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A simple theory of deep trade integration*†

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

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1 Introduction

In the last decades, the focus of trade policy has shifted from tariff to non-tariff barriers. Recent trade agreements like the Comprehensive and Progressive Agreement for TransPacific Partnership (CPTPP) or the EU-Canada Comprehensive Economic Trade Agreement (CETA) involve countries whose tariff barriers are already low. These agreements have at their core the dismantling of non-tariff barriers, raising a set of new issues from health and environment protection to the establishment of a "level-playing field", which run deep in the popular debate. In contrast to these recent developments, most of the literature in international trade considers trade liberalization as a reduction in fixed or variable trade costs (e.g. tariffs or tariff equivalent of non-tariff barriers), which is almost by definition positive from a social planner's perspective. What appears as non-tariff barriers may also reflect a country's legitimate concern for negative externalities, as recognized by Article XX of the General Agreement on Tariffs and Trade (GATT). To the extent that these concerns vary across countries, the welfare effects of a deeper trade integration become more subtle. Our paper provides a simple theory to analyze the welfare implications of removing non-tariff barriers in the presence of externalities.

We consider a simple trade model with Ricardian differences in technology and two goods, where one of the goods generates a local consumption externality.[1] All consumers buy one unit of the externality-generating good and each country sets a product standard to address the externality. The standard specifies the maximum level of externality that the consumption of a unit of the good can generate (*vertical* standards).[2] We assume that countries not only differ in their technology but also in their regulatory preferences, or "values",[3] meaning that the local consumption externality enters the utility function with a country-specific weight. Cross-country differences in regulatory preferences imply that optimal standards in autarky are heterogeneous across countries. Countries may choose different standards in an open economy as long as they remain non-discriminatory (national treatment).

On the production side, each country has one national producer of the externality-generating good. The 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.[4] We assume that producing a good at a more stringent standard is always more costly, and that firms have a cost advantage at 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 that productivity differences in the externality-generating good immediately translate into comparative advantages. In

[1] To fix ideas, think of the local pollution resulting from driving cars (e.g. NOX emissions, noise, etc). Cars 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 4.4.1.

[2] We use "standards" and "regulations" interchangeably, i.e. we do not think of standards as voluntary but as prescribed by the legislator. In our car example, a product standard would set a level of emissions of NOX allowed per km driven.

[3] The term has been used repeatedly by the EU trade commissioner Cecilia Malmström, see for instance http://trade.ec.europa.eu/doclib/docs/2015/october/tradoc_153846.pdf In that spirit, our set-up also applies to countries' pure differences in preferences such as different conceptions about animal welfare.

[4] In 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.

an open economy, the producers of the externality-generating good compete à la Bertrand on each market. Our joint assumptions of Bertrand competition and inelastic demand imply that we reach an efficient outcome in autarky with standards as the unique policy instrument. Thus, our set-up allows 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, as 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 they are 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. A planner, maximizing world welfare, internalizes this when setting the importer's standard and chooses some degree of convergence in standards (*deep trade integration*) as long as there is trade, making it more beneficial. In this setup, deep trade integration raises world welfare the most if countries have moderate differences in regulatory preferences. Absent any divergence in regulatory preferences, the non-cooperative equilibrium is efficient, so deep trade integration only generates small welfare gains between countries that have different but similar regulatory preferences, as their standards should be close in the non-cooperative equilibrium already. If countries differ too much on the other hand, even a deep integration does not make trade profitable and the planner would not seek a convergence in standards.

In our baseline setup, and in the absence of transfers, the planner's solution only benefits the country exporting the externality-generating good, but harms its importer. We extend our setup to allow for many varieties of the externality-generating good and show that an agreement with mutual concessions on standards can be Pareto improving compared to a non-cooperative situation. With intra-industry trade, each country exports and imports some varieties of the polluting good, and benefits from an adjustment of its partner's standard through its exports.If both countries are symmetric, there is only intra-industry trade in the externality-generating good and both countries benefit as much from the planner's solution. If not, some inter-industry trade takes place, and the planner's solution would benefit the net importer of externality-generating goods less, if at all. We derive a mutual concession scheme such that both countries have the same gain from a deep trade agreement and show that the depth of an agreement is stronger with large intra-industry differences in productivity, but weaker with large inter-industry differences in productivity.

In a multi-country version of our setup, we show that, with sufficient heterogeneity in regulatory preferences, a planner would not choose a worldwide harmonization of standards. Instead, a planner would choose to form regulatory blocs around the countries with the strongest comparative advantage 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 towards those 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.

We provide a number of extensions and discussions of our setup. In a version of our model that accommodates trade costs, we show that a decrease in transport costs or tariffs raises the difference in world welfare between the planner's solution and the non-cooperative one, effectively raising the gains from cooperation. We also develop a version of our model where the externality occurs at the production and not at the consumption stage, and show that the results markedly differ from our baseline. In line with the pollution haven literature, and for a given technological efficiency, countries with a lower regulatory preference export the externality-generating good. Contrary to our setup, differences in regulatory preferences can therefore create trade if a country with a comparative advantage in the externality-generating good has a weak regulatory preference. In the presence of a production externality, all countries buy from the country with the highest productivity adjusted for regulatory preferences and there is no need to form blocs.

While highly stylized, our model fits well with a number of first-order features of recent trade policy debates. Taken together, our results suggest that deep trade integration should follow reductions in tariffs and transport costs, 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.[5] Our theory implies that deep trade agreements should occur between countries that do not differ too much in values and have substantial intra-industry trade in goods that generate consumption externalities. In fact, Mattoo et al. (2020) suggest that trade agreements are deeper between developed countries, and less so between developing countries. We also think of our analysis as applying to issues of consumer safety that have been at the center of popular debates on trade agreements, such as hormone-fed beef, chlorine-washed chicken or the concentration of bacteria allowed in cheese. There is ample evidence of differences in perception across countries and resulting differences in standards for such goods (see e.g. Bradford (2020), chap. 6). While 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. This alternative interpretation of our model squares well with some of the public concerns about recent trade negotiations.

