its own welfare (21) with respect to e_1 and t_1 . The first-order conditions are

$$\frac{\partial \tilde{\mathcal{W}}^{NC}}{\partial e_1} = -(1 + \gamma)(e_1 - \kappa_1)\underline{\omega} + \frac{\partial \omega_0}{\partial e_1}t_1 = 0 \quad (\text{A.14})$$

$$\frac{\partial \tilde{\mathcal{W}}^{NC}}{\partial t_1} = \frac{\partial \omega_0}{\partial t_1}t_1 + \omega_0 = 0. \quad (\text{A.15})$$

The second derivatives are

$$\frac{\partial^2 \tilde{\mathcal{W}}^{NC}}{\partial e_1^2} = -(1 + \gamma)\underline{\omega}, \quad \frac{\partial^2 \tilde{\mathcal{W}}^{NC}}{\partial t_1^2} = -2, \quad \frac{\partial^2 \tilde{\mathcal{W}}^{NC}}{\partial t_1 \partial e_1} = -\gamma(\kappa_1 - \kappa_0),$$

and the Hessian is negative definite if and only if

$$2(1 + \gamma)\underline{\omega} - \gamma^2 \Delta \kappa^2 < 0,$$

a condition that is implied by condition (19). Combining the first-order condition gives (23).

Shallow integration: tariffs. In this case, we consider a first stage where country 1 selects a tariff t_1 to maximize the planner's objective (24) and a second stage where it sets e_1 given the choice of t_1 to maximize its own objective (21). By backward induction, we first determine the choice of e_1 in the second stage. We use the same first-order condition as for e_1 in the non-cooperative case:

$$\frac{\kappa_1 - e_1}{\kappa_1 - \kappa_0} = \frac{\gamma}{1 + \gamma} \frac{t_1}{\underline{\omega}} \quad (\text{A.16})$$

if ω_0 is interior. Plugging back in the definition of ω_0 , which cannot be larger than $\underline{\omega}$, gives the ω_0 that will prevail in the second stage as a function of the t_1 chosen in the first stage:

$$\omega_0 = \begin{cases} \underline{\omega} & \text{if } \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1 + \gamma} \frac{\Delta \kappa^2}{\underline{\omega}}} > t_1 \\ \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \left(1 - \frac{\gamma^2}{1 + \gamma} \frac{\Delta \kappa^2}{\underline{\omega}}\right) t_1 & \text{otherwise.} \end{cases}$$

The second-stage choice of e_1 is thus defined by (A.16) if $t_1 > \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1 + \gamma} \frac{\Delta \kappa^2}{\underline{\omega}}}$. If t_1 is lower, country 1 sets e_1 to ensure variety $\underline{\omega}$ is exported, that is, that it makes non-negative profits and sets $e_1 = \kappa_1$, its preferred standard if, even at this standard, variety $\tilde{\omega}$ is exported:

$$\tilde{e}_1^{NC}(t_1) = \begin{cases} \kappa_1 & \text{if } t_1 \leq \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega} \\ \kappa_1 + \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - t_1 - \underline{\omega}}{\gamma(\kappa_1 - \kappa_0)} & \text{if } \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega} \leq t_1 < \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1 + \gamma} \frac{\Delta \kappa^2}{\underline{\omega}}} \\ \kappa_1 - \frac{\gamma}{1 + \gamma} (\kappa_1 - \kappa_0) \frac{t_1}{\underline{\omega}} & \text{if } \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1 + \gamma} \frac{\Delta \kappa^2}{\underline{\omega}}} \leq t_1. \end{cases} \quad (\text{A.17})$$

In the first stage, we consider a choice of tariffs that maximizes (24) given the schedule $\tilde{e}_1^{NC}(t_1)$ in the second stage:

$$\tilde{W}^P(\tilde{e}_1^{NC}(t_1), t_1) = \begin{cases} - \int_0^{\underline{\omega}} \omega d\omega + \left(\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2\right) \underline{\omega} & \text{if } t_1 \leq \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega} \\ - \frac{1 + \gamma}{2} \frac{\left(\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - t_1 - \underline{\omega}\right)^2}{\gamma^2 \Delta \kappa^2} \underline{\omega} - \int_0^{\underline{\omega}} \omega d\omega + (t_1 + \underline{\omega}) \underline{\omega} & \text{if } \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega} \leq t_1 < \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1 + \gamma} \frac{\Delta \kappa^2}{\underline{\omega}}} \\ - \frac{1}{2} \frac{\gamma^2}{1 + \gamma} \frac{\Delta \kappa^2}{\underline{\omega}} t_1^2 - \int_0^{\omega_0} \omega d\omega + \omega_0(\omega_0 + t_1) & \text{if } t_1 \geq \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1 + \gamma} \frac{\Delta \kappa^2}{\underline{\omega}}}. \end{cases}$$

Differentiating with respect to t_1 ,

$$\frac{\partial \tilde{W}^P(\tilde{e}_1^{NC}(t_1), t_1)}{\partial t_1} = \begin{cases} 0 & \text{if } t_1 < \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega} \\ \underline{\omega} + \underline{\omega} \frac{(1+\gamma)(\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - t_1 - \underline{\omega})}{\gamma^2 \Delta \kappa^2} & \text{if } \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}}} > t_1 > \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega} \\ \frac{\gamma^2}{(1+\gamma)} \frac{\Delta \kappa^2}{\underline{\omega}} \left(\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 \right) - t_1 \left[1 + \frac{\gamma^2}{(1+\gamma)} \frac{\Delta \kappa^2}{\underline{\omega}} - \left(\frac{\gamma^2}{(1+\gamma)} \frac{\Delta \kappa^2}{\underline{\omega}} \right)^2 \right] & \text{if } t_1 > \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}}}, \end{cases}$$

where the third line uses that

$$\omega_0 = \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \left(1 - \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}} \right) t_1 \quad \frac{\partial \omega_0}{\partial t_1} = - \left(1 - \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}} \right).$$