Related Literature First and foremost, a large strand of the literature is concerned with regulatory protectionism (Baldwin (2000), Fischer and Serra (2000)), e.g, the use of non-trade instruments as a protectionist device when the use of tariffs is already restricted through cooperative trade policy (Copeland, 1990). Considering a neoclassic environment, Bagwell and Staiger (2001) showed that a shallow trade agreement - understood as a commitment on tariffs and market access - remains enough to reach efficiency. This is not necessarily true under imperfect competition: under monopolistic compe-

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

tition, Campolmi et al. (2021) show that it is possible for countries to manipulate their terms-of-trade even under market access commitment; Mei (2021) calibrates a multi-country Krugman (1980) model and finds significant welfare losses from the implementation of the WTO non-discriminatory principle compared to the first-best outcome. Reviewing the literature, Maggi and Ossa (2021) conclude that *"a deep agreement involving explicit disciplines on regulation is needed to implement an efficient outcome"* (p.34). Closer to the current paper is the delocation model à la Venables considered by Grossman et al. (2021). In their set-up, the conclusion of Maggi and Ossa applies when they augment their model with consumption externalities. The present paper builds a very streamlined model that is able to replicate this insight and takes it as a starting point. We then leverage its tractability to ask a set of novel questions. First, which countries should engage in international regulatory cooperation? Are the gains from deep trade integration maximized for country pairs that share "the same values"? Second, when can these gains be reaped without international transfers? Third, can regulatory blocs be optimal in a many-country setting? Key to answering these questions is the interplay between countries' comparative advantage and their idiosyncratic preferences over domestic policies, an aspect which has not received much attention in the literature.

Our set-up is deliberately stylized. The equilibrium standard results from a trade-off between profit-shifting and a consumption externality as in the Cournot duopoly considered by Costinot (2008).[6] Differently from Costinot (2008) however, it assumes Bertrand competition and unit consumption. We do so in order to isolate regulatory divergence as the only source of global inefficiency. When countries' regulatory preferences are aligned, the trade equilibrium replicates the optimum. Allowing 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. Similar considerations would apply to alternative imperfectly competitive environments with horizontal product differentiation. Non-cooperative policies in a model *à la* Krugman would add a terms-of-trade externality (Gros (1987) in the one-sector case), or a delocation externality (Venables (1987), Ossa (2011) in the two-sector case). Standards would then be used to manipulate these international externalities even when regulatory preferences are perfectly aligned. In all these alternative settings, we would need to augment the set of policy instruments to reach the first-best.

This paper also speaks to the empirical literature which investigates how the divergence in product standards or norms act as an impediment to trade flows. For instance, Fontagné et al. (2015) show that SPS measures decrease trade flows both at the intensive and extensive margin. Conversely, several papers show that deep trade integration involving standard harmonization increases trade flows (Disdier et al. (2015) and Schmidt and Steingress (2018)). These patterns are consistent with the view that regulatory heterogeneity can be modelled as a non-tariff barrier. This is the strategy followed in quantitative assessments of deep trade integration efforts (e.g. Egger et al. (2015) for TTIP or Dhingra et al. (2017) on Brexit). Our simple model resonates with this intuition where trade costs and regulatory divergence act in a similar

[6]Other rationales behind consumption standards include coping with the excessive entry of low-quality firms (Macedoni and Weinberger (2018)) and asymmetric information (Disdier et al. (2018)).

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.[7]

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 non-cooperative and with 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.

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 mass[8] of identical agents with quasi-linear preferences over 2 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. We assume throughout that consumers' willingness to pay V is high enough so 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:

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

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

[7] This echoes with 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)*

[8] Country size asymmetries are analyzed in 4.2.

pure differences in preferences, i.e. different perceptions of how bad pollution is, but can also capture differences in the true effect of this pollution across countries, e.g. 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.[9] 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 that $I_n > p_n$ to guarantee that 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 on its market.[10] A lower E is thus equivalent to the imposition of stricter standards, or more stringent regulations. To simplify the notation and the interpretation, we assume that there is a maximum level of externality that the good can generate, called E^M. We define $e = E^M - E$ as the stringency of the standard, i.e. the difference between the permitted externality and the maximum level of externality.

Production. Each agent in n supplies inelastically 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.

There is a single firm 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 $\bar{e}_n$, i.e. 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:

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

The first term, c_n is a country-specific (in)efficiency parameter. The second term, $\frac{1}{2}e^2$, captures the fact that it is more costly to produce a less polluting good. The last term implies that deviating from the core competence comes with strictly positive costs, 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 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.[11] Note that

[9] Our model is isomorphic to a setup where the externality is on the future self of an agent i.e. 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, this gives governments 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).

[10] We discuss other instruments, such as a Pigouvian tax in section 4.4.2.

[11] Consider a firm with a high core competence deciding to produce at a lower standard. To benefit from lower costs, it will in practice need to use lower quality inputs, less expensive machines, etc. If this adjustment process is costless, the third term is zero, but it will equivalently be zero if the firm moves to a standard above its core competence, as the costs of producing at a higher standard would be fully captured by the second term in (2). There is thus no clear rationale for why the third term in (2) should be biased towards higher vs lower standards.

it does not mean that reducing e below the core competence increases costs. In fact, we assume that the second term always dominates and that it is more expensive to produce a high e good regardless of the firm's core competence, i.e. that $\frac{\partial l(e;\bar{e}_n,c_n)}{\partial e} > 0$ for all e and 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 will become clear 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.

Autarky and core competence. In autarky, the government in country n first sets the minimum e_n allowed on its market, which is the standard at which the firm produces under the assumptions above. After the government's choice, the monopoly in n chooses first its core competence $\bar{e}_n$, and second the price at which it sells. 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: $p_n = V$. The monopolist thus makes profits $V - l(e_n; c_n, \bar{e}_n)$, where we assume that V is large enough for the firm to generate profits for some $\bar{e}_n$. When choosing its core competence, the firm minimizes its costs of production by setting $e_n = \bar{e}_n$.
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 agent. 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:

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

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:

$$\mathcal{W}_n^A = \mathcal{V}_n - c_n. \tag{3}$$

From now on, we assume in our baseline model that the core competence of firms are fixed at their autarky level. While this can be thought of as a short-run assumption, it captures the well-known difficulty of adjusting inputs and technology to a different standard. In section 4.2, we show that this assumption, perhaps surprisingly, is innocuous.

2.2 Open economy

We now assume that goods can be traded costlessly across borders and that the numeraire good is produced in each country, pinning down wages to one. Since 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. 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 on market n:

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

as 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:

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

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 there is a discrepancy 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 of firms, 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. It is worth pointing out that importing good X in this framework does not generate any surplus[12] as the full surplus from trade is captured by the exporter in Bertrand competition. The above formulas easily extend to country 1.

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:

$$e_n^* = \kappa_n. \tag{6}$$

[12]Note that $-p(e_0) + \pi_{00}(e_0) = -\frac{\gamma}{2}(e_0 - \kappa_0)^2$, which is independent of which firm sells in country 0. If country 0 imports good X from country 1, $\pi_{00} = 0$ and $p_0(e_0) = l_0(e_0)$, while if 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.

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 $c_0 < c_1$, i.e. 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, i.e. if:

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

where $\Delta\kappa^2 \equiv (\kappa_1 - \kappa_0)^2$ is the distance between the $\kappa's$ of the two countries. The cost difference measures the strength of country 0's comparative advantage in good X,[13] and is related to the efficiency gains from trade. Since 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, it is not the consumption externality *per se* which 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:

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

and the planner's choice of standards is:

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

If the comparative advantage of country 0 is strong enough compared 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 towards 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

[13] Due 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.