Evaluating the second line at $t_1 = \frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}$ shows it is positive, implying choosing a t_1 in the first range is suboptimal. Evaluating the second line at $t_1 = \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}}}$ shows it is positive as long as

$$2\underline{\omega} - \frac{\gamma^2}{1+\gamma} \Delta \kappa^2 - \frac{1}{2} + \frac{\gamma}{2} \Delta \kappa^2 > 0, \quad (\text{A.18})$$

which holds under our regularity condition (19). The optimal choice of tariff under a shallow agreement \tilde{t}_1^{SH} is thus in the third range. Evaluating the third line at the lower cutoff $t_1 = \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}}}$, we can show it has the same sign as

$$\chi \equiv \underline{\omega} + \frac{\gamma^2}{1+\gamma} \Delta \kappa^2 - \frac{1}{2} + \frac{\gamma}{2} \Delta \kappa^2 - \left(\frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}} \right)^2 \underline{\omega}. \quad (\text{A.19})$$

- If χ is negative, the optimum is such that $\tilde{\omega}_0^{SH} = \underline{\omega} > \tilde{\omega}_0^{NC}$ and $\tilde{t}_1^{SH} = \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 - \underline{\omega}}{1 - \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}}} < \tilde{t}_1^{NC}$, where the inequality holds under our regularity condition (19). At this tariff, all varieties are traded under a shallow agreement, and (19) ensures (A.13) holds if $\chi < 0$, so that $\tilde{\omega}_0^{SH} = \tilde{\omega}_0^P = \underline{\omega}$. Equation (19) also ensures $\tilde{t}_1^{SH} < \underline{\omega}$, implying the standard under a shallow agreement is $\tilde{e}_1^{SH} > \tilde{e}_1^P$.
- If χ is positive, the optimum tariff and corresponding $\tilde{\omega}_0^{SH}$ are given by

$$\tilde{t}_1^{SH} = \frac{\frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}} \left(\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 \right)}{1 + \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}} - \left(\frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}} \right)^2} \quad \tilde{\omega}_0^{SH} = \frac{\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2}{1 + \frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}} - \left(\frac{\gamma^2}{1+\gamma} \frac{\Delta \kappa^2}{\underline{\omega}} \right)^2}$$

and $\tilde{\omega}_0^{SH} < \underline{\omega}$. Under our regularity condition (19), this implies $\tilde{t}_1^{SH} < \tilde{t}_1^{NC}$, that is, a lower tariff under a shallow agreement than with no cooperation, and that $\tilde{\omega}_0^{SH} < \tilde{\omega}_0^P$, that is, less trade than in the planner. It is also easy to check that $\tilde{t}_1^{SH} < \tilde{\omega}_0^P$, which implies $\tilde{e}_1^{SH} < \tilde{e}_1^P$.

Because $\tilde{e}_1^{NC} = \tilde{e}_1^{NC}(t_1^{NC})$ and $\tilde{e}_1^{SH} = \tilde{e}_1^{NC}(t_1^{SH})$, and because e_1 is lower for larger t_1 , we obtain that $\tilde{e}_1^{NC} < \tilde{e}_1^{SH}$ regardless of the sign of χ , that is, a larger adjustment of standards in the non-cooperative case

than in the shallow agreement.

Shallow integration: non-violation. Under non violation, we consider an initial standard $e_1^I > e_1^P$, that is, a standard that does not take into account the exporter's core competence as much as the planner would. Note this case holds regardless of whether we take the autarky standard ($e_1^I = \kappa_1$) or the non-cooperative standard that prevails with tariffs ($e_1^I = \tilde{e}_1^{NC}$) as a starting point. In a first stage, country 1 would set a maximum \bar{t}_1 that defines market access for country 0. The profits of firms from country 0 when selling to 1 are

$$\pi_0 = - \int_0^{\omega_0} \omega d\omega + \left[\frac{1}{2} - \frac{\gamma}{2} \Delta \kappa^2 + \gamma(\kappa_1 - \kappa_0)(\kappa_1 - e_1) - t_1 \right] \omega_0.$$

Concentrating on the case of an internal solution, this simplifies to

$$\pi_0 = - \int_0^{\omega_0} \omega d\omega + \omega_0^2 = \frac{1}{2} \omega_0^2$$

so that using ω_0 as a measure of market access captures both the volume of trade and the profits (or welfare) for 0.³⁶ In the second stage, country 1 maximizes

$$\begin{aligned} \max_{t_1, e_1} \mathcal{W}^{NC}(t_1, e_1) &= -\frac{1+\gamma}{2}(e_1 - \kappa_1)^2 + t_1 \omega_0(t_1, e_1) \\ \text{s.t.} \quad t_1 &\leq \bar{t}_1 \quad \text{and} \quad \pi_0 \geq \pi_0(\bar{t}_1, e_1^I), \end{aligned}$$

where the condition on profits can be rewritten as $\omega_0(t_1, e_1) \geq \omega_0(\bar{t}_1, e_1^I)$. As long as the bound \bar{t}_1 is below the non-cooperative choice t_1^{NC} , country 1 sets $t_1 = \bar{t}_1$ and country 1 chooses the closest e_1 to κ_1 compatible with $\omega_0(\bar{t}_1, e_1) \geq \omega_0(\bar{t}_1, e_1^I)$, that is, $e_1 = e_1^I$. Any non-negative tariff bound in the first stage will not generate enough market access, and country 1 will keep its initial standard. As long as tariffs cannot be negative, this finding is true even in the case of renegotiation in the sense of Bagwell and Staiger (2001).