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. *A cooperative equilibrium features 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 cooperative and the non-cooperative equilibria is non-monotonic in the distance between countries' regulatory preferences. The gains from cooperation are lower for country pairs which 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). 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) compared to the differences in the perception about the externality. The second part of the Proposition compares different pairs of countries which 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 it is optimal not to trade good X.

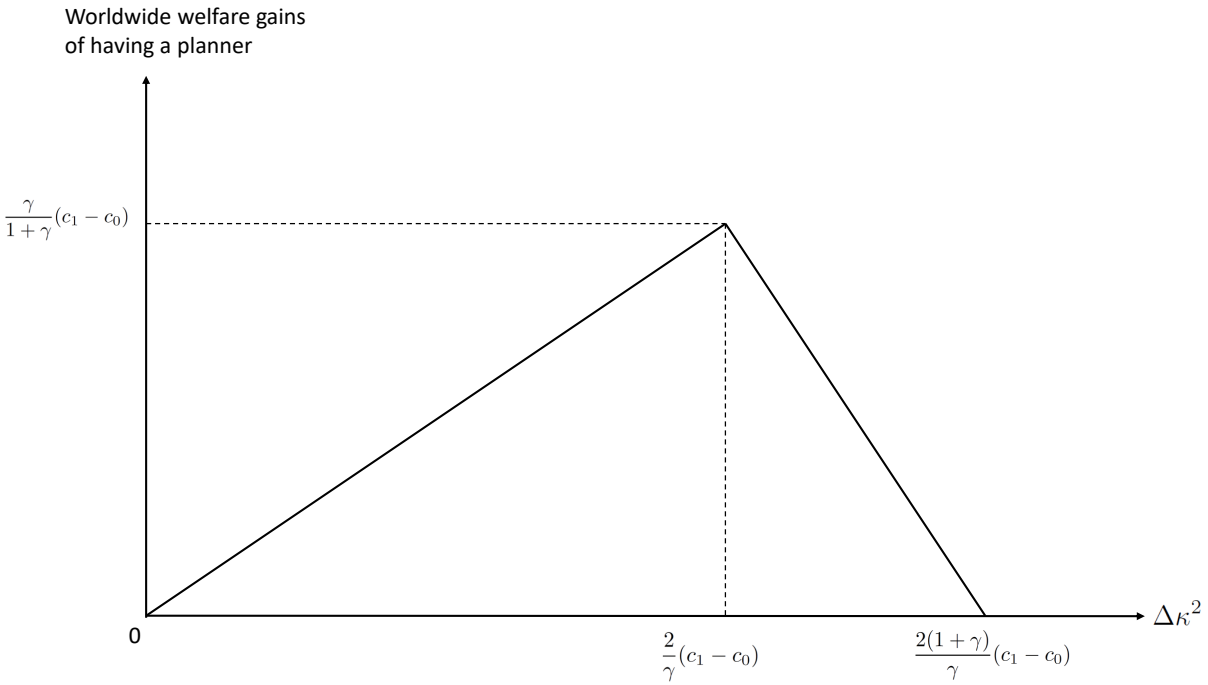
3 Trade agreements with many varieties

We now extend our baseline model to allow for the existence of a continuum of varieties that generate an externality. This extension serves two main purposes. First, and in line with Dornbusch et al. (1979)'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, generating additional insights. Second, it sets the stage for deep trade agreements 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.

3.1 Model with a continuum of varieties.

Setup There is a mass one of externality-generating varieties of good X, indexed by $\omega \in [0, 1]$. A country n has the same perception of the externality regardless of which variety generates it (κ_n does not depend on ω), and applies a unique

Figure 1: Welfare gains of coordination



The vertical axis shows the difference between the worldwide welfare between the planner's solution and the non-cooperative one. 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 there is trade in the planner's solution but not in the non-cooperative one.

minimum standard e_n to all goods. 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 goods such that country 1 has a relatively better technology for goods with a higher index. Formally, we define $A(\omega) = c_0(\omega) - c_1(\omega)$, with $A'(\omega) > 0$. We also assume that $A(0) < 0 < A(1)$ to guarantee that each country has a comparative advantage (compared to the numeraire) in at least some of the externality generating goods. Within goods, the structure is the same 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, which is the profit maximizing choice in autarky.

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) be positive. Country 0 exports to country 1 all goods such that:

$$-A(\omega) + \frac{\gamma}{2}(e_1 - \kappa_1)^2 - \frac{\gamma}{2}(e_1 - \kappa_0)^2 \geq 0, \tag{10}$$

while country 1 exports to 0 all goods with:

$$A(\omega) + \frac{\gamma}{2}(e_0 - \kappa_0)^2 - \frac{\gamma}{2}(e_0 - \kappa_1)^2 \geq 0. \tag{11}$$

We define the variety ω_0 as the one for which the firm in 0 is indifferent between selling in 1 or not ((10) holds with equality), so that all varieties in $[0, \omega_0]$ are exported from 0 to 1. We define the variety $1 - \omega_1$ as the one for which the firm in 1 is indifferent between selling in 0 or not, so that all varieties in $[1 - \omega_1, 1]$ are exported from 1 to 0. As in our baseline, whether a firm exports a good to a destination only depends on the standard in that destination.

With this setup, the welfare of country 0 and 1 are respectively given by:

$$\mathcal{W}_0 = \mathcal{V}_0 - E[c_0] - \frac{1+\gamma}{2}(e_0 - \kappa_0)^2 - \int_0^{\omega_0(e_1)} A(\omega) d\omega + \omega_0(e_1) \left[\frac{\gamma}{2}(e_1 - \kappa_1)^2 - \frac{\gamma}{2}(e_1 - \kappa_0)^2 \right] \tag{12}$$

$$\mathcal{W}_1 = \mathcal{V}_1 - E[c_1] - \frac{1+\gamma}{2}(e_1 - \kappa_1)^2 + \int_{1-\omega_1(e_0)}^1 A(\omega) d\omega + \omega_1(e_0) \left[\frac{\gamma}{2}(e_0 - \kappa_0)^2 - \frac{\gamma}{2}(e_0 - \kappa_1)^2 \right], \tag{13}$$

where the profits on foreign markets now consist of the profits of the firms producing all exported varieties.