A.4 Mutual Recognition

We define the standard set by country n on the firm from j as \check{e}_{jn} . Mutual recognition in the sense of Costinot (2008) implies the actual standard faced by firm j in any market is

$$e_{j0} = e_{j1} = \min\{\check{e}_{j0}, \check{e}_{j1}\} \equiv m_j,$$

³⁶As discussed in Grossman et al. (2021), and as is apparent if $\omega_0 = \underline{\omega}$, the concept of market access is rendered more complicated by the fact that no clear mapping exists between trade volume ($\underline{\omega}$) and welfare (π_0) in setups with vertical differentiation.

which is akin to having a firm-specific standard, denoted as m_j . For firms 0 and 1, the profits of selling abroad become, respectively,

$$\pi_{01} = -\pi_{10} = l_1(m_1) - l_0(m_0).$$

Contrary to our baseline, a firm faces effectively the same standard in both markets. This finding implies that if firm 1 is cheaper in market 1, it is also cheaper in market 0. Mutual recognition therefore implies all varieties are traded. In our baseline, all varieties may not be traded, because firms face different standards in both markets: if firm 1 is cheaper in market 1, firm 0 can still be cheaper in market 0 if the standard in 0 is closer to the core competence of firm 0. Mutual recognition thus fosters trade in our setup. Taking this connection into account in (27), the welfare of country 1 for a given variety becomes

$$\mathcal{W}_1 = \begin{cases} \mathcal{V}_1 - \frac{1}{2}\kappa_1^2 - l_1(m_1) + \kappa_1 m_0 & \text{if } \pi_{01} > 0 \\ \mathcal{V}_1 - \frac{1}{2}\kappa_1^2 - l_1(m_1) + \kappa_1 m_1 + \pi_{10} & \text{if } \pi_{10} > 0 \end{cases}$$

We now study the reaction function of country 1 given the choice of standards by country 0 (\check{e}_{00} and \check{e}_{10}).

Regardless of whether it imports, country 1 wants to set m_0 as high as possible. If country 1 imports, a high m_0 reduces the externality without affecting the price. If it exports, a higher m_0 means its competitor faces a higher standard, and firm 1 can set a higher price on the export market. This finding implies country 1 sets $\check{e}_{01} \geq \check{e}_{00}$ (the exact level of which is irrelevant) and that $m_0 = \check{e}_{00}$; that is, the standard faced by firm 0 in any market will be the one imposed by its home government.

The optimal choice of m_1 depends on the export status of country 1. Conditional on importing, country 1 sets m_1 as low as possible. A low m_1 makes its domestic firm more competitive, reduces the price that firm 0 can charge, but does not affect the externality, determined by m_0 . Country 1 thus sets \check{e}_{11} at the lowest possible level $\frac{\gamma}{1+\gamma}E^M$ if $\pi_{01}(m_0, \frac{\gamma}{1+\gamma}E^M) > 0$ or such that $\pi_{01}(m_0, \check{e}_{11}) = 0$ otherwise (such that it does not violate the condition that it imports). If it exports, country 1 would want to set $m_1 = \frac{1+2\gamma}{2(1+\gamma)}\kappa_1 \equiv m_1^X$, namely, a lower standard than it would in our non-cooperative baseline case. The reason is that by reducing the standard for their firm, which also applies to market 0 under mutual recognition, they can decrease their costs and increase their profits there without bearing the costs of lower standards. This decrease is only feasible if $m_1^X < \check{e}_{10}$ and if $\pi_{01}(m_0, m_1^X) \geq 0$, the condition for exporting. Otherwise, m_1 conditional on exporting is constrained by those conditions. To derive the full reaction function for \check{e}_{11} , we would need to consider that the export status depends on the choice of \check{e}_{11} . To simplify the analysis, we now only concentrate on the parts of the reaction function that are relevant for the Nash equilibrium.

Given our previous analysis, at a Nash equilibrium, $m_0 = \check{e}_{00}$ and $m_1 = \check{e}_{11}$; that is, we do not need to

look at \check{e}_{01} and \check{e}_{10} (as assumed in Costinot (2008)). Assume a Nash equilibrium with m_0 and m_1 such that country 0 exports and country 1 imports. Given the analysis above, it should have the following properties:

- $l_1(m_1) \geq l_0(m_0)$ with an equality if m_1 is above the minimum admissible value for standards. If country 0 exports, firm 0 should make non-negative profits, but the importer wants to squeeze the exporters' profits as much as possible.
- $m_0 > m_1$, which guarantees countries do not want to make small deviations from their standard to change their export status. When $l_1(m_1) = l_0(m_0)$, country 0 could marginally raise its m_0 and become an importer. In that case, it would import at the same costs a good generating more externality and has no incentive to do so. By the same reasoning, this condition prevents country 1 from marginally decreasing m_1 to become an exporter.
- $m_0 \leq m_0^X$. Country 0 wants to maximize its welfare given that it exports. It would never set an $m_0 > m_0^X$, because it could still export at m_0^X and generate higher welfare. If m_1 is very low, the condition $l_1(m_1) \geq l_0(m_0)$ may prevent the exporter from setting m_0^X , in which case, it would set the highest $m_0 < m_0^X$ compatible with the constraint.
- We finally need that country 1's welfare as an importer of a variety with m_0 is larger than its welfare if it were to become an exporter of that variety at the standard (m_1^X). For the m_0, m_1 combination that we consider, profits are zero. To become an exporter, firm 1 would need to set $m_1^X < m_1$, which, combined with the above conditions, would imply $m_0^X > m_0 > m_1 > m_1^X$. This is, however, a contradiction if $\kappa_1 > \kappa_0$, because m_n^X is proportional to κ_n . If $\kappa_1 > \kappa_0$, the conditions above are sufficient for a Nash equilibrium where 0 is the exporter. If $\kappa_1 < \kappa_0$, we need the additional condition that $\kappa_1(m_0 - m_1^X) - 2(l_0(m_0) - l_1(m_1^X)) > 0$ to ensure firm 1 would not become an exporter at m_1^X .

For goods where country n has a strong comparative advantage, all Nash equilibria are such that n exports, and the maximum standard at which it exports is $m_n^X < \kappa_n$. For goods where the lowest-cost producer is different for high standards than for low standards, some Nash equilibria can exist where the high- κ country is the exporter or where the low- κ country is the exporter. In any case, they would both choose a standard below their core competence. Under mutual recognition, all varieties are traded, and for each variety, the exporter sells at a standard below its core competence.

A.5 Proof of Lemma 1

Consider 3 countries, j , k , and l , such that $\kappa_j < \kappa_k < \kappa_l$. We want to show that if country n sells to j and to l , it also sells to k . If n sells to j and l , rewriting (28) shows that, for any n' ,

$$c_n - c_{n'} < \gamma(\kappa_{n'} - \kappa_n) \left(\frac{\kappa_{n'} + \kappa_n}{2} - \kappa_j \right) + f_{n'j} - f_{nj} \quad (\text{A.20})$$

$$c_n - c_{n'} < \gamma(\kappa_{n'} - \kappa_n) \left(\frac{\kappa_{n'} + \kappa_n}{2} - \kappa_l \right) + f_{n'l} - f_{nl}. \quad (\text{A.21})$$

For n and n' not in j , k , and l , it is immediate that if the two conditions above hold, they must also hold for a country k with $\kappa_j < \kappa_k < \kappa_l$. Assuming f is small enough is equivalent to saying the fixed cost of export does not change this result. Formally, it is straightforward to see that if $n' = j$ or $n' = l$ or $n = k$, the result also holds without additional assumptions on the size of f . If country n can sell at a lower cost than the domestic producer in j , despite the fixed costs of exports, it is an even stronger signal about its relative productivity relative to the producer from j . Similarly, if $n = k$, selling is easier because it does not pay the fixed costs of exports. If $n = j$ or $n = l$ or $n' = k$, the fixed costs of exports make proving the result more difficult. A sufficient condition is that f be smaller than γ times the square of the minimum distance between the κ 's of any two countries.

A.6 Transport costs

To simplify the exposition, we assume without loss of generality that $\Delta\kappa \equiv \kappa_1 - \kappa_0 > 0$; that is, country 1 has a stronger concern for the externality. If firm 0 faces costs t_{01} per unit exported to country 1, it exports if and only if (as in our analysis of tariffs in section 3.3.),

$$c_1 - c_0 - t_{01} + \frac{\gamma}{2}(e_1 - \kappa_1)^2 - \frac{\gamma}{2}(e_1 - \kappa_0)^2 \geq 0 \quad (\text{A.22})$$

or

$$c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2 - \gamma(e_1 - \kappa_1)\Delta\kappa \geq 0. \quad (\text{A.23})$$

The welfare of country 0 is

$$\mathcal{W}_0 = \mathcal{V}_0 - c_0 + \max \left\{ c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2 - \gamma(e_1 - \kappa_1)\Delta\kappa, 0 \right\}. \quad (\text{A.24})$$

In contrast to a tariff, a transport cost does not generate any revenue for country 1's welfare is as in our baseline:

$$\mathcal{W}_1 = \mathcal{V}_1 - c_1 - \frac{1+\gamma}{2}(e_1 - \kappa_1)^2. \quad (\text{A.25})$$

The solution of the model with transport costs is such that

- In the non cooperative equilibrium, $e_1 = \kappa_1$, $e_0 = \kappa_0$ and trade occurs when $c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2 > 0$.
- In the planner's solution, $e_1 = \frac{\kappa_1 + \gamma\kappa_0}{1+\gamma}$, $e_0 = \kappa_0$ and trade occurs when $c_1 - c_0 - t_{01} - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 > 0$.

Worldwide welfare in both situations is thus given by

$$\begin{aligned} \mathcal{V}_1 + \mathcal{V}_0 - c_0 - c_1 + \max\{c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2, 0\} & \quad \text{if non-cooperative} \\ \mathcal{V}_1 + \mathcal{V}_0 - c_0 - c_1 + \max\{c_1 - c_0 - t_{01} - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2, 0\} & \quad \text{under the planner.} \end{aligned} \quad (\text{A.26})$$

Computing the difference between the global welfare under the planner and under the non-cooperative equilibrium $\Delta\mathcal{W} = W_1(e_0^{*P}, e_1^{*P}) + W_0(e_0^{*P}, e_1^{*P}) - W_1(e_0^*, e_1^*) + W_0(e_0^*, e_1^*)$ shows that

$$\Delta\mathcal{W} = \begin{cases} \frac{1}{2}\frac{\gamma^2}{1+\gamma}\Delta\kappa^2 & \text{if } t_{01} \leq c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2 \\ c_1 - c_0 - t_{01} - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 & \text{if } c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2 \leq t_{01} < c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 \\ 0 & \text{if } c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 \leq t_{01}. \end{cases} \quad (\text{A.27})$$

Decreasing transport costs weakly raises $\Delta\mathcal{W}$, making the planner more beneficial from a world perspective. Similarly, standards in the planner's case weakly converge across countries when transport costs go down, from $e_1^{*P} - e_0^{*P} = \kappa_1 - \kappa_0$ when $t_{01} > c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2$ to $e_1^{*P} - e_0^{*P} = \frac{\kappa_1 - \kappa_0}{1+\gamma}$ when $t_{01} < c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2$.

A.7 Minimum standard vs. Pigouvian tax

In section 4.3.3, we consider a case where countries use a tax on the externality rather than a minimum standard. Under the assumptions of this section, the welfare of country 1 if it imports is:

$$\mathcal{W}_1(t_1) = \mathcal{V}_1 - \frac{1}{2}\kappa_1^2 + \kappa_1 e_{01} - c_1 - \frac{1}{2}e_{11}^2 - \frac{\gamma}{2}(e_{11} - \kappa_1)^2 + t_1(e_{11} - e_{01}), \quad (\text{A.28})$$

where e_{01} and e_{11} are functions of t_1 in line with (43). Similar to the national treatment, the externality depends on the good sold by firm 0 in country 1 (e_{01}). The costs that consumers face are the costs of the local firm (the exporter charges a price equal to that of the local firm in our Bertrand setup), which depends on e_{11} , including the cost due to the tax. Country 1 collects a revenue from firm 0 which decreases in e_{01} . Rearranging country

1's welfare gives (46). Additionally, using that $e_{11} - e_{01} = \frac{\gamma}{1+\gamma}(\kappa_1 - \kappa_0)$ and that $e_{11} - \kappa_1 = \frac{t_1 - \kappa_1}{1+\gamma}$, we obtain

$$\mathcal{W}_1(t_1) = \mathcal{V}_1 - c_1 - \frac{1}{2} \frac{(t_1 - \kappa_1)^2}{1 + \gamma} + \frac{\gamma}{1 + \gamma} (t_1 - \kappa_1)(\kappa_1 - \kappa_0).$$

Maximizing welfare with respect to t_1 under the constraints that country 0 exports gives equation (47).

In the non-cooperative case, and as trade takes place, the level of externality that firm 0 chooses in country 1 is

$$e_{01} = \begin{cases} \kappa_1 - \frac{(\frac{1}{2} + \gamma) \frac{\gamma}{1+\gamma} \Delta \kappa^2 - c_1 + c_0}{\gamma \Delta \kappa^2} (\kappa_1 - \kappa_0) & \text{if } \frac{1}{2} \frac{\gamma}{1+\gamma} \Delta \kappa^2 \leq c_1 - c_0 < \frac{\gamma}{1+\gamma} (\gamma + \frac{1}{2}) \Delta \kappa^2 \\ \kappa_1 & \text{if } c_1 - c_0 \geq \frac{\gamma}{1+\gamma} (\gamma + \frac{1}{2}) \Delta \kappa^2, \end{cases} \quad (\text{A.29})$$

which obtains by plugging the t_1 chosen by country 1 into the expression for e_{01} in (43). If $c_1 - c_0 > \frac{\gamma}{1+\gamma} (\gamma + \frac{1}{2}) \Delta \kappa^2$, $e_{01} = \kappa_1$ and $e_{11} = \kappa_1 + \frac{\gamma}{1+\gamma} (\kappa_1 - \kappa_0)$. Country 1 sets a t_1 such that the standard at which it consumes is the same as in autarky ($e_{01} = \kappa_1$). At the tax level that induces firm 0 to pick this e , the firm from country 1 sets an even higher e_{11} . On the one hand, this finding implies higher costs of production for the domestic firm, meaning country 1 would obtain less of the surplus from trade. Because its good generates less externality, however, it would need to pay less taxes than what the exporter does, allowing country 1 to capture some of the surplus. Combining these two effects shows that if $c_1 - c_0 > \frac{\gamma}{1+\gamma} (\gamma + \frac{1}{2}) \Delta \kappa^2$,

$$\mathcal{W}_1(\kappa_1 + \gamma(\kappa_1 - \kappa_0)) = \mathcal{V}_1 - c_1 + \frac{1}{2} \frac{\gamma^2}{1 + \gamma} \Delta \kappa^2,$$

which is larger than \mathcal{W}_1^A , the welfare under non-cooperation when country 1 uses standards.