Non-cooperative equilibrium. In a non-cooperative situation, e_n has no impact on the profits made by firms from n on their foreign market. The choice of standard by each country is as in autarky: $e_n = \kappa_n$. Plugging the equilibrium standards in (11) and (10) leads back to (7) for each good ω. In other words, for each variety, trade will happen when a

country's cost advantage offsets the regulatory mismatch. In particular, we have:

$$-A(\omega_0^*) = A(1-\omega_1^*) = \frac{\gamma}{2}\Delta\kappa^2. \tag{14}$$

if $-A(0) < \frac{\gamma}{2}\Delta\kappa^2$ and if $A(1) < \frac{\gamma}{2}\Delta\kappa^2$, i.e. if the solutions are interior. We assume that it is the case to simplify the exposition. The introduction of a continuum of varieties restores industry-level trade responses at the intensive margin through the variations of the cutoffs ω_0 and ω_1. Equation (14) is the counterpart to the condition for trade in the non-cooperative case of our baseline (7) and replicates the insights of Proposition 1, defining a set of varieties for which the technological advantage dominates the difference in perception $\Delta\kappa^2$. Both ω_0^* and ω_1^* increase as the differences between regulatory preferences across countries ($\Delta\kappa^2$) shrink, meaning that countries trade more if they have more similar κ's. Contrary to our baseline, differences in technology are not characterized by a single number ($c_0 - c_1$) but by a function ($A(\omega)$), making the comparative statics with respect to technology slightly richer. If countries have a symmetric technology, in the sense that $A(\omega) = -A(1-\omega)$ for all ω, it is immediate that $\omega_0^* = \omega_1^*$ and that each country exports the same mass of varieties to the other. We consider two movements of the A function from such a symmetric case. One is a *rotation* of A, such that the technology remains symmetric but that $|A(\omega)|$ increases for all ω's. This means that there are stronger intra-industry differences in productivity across varieties of good X between countries, giving rise to more trade (ω_0^* and ω_1^* increase). A second is a downward shift of the A function. $A(\omega) < -A(1-\omega)$ for all ω. In this case, the inter-industry differences in productivity between varieties of good X and the numeraire are larger for country 0. This creates a *comparative advantage* in good X and implies that $\omega_0^* > \omega_1^*$, i.e. country 0 exports relatively more of good X than country 1.

Planner. The planner maximizes the sum of welfare and takes into account the impact on the profits of the other countries. The first order conditions for e_0 and e_1 are:[14]

$$e_0^{*P} = \kappa_0 + \frac{\gamma}{1+\gamma}\omega_1^{*P}(\kappa_1 - \kappa_0), \qquad e_1^{*P} = \kappa_1 + \frac{\gamma}{1+\gamma}\omega_0^{*P}(\kappa_0 - \kappa_1). \tag{15}$$

The optimal standard of country 0 from the planner's perspective is a weighted average of its own perception of the externality and of that of country 1. The more it imports from country 1, the more country 0 has an effect on country 1's profits and the more country 0 should take κ_1 into account from the planner's perspective. A similar logic holds for country 1. In the case of two-way trade, the planner now makes both countries adjust their standard toward the other partner, the extent of the adjustment depending on how many varieties of good X they import. Equation (15) also nests our baseline trade model. When $\omega_0 = 1$ and $\omega_1 = 0$, country 0 only exports and country 1 only imports, in which case we replicate the planner's choice in (9). Plugging the optimal standards (15) back in (10) and (11), we obtain the following

[14] We describe in the appendix 6.2 the conditions on the technology that are needed for the second order conditions to hold.

definitions of ω_n^{*P} if they are interior:

$$\begin{aligned} -A(\omega_0^{*P}) &= \frac{\gamma}{2}\Delta\kappa^2\left(1-\frac{2\gamma}{1+\gamma}\omega_0^{*P}\right) \\ A(1-\omega_1^{*P}) &= \frac{\gamma}{2}\Delta\kappa^2\left(1-\frac{2\gamma}{1+\gamma}\omega_1^{*P}\right) \end{aligned}$$

Comparing the above equations to (14), shows that $\omega_0^{*P} \geq \omega_0^*$ and $\omega_1^{*P} \geq \omega_1^*$, with at least one strict inequality. More goods are traded under the planner than under the non-cooperative equilibrium. As in the non-cooperative equilibrium, the trade openness in the planner's case (ω_0^{*P} and ω_1^{*P}) is higher for country pairs with a lower $\Delta\kappa^2$. Similarly, changes in technology differences ($A(\omega)$) have a qualitatively similar effect as in the non-cooperative case. From equation (15), and in contrast to the non-cooperative case, the degree of openeness matters for the determination of consumption standards. As long as at least ω_0^{*P} or ω_1^{*P} is strictly positive, consumption standards are more similar across countries under the planner's case, replicating the insights of Proposition 2.1 with a continuum of varieties. Such a convergence in standards is thus stronger for country pairs with a smaller $\Delta\kappa^2$ and the larger the differences in productivity within good X across countries (the *rotation* described above). If country 0 has a comparative advantage in good X, $\omega_0^{*P} > \omega_1^{*P}$, and country 1 adjusts its standard relatively more as it imports relatively more of good X.

If both countries have the same perception of externalities ($\Delta\kappa^2 = 0$), the planner's solution boils down to the non-cooperative one and moving to a planner's solution does not generate any welfare gain. On the other hand, if $\Delta\kappa^2$ is so high that $\omega_0^{*P} = \omega_1^{*P} = 0$, there is no trade in the non-cooperative and in the planner's solution and the planner does again not generate any welfare gain. For country pairs with intermediate ranges of $\Delta\kappa^2$, however, the planner generates an aggregate welfare gain compared to the non-cooperative situation. In line with Proposition 2.2 in our baseline, the difference in world welfare between the planner's solution and the non-cooperative remains non-monotonic in $\Delta\kappa^2$, with small gains for small and for large differences in κ. The exact shape of this difference depends on the function A that parameterizes technological differences.

3.2 Trade agreements.

In our baseline model, implementing the planner's solution would require to force concessions on the importer so that the exporter is able to increase its profits further. A mutually beneficial trade agreement would therefore require international transfers. Instead, in a setting with intra-industry trade - or inter-varieties trade - a trade agreement through mutual concessions may be feasible without transfers. In the following, we assume without loss of generality that $\kappa_0 < \kappa_1$.

Pareto-improving coordination without transfers: mutual concessions. To derive the conditions under which mutual concessions are feasible, we explore the welfare changes for small changes in standards. A change in standard is referred to as a concession to n by country i if e_i moves away from κ_i and closer to κ_n. From the previous section, totally

differentiating (12) and (13) w.r.t. e_0 and e_1 leads to

$$d\mathcal{W}_0 = -\gamma\left(\kappa_1 - \kappa_0\right)\omega_0 de_1 - (1+\gamma)(e_0 - \kappa_0)de_0 \tag{16}$$

$$d\mathcal{W}_1 = \gamma(\kappa_1 - \kappa_0)\omega_1 de_0 + (1+\gamma)\left(\kappa_1 - e_1\right)de_1 \tag{17}$$

The above equation shows that country 0 will gain from a standard concession of country 1, i.e. $de_1 < 0$, to an extent that is proportional to its export intensity ω_0. However, making a concession, i.e. $de_0 > 0$, it deviates from its first-best standard, leading to a sub-optimal externality level. When standards are set in a Nash fashion, the first term on the RHS of the above equations is null and we verify that each country keeps its autarky standard $e_i = \kappa_i$. Thus, inspecting local changes in standards around the non-cooperative equilibrium leads to

$$d\mathcal{W}_0 + d\mathcal{W}_1 = \gamma(\kappa_1 - \kappa_0)\omega_1 de_0 - \gamma\left(\kappa_1 - \kappa_0\right)\omega_0 de_1$$

If a country changes its standard towards its trade partner's, it remains indifferent at the margin but its trade partner's welfare increases. This opens-up the possibility of a Pareto-improvement without international transfers through mutual concessions. The above equations show that, starting from the non-cooperative equilibrium, a necessary and sufficient condition is to have intra-industry trade at the non-cooperative equilibrium, i.e. $\omega_0\omega_1 > 0$, If instead $\omega_0\omega_1 = 0$, then, very much like in our baseline one-way trade model, a non-importing country would not be able to make concessions.

The mutual concession path. We explore the implementation of a mutual concessions path in terms of welfare, i.e. a gradual change in standard setting such that $d\mathcal{W}_0 = d\mathcal{W}_1$. In this event, the increment in standard from the non-cooperative equilibrium would have to verify $\omega_0 de_1 + \omega_1 de_0 = 0$. In words, the country which is most open to trade - thanks to its technological advantage - is the one that must undertake the largest change in its standard. Intuitively, this is because it benefits more from a concession of its trading partner as total producer surplus is proportional to the range of products that it exports. More generally, mutual concessions obtained at any (e_0, e_1) must verify $d\mathcal{W}_0 = d\mathcal{W}_1$, i.e.:

$$-\left[\gamma\left(\kappa_1 - \kappa_0\right)\omega_0(e_1) + (1+\gamma)\left(\kappa_1 - e_1\right)\right]de_1 = \left[(1+\gamma)(e_0 - \kappa_0) + \gamma(\kappa_1 - \kappa_0)\omega_1(e_0)\right]de_0 \tag{18}$$

so that we can define a mutual concession path $e_1 = f(e_0)$ implicitly by

$$f'(e_0) = -\frac{(1+\gamma)(e_0 - \kappa_0) + \gamma(\kappa_1 - \kappa_0)\omega_1(e_0)}{\gamma\left(\kappa_1 - \kappa_0\right)\omega_0(f(e_0)) + (1+\gamma)\left(\kappa_1 - f(e_0)\right)}$$

with $f(\kappa_0) = \kappa_1$.

That these changes in standards are welfare increasing for each country impose the following constraints. Using (16),

(17), and the fact that $d\mathcal{W}_0|_{e_1=f(e_0)} > 0$ and $d\mathcal{W}_1|_{e_1=f(e_0)} > 0$ along the mutual concessoin path $f(.)$ implies

$$\frac{\gamma(\kappa_1-\kappa_0)\omega_1}{(1+\gamma)(\kappa_1-e_1)} > -f'(e_0) > \frac{(1+\gamma)(e_0-\kappa_0)}{\gamma(\kappa_1-\kappa_0)\omega_0},$$

Mutual concessions will occur until $d\mathcal{W}_0|_{e_1=f(e_0)} = d\mathcal{W}_1|_{e_1=f(e_0)} = 0$ or, equivalently,

$$\frac{\gamma(\kappa_1-\kappa_0)\omega_1(e_0^{MC})}{(1+\gamma)\left(\kappa_1-f(e_0^{MC})\right)} = -f'(e_0^{MC}) = \frac{(1+\gamma)(e_0^{MC}-\kappa_0)}{\gamma(\kappa_1-\kappa_0)\omega_0(f(e_0^{MC}))} \tag{19}$$

which pins down implicitly the optimal mutual concession standards e_0^{MC} and $e_1^{MC} = f(e_0^{MC})$. We can compare the mutual concession outcome to the unconstrained solution of the planner: the marginal impact of a change in standards on the world social welfare is given by

$$d\mathcal{W}_0 + d\mathcal{W}_1 = \left(\gamma(\kappa_1-\kappa_0)\omega_1(e_0) - (1+\gamma)(e_0-\kappa_0)\right)de_0 + \left((1+\gamma)(\kappa_1-e_1) - \gamma(\kappa_1-\kappa_0)\right)\omega_0(e_1)de_1 \tag{20}$$

Using (19), evaluating the above equation at the mutual concession outcome implies that, for $de_0 de_1 > 0$, both terms on the RHS have the same sign.[15] This implies that. as soon as the mutual concession outcome is not first-best, welfare can be increased by either increasing or decreasing both standards. Instead, the mutual concessions outcome was reached starting from the non cooperative equilibrium by increasing the lower standard and decreasing the other.

From the perspective of the planner, under mutual concessions, one country *overshoots* in the sense that it changes its standard more than it should: its imports generate too much consumption externalities compared to the gains in market access it grants to its trade partner. Instead, the latter does not adjust its standard enough. Technological differences determine which country overshoots as we illustrate in the next section.

A closed-form example We investigate the case of a linear technology profile: $A(\omega) = \omega - 1/2 - \delta$ with $-1/2 < \delta < 1/2$. Without loss of generality, we consider in what follows that country 0 has a technological advantage, i.e. $\delta > 0$.

It is easily verified that, given (e_0, e_1), this technological advantage increases (resp. decreases) the set of products exported by 0 (resp. by 1) :

$$\omega_0 \equiv \frac{1}{2} + \delta - \gamma\frac{\Delta\kappa^2}{2} + \gamma\Delta\kappa(\kappa_1 - e_1); \quad \omega_1 \equiv \frac{1}{2} - \delta - \gamma\frac{\Delta\kappa^2}{2} + \gamma\Delta\kappa(e_0 - \kappa_0).$$

[15] This result is obtained using that, at the mutual concession outcome:

$$\frac{\gamma(\kappa_1-\kappa_0)\omega_1(e_0^{MC})}{(1+\gamma)(e_0^{MC}-\kappa_0)} = \frac{(1+\gamma)\left(\kappa_1-f(e_0^{MC})\right)}{\gamma(\kappa_1-\kappa_0)\omega_0(f(e_0^{MC}))}.$$

The optimal standards are given by

$$e_0^P = \kappa_0 + \frac{\gamma\Delta\kappa}{k'}(k-\delta)\,; \quad e_1^P = \kappa_1 - \frac{\gamma\Delta\kappa}{k'}(k+\delta)$$

where we denote by $k = \frac{1}{2} - \gamma\frac{\Delta\kappa^2}{2}$, $\tilde{k} = 1+\gamma+\gamma^2\Delta\kappa^2$ and $k' = 1+\gamma-\gamma^2\Delta\kappa^2$ three positive constants which depend on regulatory preferences only. Starting from the non-cooperative equilibrium, the planner finds it optimal for the country with a technological disadvantage to adjust more its standard: $\kappa_1 - e_1^P > e_0^P - \kappa_0$. This implies opening its market relatively more to foreign firms and allowing thereby larger gains from trade.