If $\frac{1}{2} \frac{\gamma}{1+\gamma} \Delta \kappa^2 < c_1 - c_0 < \frac{\gamma}{1+\gamma} (\gamma + \frac{1}{2}) \Delta \kappa^2$, $t_1 = \tilde{t}_1$. At the bottom of the range, when $c_1 - c_0 = \frac{1}{2} \frac{\gamma}{1+\gamma} \Delta \kappa^2$, $e_{01} = \frac{\kappa_1 + \gamma \kappa_0}{1 + \gamma}$, which corresponds to the standard chosen by the planner in our baseline. As $c_1 - c_0$ increases, the standard is closer to the core competence of country 1 and equal to it if $c_1 - c_0 \geq \frac{\gamma}{1+\gamma} (\gamma + \frac{1}{2}) \Delta \kappa^2$.

Furthermore,

$$\tilde{t}_1 - \kappa_1 = \frac{1 + \gamma}{\gamma(\kappa_1 - \kappa_0)} \left(c_1 - c_0 - \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta \kappa^2 \right).$$

Plugging in welfare gives

$$\mathcal{W}_1(\tilde{t}_1) = \mathcal{V}_1 - c_1 + \frac{1}{2} \frac{1 + \gamma}{\gamma^2 \Delta \kappa^2} \left(c_1 - c_0 - \frac{1}{2} \frac{\gamma}{1 + \gamma} \Delta \kappa^2 \right) \left[\frac{\gamma^2 \Delta \kappa^2}{1 + \gamma} - \left(c_1 - c_0 - \frac{\gamma}{1 + \gamma} \left(\frac{1}{2} + \gamma \right) \Delta \kappa^2 \right) \right],$$

which is larger than \mathcal{W}_1^A under the parameter range where $t_1 = \tilde{t}_1$.

As long as $c_1 - c_0 > \frac{1}{2} \frac{\gamma}{1+\gamma} \Delta \kappa^2$, the welfare of country 1 is higher than a minimum standard when it imposes a tax on externalities. The reason is akin to the relaxation of the national treatment: the fact that the

exporter and the domestic firm would choose different levels of externality generation allows the importer to capture part of the exporter's rent.

From a global welfare perspective, we now ask whether, in a non-cooperative setup, $\mathcal{W}_0 + \mathcal{W}_1$ is higher or lower with standards. Because country 0 will choose $e_{00} = \kappa_0$ regardless of what happens in country 1. World welfare boils down to

$$\mathcal{W}_1(t_1) + \mathcal{V}_0 - c_0 + \pi_{01}(t_1) = \mathcal{V}_1 - c_1 + \mathcal{V}_0 - c_0 - \frac{1}{2}(e_{01} - \kappa_1)^2 - \frac{\gamma}{2}(e_{01} - \kappa_0)^2,$$

where we add (A.28) with (44). From the planner's perspective, the only e that matters is the one at which the good is actually sold. e_{11} only serves to transfer surplus across countries, but $\frac{1}{2}(e_{01} - \kappa_1)^2$ captures the mismatch in terms of preferences for country 1, and $\frac{\gamma}{2}(e_{01} - \kappa_0)^2$ captures the additional costs for the exporter of producing at a different e than its core competence.

The partial adjustment of the standard at which goods are produced and sold (e_{01} , see (A.29)) ensures that when $\frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 < c_1 - c_0 < \frac{\gamma}{1+\gamma}(\gamma + \frac{1}{2})\Delta\kappa^2$, a non-cooperative setting with taxes attains a higher world welfare than a non-cooperative setting with minimum standards (our baseline). Out of this range, $e_{01} = e_1^{NC} = \kappa_1$, and both cases yield the same world welfare. As in our baseline, however, a non-cooperative setting with taxes yields too little adjustment of standards compared with a planner—hence the need for a planner setting domestic taxes.

Choosing a tax, the planner would want to set $e_{01} = \frac{\kappa_1 + \gamma\kappa_0}{1+\gamma}$ as in our baseline with standards. It would thus set $t_1 = \kappa_1$, also implying $e_{11} = \kappa_1$. The profits of the exporter are

$$\pi_{01} = c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2,$$

and trade would take place under the same condition as the planner in our baseline. Letting the planner choose on a standard or on a tax is equivalent in our setup.

A.8 Variable quantities

We denote q quantities and t , a consumption tax, and focus on the open-economy case. Consumer utility over the polluting good is given by an increasing, concave, and twice continuously differentiable function $V(q)$. The welfare function of the exporting country is now

$$\mathcal{W}_0 = I_0 + V(q_0) - l_0(e_0)q_0(e_0, t_0) - \kappa_0 E_M q_0 + \kappa_0 e_0 q_0 + \pi_{01}(e_1, t_1),$$

where

$$\pi_{01}(e_1, t_1) = (l_1(e_1) - l_0(e_1))q_1(e_1, t_1).$$

We now show the consumption standards in the non-cooperative equilibrium are equal to those in our baseline in the presence of a consumption tax. It can be seen by taking the FOC wrt e_0 :

$$(V'(q_0) - l_0 - \kappa_0 E_M + \kappa_0 e_0) \frac{\partial q_0}{\partial e_0} + \left(\kappa_0 - \frac{\partial l_0}{\partial e_0} \right) q_0 = 0. \quad (\text{A.30})$$

This expression shows that without a second instrument, the consumption standard would be chosen to mitigate both the externality (second term on the LHS) and the monopolistic distortion (first term on the LHS), where $V'(q_0)$ is the monopoly price and $-l_0 - \kappa_0 E_M + \kappa_0 e_0$ is the marginal *social* cost of production.