The mutual concession path $e_1 = f(e_0)$ is obtained by integrating each side of (18) from κ_i to e_i:[16]

$$\gamma\Delta\kappa(k+\delta)(\kappa_1 - e_1) + \frac{1}{2}\tilde{k}(\kappa_1 - e_1)^2 = \gamma\Delta\kappa(k-\delta)(e_0 - \kappa_0) + \frac{1}{2}\tilde{k}(e_0 - \kappa_0)^2$$

The above expression shows on the contrary that the country with a technological advantage needs to make a stronger adjustment with respect to its standard: $\kappa_1 - e_1 < e_0 - \kappa_0$. This adjustment compensates for the larger profits its firms make following an identical change in standards.

From a social welfare perspective, the optimal standards that can be reached under mutual concessions, $\left(e_0^{MC}, e_1^{MC}\right)$ where $e_1^{MC} = f(e_0^{MC})$, are obtained using (20). Rearranging, we get:

$$-k'\left(\left(e_1^{MC} - e_1^P\right)f'(e_0^{MC}) + \left(e_0^P - e_0^{MC}\right)\right) = 0$$

Since $\kappa_1 - e_1^{MC} < e_0^{MC} - \kappa_0$ and since $\kappa_1 - e_1^P > e_0^P - \kappa_0$, the above expression implies $e_1^{MC} - e_1^P > 0 > e_0^P - e_0^{MC}$. Thus, under mutual concessions, the country with a technlogical advantage makes larger concessions than optimal.

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 that firms need to pay a fixed cost of export F, which can be arbitrarily small, before competing in prices in a foreign market. Since it is

[16] Equivalently, the mutual concession path is given by

$$f(e_0) = \kappa_1 + \gamma\Delta\kappa\frac{(k+\delta)}{\tilde{k}} - \sqrt{\left(\gamma\Delta\kappa\frac{(k-\delta)}{\tilde{k}} + (e_0 - \kappa_0)\right)^2 + 4k\delta\left(\frac{\gamma\Delta\kappa}{\tilde{k}}\right)^2}$$

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 on 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:

$$c_n + \frac{\gamma}{2}(e_i - \kappa_n)^2 + F_{ni} = \min_{n'} \left\{ c_{n'} + \frac{\gamma}{2}(e_i - \kappa_{n'})^2 + F_{n'i} \right\}. \tag{21}$$

We define the indicator $\mathbb{1}_{ni}$ as taking value 1 if firm n exports to i, i.e. if (21) 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, as 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:

$$\mathcal{W}_n = \mathcal{V}_n - \frac{1}{2}(e_n - \kappa_n)^2 - p(e_n) + \pi_{nn}(e_n) + \sum_{i \neq n} \pi_{ni}(e_i) = \mathcal{V}_n - \frac{1+\gamma}{2}(e_n - \kappa_n)^2 + \sum_{i \neq n} \mathbb{1}_{ni} \times (l_i(e_i) - l_n(e_i) - F) \tag{22}$$

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 or not. The only difference compared 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 (22) and sets, as in autarky:[17]

$$e_n^* = \kappa_n. \tag{23}$$

Plugging back in (21) shows that, in the non-cooperative equilibrium, the firm from country n sells good X in i if and only if:

$$c_n + \frac{\gamma}{2}\Delta\kappa_{ni}^2 + F_{ni} = \min_{n'} \left\{ c_{n'} + \frac{\gamma}{2}\Delta\kappa_{n'i}^2 + F_{n'i} \right\}, \tag{24}$$

[17] The 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.

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 (24) that, if country n has a higher efficiency (lower c_n), it sells to a weakly larger set of countries, and that 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.*

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

$$\sum_i \left[\mathcal{V}_i - c_i - \frac{1}{2}(e_i - \kappa_i)^2 - \min_n \left\{ c_n + \frac{\gamma}{2}(e_i - \kappa_n)^2 + F_{ni} \right\} \right] \tag{25}$$

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

$$e_i^{*P} = \frac{\kappa_i + \gamma\kappa_n}{1+\gamma}. \tag{26}$$

The planner again takes into account that any country which buys from i has an impact on n's profits when setting its consumption standard. Plugging back in (25) shows that, in the planner's solution, country i buys from country n if and only if:

$$c_n + \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa_{ni}^2 + F_{ni} = \min_{n'} \left\{ c_{n'} + \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa_{n'i}^2 + F_{n'i} \right\}. \tag{27}$$

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 there is sufficient dispersion in κ's and in c across countries, (24) and (27) further imply that there is more than one exporter, the case we concentrate on in the following. Using (24), (26) and (27), we can derive the following results:

Proposition 3. *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 (24) and (27). These 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 3 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 (23). In the planner's solution, (26) shows that all countries importing from a given exporter set a standard that is a weighted average between their own κ_i and that of the exporter κ_n. This implies that 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. This is the sense in which we talk of the formation of regulatory blocs, centered around the most productive countries.

These results echo the literature on regional and bilateral trade agreement. Krugman (1991) or 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 is a natural set of countries 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 that firms choose their core competence in autarky, but can not adjust it once trade opens up. We now assume that 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 that our baseline results still hold; second we make use of this extension to analyse 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 on both markets. As in the baseline model, the firm with the lowest marginal costs in market n, i.e. 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 on 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 on both markets in equilibrium. It can charge at most a price $c_1 + \frac{1}{2}e_1^2$ on 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, i.e. if its profits on 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 compared 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 on 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 as the exporter can extract the whole surplus due to Bertrand competition. This 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:

$$\mathcal{W}_0(e_0, e_1) = \mathcal{V}_0 - c_0 - \frac{1}{2}(e_0 - \kappa_0)^2 + \max\{0, \Delta\pi(e_0, e_1)\} \tag{28}$$

thereby setting:

$$e_0^{*C} = \frac{\kappa_0 + \frac{\gamma}{2}\kappa_1}{1 + \frac{\gamma}{2}}. \tag{29}$$

If it exports, country 0 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, but also that of the importing country. This reduces country 0's domestic welfare compared to autarky, as its consumption standard is less in line with its perception of the externality, but allows country 0 to reap higher profits on market 1. If firm 0 sells to country 1, the welfare of country 0 is given by:

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

Country 0 only sets e_0 if it is preferable to export to country 1 than to sell only domestically, i.e. 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 both countries.[18] 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 it less costly to sell at the two different standards and makes it more likely that trade happens.

Even with endogenous core competence, it is worth noting that 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 towards the κ of the exporter and to set:

$$e_0^{*CP} = \frac{\left(1+\frac{\gamma}{2}\right)\kappa_0 + \frac{\gamma}{2}\kappa_1}{1+\gamma} \qquad e_1^{*CP} = \frac{\left(1+\frac{\gamma}{2}\right)\kappa_1 + \frac{\gamma}{2}\kappa_0}{1+\gamma}$$

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 the mass of consumers in country n. While 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 $M_0 l(e_0; c_0, \bar{e}_0) +$

[18] The objectives of the firm in 0 and of country 0 are different: the firm only maximizes its profits while the country also takes into account the impact of a mismatch between e_0 and κ_0 as reflected in (28). Country 0 sets $e_0 = e_0^{*C}$ only if, at this standard, its welfare is higher than in autarky, i.e. if $-\frac{1}{2}(e_0^{*C} - \kappa_0)^2 + \Delta\pi\left(e_0^{*C}, \kappa_1\right) > 0$, 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, it means that it does not want to export. It is immediate from (28) that, if the country does not want to export at $e_0 = \kappa_0$, the firm also does not want to export.

$M_1 l(e_1; c_0, \bar{e}_0)$ and picks:

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

i.e. it chooses as core competence a weighted average of the two countries standards, with weights reflecting their relative size. The change in profits if the firm exports compared to not exporting becomes:

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

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:

$$e_0^{*C} = \frac{\kappa_0 + \gamma\frac{M_1}{M_0+M_1}\kappa_1}{1 + \gamma\frac{M_1}{M_0+M_1}}. \tag{30}$$

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, i.e. if:

$$c_1 - c_0 > \frac{1}{2}\frac{\gamma\frac{M_0}{M_0+M_1}}{1 + \gamma\frac{M_1}{M_0+M_1}}\Delta\kappa^2. \tag{31}$$

If the above condition does not hold, there is no trade in the non-cooperative equilibrium and country 0 sets its standard at the autarky level $e_0 = \kappa_0$. Equations (30) and (31) 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 for example Bradford (2020) for illustrations).

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

$$e_0^{*CP} = \frac{\left(1 + \frac{\gamma M_0}{M_0+M_1}\right)\kappa_0 + \frac{\gamma M_1}{M_0+M_1}\kappa_1}{1+\gamma} \qquad e_1^{*CP} = \frac{\left(1 + \frac{\gamma M_1}{M_0+M_1}\right)\kappa_1 + \frac{\gamma M_0}{M_0+M_1}\kappa_0}{1+\gamma} \tag{32}$$

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

$$c_1 - c_0 > \frac{\gamma}{2}\frac{M_0}{M_0 + M_1}\frac{\Delta\kappa^2}{1+\gamma}. \tag{33}$$

Comparing (31) and (33), and using (32) immediately shows that Propositions 1 and 2 also hold with asymmetric sizes.

4.3 Trade costs

We now extend our baseline model to allow for tariffs or transport costs, which we think of as given when countries choose their standards. From the perspective of the firm from n, this 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. Since the local producer in country 1 is not affected by a tariff or transport cost, 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 the appendix.

Transport costs. In the case of transport costs, t_{01} is not associated with any additional revenue from the perspective of country 1.[19] Country 1's welfare when it imports is the same as in our baseline analysis:

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

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, i.e. if:

$$c_1 - c_0 > t_{01} + \frac{\gamma}{2}\Delta\kappa^2. \tag{34}$$

This 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 chosen by the planner 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:

$$e_0^{*P} - e_1^{*P} = \begin{cases} \kappa_0 - \kappa_1 & \text{if } c_1 - c_0 - t_{01} < \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 \\ \frac{\kappa_0 - \kappa_1}{1+\gamma} & \text{otherwise.} \end{cases} \tag{35}$$

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

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 the appendix, 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.[20]

Equation (34) makes explicit that 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 that differences in standards are too high in a non-cooperative equilibrium and reducing them is equivalent to a reduction in transport costs. However, equation (35) 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).

Tariffs. If t_{01} is a tariff, it generates a revenue for country 1 when it imports, in which case it has welfare:

$$\mathcal{W}_1 = \mathcal{V}_1 - c_1 - \frac{1+\gamma}{2}(e_1 - \kappa_1)^2 + t_{01}.$$

The case of the planner's problem with a tariff is particularly simple as a tariff amounts to a transfer from country 0 to country 1, leaving global welfare unaffected. The planner's solution is thus identical with or without tariffs. We focus in the following on the case where trade occurs in the planner's solution, i.e. where $c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 > 0$.

In the non-cooperative problem, tariff revenues give rise to a discontinuity between the welfare that country 1 obtains in autarky and the one it obtains when importing good X. Under some parameter constellations, tariffs provide the means for country 1 to appropriate some of the surplus from trade, which is fully captured by firm 0 in the baseline. When maximizing its welfare, country 1 takes into account that it can only import - and obtain a tariff revenue - if $\pi_{01} \geq 0$. It may thus be optimal to deviate from its autarky standard and take a step towards country 0 if it makes firm 0 export. To simplify the exposition, we assume without loss of generality that $\kappa_1 > \kappa_0$. If it imports, country 1 picks $e_1^* = \kappa_1$ if $\pi_{01}(\kappa_1) \geq 0$. If $\pi_{01}(\kappa_1) < 0$, it chooses the largest e_1^* that makes the participation constraint of the exporter binding. Since the profits of the exporter are decreasing in t_{01}, country 1 needs to pick a lower e_1^* the higher the t_{01} if it wants to import. We concentrate in the following on the case where $t_{01} < \tilde{t}_{01} \equiv c_1 - c_0 + \frac{\gamma}{2}\frac{\gamma-1}{1+\gamma}\Delta\kappa^2$, which guarantees that $e_1^{*P} \leq e_1^*(t_{01}) \leq \kappa_1$, with at least one strict inequality.[21] Since a tariff makes the importer capture some of the surplus from trade, it internalizes the impact of its choice of consumption standard on global efficiency. While it does fully so if $t_{01} = \tilde{t}_{01}$, replicating the planner's solution,[22] a shallow trade liberalization makes the importer appropriate less of

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

[21] We show in the appendix that, if tariffs were endogenously chosen, country 1 would never choose a higher tariff. It therefore seems meaningful to limit our study of the consequences of an exogenous tariff reduction to this parameter range.

[22] This comes from the fact that, for global efficiency, the importer is the only one that should change its standard compared to the non-cooperative

the surplus, and consider global efficiency less strongly. The non-cooperative equilibrium becomes less efficient with a decrease in tariffs, implying that the difference between global welfare under a planner and in a non-cooperative situation ($\Delta\mathcal{W}$) is decreasing in tariffs.

Proposition 4. *A shallow trade liberalization (decrease in tariffs or transport costs) raises the gains from international regulatory cooperation.*

4.4 Discussion

4.4.1 Externality

A key ingredient of our setup is that consumption generates externalities, over which countries have heterogeneous perceptions. We here discuss the role and definition of these externalities, and how they compare to externalities that occur through the production process.