When introducing a consumption tax t_0 , the FOC wrt t_0 leads to

$$(V'(q_0) - l_0 - \kappa_0 E_M + \kappa_0 e_0) \frac{\partial q_0}{\partial t_0} = 0$$

so that the first term on the LHS of (A.30) cancels out. As in our baseline model with unit consumption, the choice of the standard boils down to reducing the externality. The second term on the LHS of (A.30) is proportional to $\kappa_0 - e_0$, leading back to the same consumption standard. Likewise, we find $e_1 = \kappa_1$. Trade occurs when the firm from country 0 finds exporting to be profitable, that is, $c_1 - c_0 > \frac{\gamma}{2} (\Delta\kappa)^2$. Under cooperation, we find again $e_1^P = \frac{\kappa_1 + \gamma\kappa_0}{1 + \gamma}$ and $e_0^P = \kappa_0$. Trade occurs when and only when $c_1 - c_0 > \frac{\gamma}{2} \left(\frac{\Delta\kappa}{1 + \gamma} \right)^2$.

Turning to the non-monotonicity of the gains from deep integration, we proceed as follows: we compare the gains from trade between different country pairs holding κ_1 fixed and varying κ_0 . Our aim is to study the variation of $\frac{\partial[\mathcal{W}^{NC} - \mathcal{W}^P]}{\partial \kappa_0}$, where $\mathcal{W} = \mathcal{W}_0 + \mathcal{W}_1$ denotes world welfare. Using the envelope theorem for country 0 and noting \mathcal{W}_1 doesn't depend on κ_0 , we get that

$$\frac{\partial \mathcal{W}^{NC}}{\partial \kappa_0} = (e_0^{NC} - E_M) q_0^{NC} + \frac{\partial \pi_{01}(e_1^{NC}, t_1^{NC})}{\partial \kappa_0}$$

where

$$\pi_{01}^{NC} = \left(c_1 - c_0 - \frac{\gamma}{2} \Delta\kappa^2 \right) q_1^{NC} \Rightarrow \frac{\partial \pi_{01}(e_1^{NC}, t_1^{NC})}{\partial \kappa_0} = \gamma \Delta\kappa q_1^{NC},$$

and where $\Delta\kappa = \kappa_1 - \kappa_0$. The implication above is obtained observing that q_1^{NC} does not depend on κ_0 . The reason is that q_1^{NC} is defined implicitly through the first-order condition with respect to t_1 . Likewise, the envelope theorem now applied to world welfare leads to

$$\frac{\partial \mathcal{W}^P}{\partial \kappa_0} = (e_0^P - E_M) q_0^P + \gamma (e_1^P - \kappa_0) q_1^P.$$

Because $e_0^P = e_0^{NC}$ and $q_0^{NC} = q_0^P$, we obtain that

$$\frac{\partial [\mathcal{W}^{NC} - \mathcal{W}^P]}{\partial \kappa_0} = \gamma(e_1^{NC} - \kappa_0)q_1^{NC} - \gamma(e_1^P - \kappa_0)q_1^P.$$

Now, note q_1^P is defined implicitly through

$$V'(q_1^P) - l_0(e_1^P) - \kappa_1 E_M + \kappa_1 e_1^P = 0,$$

whereas q_1^{NC} is defined through

$$V'(q_1^{NC}) - l_1(e_1^{NC}) - \kappa_1 E_M + \kappa_1 e_1^{NC} = 0.$$

It is useful to define $f(\kappa_0, \kappa_1) := l_0(e_1^P) + \kappa_1 E_M - \kappa_1 e_1^P$ where $f(\kappa_1, \kappa_1) = l_1(e_1^{NC}) + \kappa_1 E_M - \kappa_1 e_1^{NC}$. We note $\kappa_0 \rightarrow f(\kappa_0, \kappa_1)$ reaches a minimum³⁷ for $\kappa_0 = \kappa_1$ and so $V'(q_1^P) \geq V'(q_1^{NC})$. Because V is concave, we obtain that $q_1^P < q_1^{NC}$. Because we also know $|e_1^P - \kappa_0| < |e_1^{NC} - \kappa_0|$, we can conclude on the variations of the welfare gap: for $\kappa_0 < \kappa_1$, we have that $0 < e_1^P - \kappa_0 < e_1^{NC} - \kappa_0$, so $\frac{\partial [\mathcal{W}^{NC} - \mathcal{W}^P]}{\partial \kappa_0} > 0$, and it reaches 0, its maximum, at $\kappa_0 = \kappa_1$. Increasing κ_0 further, we get that $0 > e_1^P - \kappa_0 > e_1^{NC} - \kappa_0$, in which case $\frac{\partial [\mathcal{W}^{NC} - \mathcal{W}^P]}{\partial \kappa_0} < 0$. Compared with our baseline model, when both the equilibrium and the planner solution feature trade, regulatory divergence raises the gains from trade. The maximum is reached at the same point, that is, when $c_1 - c_0 = \frac{\gamma}{2} (\Delta\kappa)^2$. For larger differences in regulatory preferences, we enter a regime where the planner's solution still features trade while the non-cooperative outcome is autarky. In that case, the gap between the non-cooperative and the cooperative welfare is given by:

$$\frac{\partial [\mathcal{W}_0^A + \mathcal{W}_1^A - \mathcal{W}^P]}{\partial \kappa_0} = (\kappa_0 - E_M) (q_0^A - q_0^P) - \gamma(e_1^P - \kappa_0)q_1^P \equiv -\gamma(e_1^P - \kappa_0)q_1^P.$$

Thus, when $\kappa_0 > \kappa_1$ and $c_1 - c_0 < \frac{\gamma}{2} (\Delta\kappa)^2$, a further increase in κ_0 increases the regulatory gap. In turn, $\mathcal{W}^A - \mathcal{W}^P$ also increases implying that the welfare gap $|\mathcal{W}^A - \mathcal{W}^P|$ decreases in absolute terms. The gap keeps decreasing until the planner solution no longer features trade. In that case, again, $\mathcal{W}_0^{NC} + \mathcal{W}_1^{NC} = \mathcal{W}^P$. The prediction of our baseline model carries through, but the shape of the welfare gap as a function of regulatory preferences is no longer linear in $\Delta\kappa^2$ as it depends on the curvature of the inverse demand $V'(\cdot)$.

³⁷The reason is that $f(\kappa_0, \kappa_1) = \frac{\gamma}{2}(e_1^P - \kappa_0)^2 + \frac{1}{2}e_1^{P2} + \kappa_1 E_M - \kappa_1 e_1^P$ with $e_1^P = \frac{\kappa_1 + \gamma\kappa_0}{1 + \gamma}$ implies $\frac{\partial f}{\partial \kappa_0}(\kappa_0, \kappa_1) = Cst * (\kappa_0 - \kappa_1)$, where Cst is a positive constant.

A.9 A more general cost function

We here show that the second part of Proposition 2 still obtains under the more general cost function outlined in section 4.4. The difference in welfare between the planner and non-cooperative case if trade occurs in both cases is

$$\kappa_1(e_1^P - \bar{e}_1) - \varphi(e_1^P, \bar{e}_0) + \varphi(\bar{e}_1, \bar{e}_0). \quad (\text{A.31})$$

For $\kappa_1 = \kappa_0$, $\bar{e}_1 = \bar{e}_0$, the condition for trade is satisfied and the welfare under a planner is the same as in the non-cooperative case. Starting from that, we consider an increase in the distance between the κ 's as moving κ_0 away from κ_1 or moving \bar{e}_0 away from \bar{e}_1 . Differentiating equation (A.31) with respect to κ_0 ,

$$\underbrace{\kappa_1 \frac{\partial e_1^P}{\partial \kappa_0} - \varphi_e(e_1^P, \bar{e}_0) \frac{\partial e_1^P}{\partial \kappa_0}}_{=0} + \underbrace{\frac{\partial \bar{e}_0}{\partial \kappa_0}}_{>0} (\varphi_{\bar{e}}(\bar{e}_1, \bar{e}_0) - \varphi_{\bar{e}}(e_1^P, \bar{e}_0)),$$

where $\varphi_{\bar{e}}$ denotes the derivative with respect to the second argument (the core competence). If trade occurs under a planner but not in the non-cooperative case, the gain in world welfare from a planner is

$$\kappa_1(e_1^P - \bar{e}_1) + \varphi(\bar{e}_1, \bar{e}_1) + c_1 - c_0 - \varphi(e_1^P, \bar{e}_0).$$

Differentiating with respect to κ_0 gives

$$-\frac{\partial \bar{e}_0}{\kappa_0} \varphi_{\bar{e}}(e_1^P, \bar{e}_0).$$

Increasing the distance between κ_0 and κ_1 in this case necessarily decreases the difference in welfare, because $\varphi_{\bar{e}}(e_1^P, \bar{e}_0)$ is positive for $\kappa_0 > \kappa_1$ (increasing the distance between κ 's means $d\kappa_0 > 0$) and negative for $\kappa_0 < \kappa_1$ ($d\kappa_0 < 0$).

Consider first the case where $\varphi_{e\bar{e}}$ is always positive, as in our baseline. The difference in welfare increases until the difference in κ is such that no trade occurs in the non-cooperative case. For high-enough differences in κ , $\varphi_{e\bar{e}} > 0$ implies trade will in fact no longer take place in the non-cooperative case. Thereafter, a further increase in the distance between κ 's decreases the difference in welfare until it hits zero when no trade occurs even in the planner's case.

Even if $\varphi_{e\bar{e}}$ is not always negative, the results of Proposition 2 remain valid. By definition of the core competence, because $\varphi_{\bar{e}}(e, \bar{e}) \geq 0$ if $\bar{e} \geq e$, it must be that $\varphi_{e\bar{e}} > 0$ when e is sufficiently close to \bar{e} .³⁸ Starting from $\kappa_0 = \kappa_1$ and increasing the distance between the two, an increase first occurs in the difference in welfare between the planner and the non-cooperative case. If, at some point in the range where (A.31) holds, $\varphi_{e\bar{e}}$

³⁸Note we can accommodate a case where the derivative is infinite at $e = \bar{e}$ and $\varphi_{e\bar{e}} < 0$ after that point, in which case, the difference in welfare will jump from zero to a peak for a very small difference in κ 's and decrease after that point.

becomes negative on that range, the difference in welfare will peak at that point and then decrease but remain strictly positive until no trade occurs in the non-cooperative case. If that condition hits, a further decrease will occur in the difference in welfare after that point, which reaches zero when no trade occurs in the planner. The pattern whereby a planner experiences no gain for $\kappa_1 = \kappa_0$, that this difference first increases with the distance between κ_1 and κ_0 and then decreases again is thus robust.