Externality vs. preferences. 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 buying 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, i.e. if $p_{in} - \kappa_i e_{in} = \min_{n'}\{p_{in'} - \kappa_i e_{in'}\}$, with p_{in} the price charged by firm n in i and e_{in} 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 $p_{in} - l_n(e_{in})$. It chooses $e_{in} = \frac{\kappa_i + \gamma\kappa_n}{1+\gamma}$, which minimizes its marginal costs net of $\kappa_i e_{in}$. If country 0 sells in country 1, it thus charges a price which makes consumers indifferent between buying its good or that of firm 1, i.e. $p_{i0} = l_1(e_{i1}) - \kappa_i e_{i1} + \kappa_i e_{i0}$. 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 is also what a planner would choose 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). A model with quality, since it does not call for national regulations, does not generate the cross-country externality that is key to our model.

Production vs. consumption externality. In this section we consider the case of an externality that arises through production and not through consumption.[23] 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, since production equals consumption, this change is immaterial and the optimal policy in each country remains to set $e_n = \kappa_n$. In an open-

equilibrium. In a setup with an endogenous core competence, where the planner's choice of standard differs from the non-cooperative ones for both countries, an import tariffs cannot guarantee a globally efficient equilibrium.

[23] This case has been extensively studied in the literature on trade and the environment starting with the seminal contribution of Copeland and Taylor (1994).

economy, however, producing for the export market is now associated with a higher externality. Everything else being equal, there is a direct gain for the importer from *offshoring* the externality .

The firm from 0 now finds it profitable to export to country 1 when $l_1(e_1) - l_0(e_0) > 0$. The difference with equation (4) is 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 compared 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:

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

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 $l_1(e_1) - l_0(\kappa_0) > 0$. There is however no direct alignment 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 $\kappa_0 \left(E^M - \kappa_0\right) + l_1(e_1) - l_0(\kappa_0)$. 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 that exports are beneficial for the country as a whole. We assume that this is the case and that, after the choice of standards, countries can forbid their national firm to export if they deem it beneficial.[24]

Country 1 has welfare $L_1 + V - l_1(e_1)$ if it imports and the condition for country 1 to benefit from importing 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) and may face a change in price compared to autarky (left hand side). This change in price is itself 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 that country 0 exports to 1 as long as:

$$c_1 + \frac{1}{2}\kappa_1^2 + \kappa_1 \left(E^M - \kappa_1\right) > c_0 + \frac{1}{2}\kappa_0^2 + \kappa_0 \left(E^M - \kappa_0\right). \tag{36}$$

[24] In the case of consumption externalities, as apparent in equation (5), there is no misalignment 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 is not the case with a production externality, as 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 there would be no pure strategy Nash equilibrium in the choice of production standards. The proof is available upon request.

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 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, i.e. if the inequality is reversed, patterns of trade switch and country 1 exports good X to country 0. As long as (36) does not hold with equality, some trade takes place in equilibrium along the lines of those extended comparative advantages. This is a stark difference with 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. This 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. It is also worth pointing out that, with production standards, the non-cooperative solution is the same as the solution of the planner in the presence of minimum standards. The planner also chooses the country with the lowest $c_n + \frac{1}{2}\kappa_n^2 + \kappa_n \left(E^M - \kappa_n\right)$ as exporter and sets $e_n = \kappa_n$ for the exporter, as in the non-cooperative case.

4.4.2 Policy instruments

Our baseline model only allows countries to use minimum standards as policy. We now allow for different types of instruments, related to environmental or trade policy, to assess the robustness of our analysis to different policy options.

Minimum standard vs. Pigouvian tax. In our setup, governments address the externality arising from the consumption of good X through a minimum standard. While we consider this a more realistic modeling choice, we now modify our setup to allow for the imposition of a Pigouvian tax instead. Assume that a country can set a tax $t \times (E^M - e)$ per unit sold, i.e. a tax that depends on the level of the externality. As in our baseline, consumers buy the cheapest good on offer, as 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_{in}, that minimizes $l(e_{in}; c_n, \bar{e}_n) + t_i(E^M - e_{in})$, i.e.

$$e_{in} = \frac{t_i + \gamma \bar{e}_n}{1 + \gamma}. \tag{37}$$

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 to:[25]

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

[25]Note that 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.

and country n sets, in autarky, $t_n = \kappa_n$. This 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:

$$\pi_{10} = \max\left\{c_1 - c_0 + \frac{1}{2}e_{11}^2 - \frac{1}{2}e_{10}^2 + \frac{\gamma}{2}(e_{11} - \kappa_1)^2 - \frac{\gamma}{2}(e_{10} - \kappa_0)^2 - t_1(e_{11} - e_{10}), 0\right\},$$

where e_{in} is given by (37). If country 0 exports to 1, the respective welfare of each country are:

$$\mathcal{W}_0 = V - c_0 - \frac{1}{2}e_{00}^2 - \frac{\gamma}{2}(e_{00} - \kappa_0)^2 - \kappa_0(E^M - e_{00}) + \pi_{10} \tag{38}$$

$$\mathcal{W}_1 = \mathcal{W}_1^A + (t_1 - \kappa_1)(e_{11} - e_{10}) - \frac{1+\gamma}{2}(e_{11} - \kappa_1)^2. \tag{39}$$

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 (37). Equation (39) thus differs from its counterpart in the baseline by including a term $(t_1 - \kappa_1)(e_{11} - e_{10})$. In contrast to the baseline case, the importer can now capture part of the surplus from trade. If $\kappa_1 > \kappa_0$ ($e_{11} > e_{10}$) 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 (39) 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 participation constraint of the firm from 0, country 1 sets a tax:

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

The first line above corresponds to the case where there is no trade 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. In the third line, firm 0 produces at $e_{10} = \kappa_1$ for country 1 and both countries have some benefit from trade. It is worth pointing out that the condition for trade to happen with a Pigouvian tax is the same as that of the

planner in our baseline (8). Since 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 $e_{10} = \frac{\kappa_1+\gamma\kappa_0}{1+\gamma}$ 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 compared to what is optimal from a planner's perspective.

Violation of National Treatment. In our baseline analysis, we did not allow countries to apply different consumption standards to imported and to domestic goods. We were thus assuming that national treatment, one of the pillars of the World Trade Organization does hold. We here consider the case where a country can set two independent consumption standards. Country i sets a consumption standard e_{in} for goods produced in n. We focus only on the behavior of the potential importer, country 1, as the exporter's optimal policy is unaffected.

If it exports, firm 0 now makes profits in country 1 equal to $l_1(e_{11}) - l_0(e_{10})$ and if it wants to import, country 1 chooses standards e_{10} and e_{11} to maximize welfare subject to the participation constraint of the exporter:

$$\max_{e_{10},e_{11}} \mathcal{V}_1 - \frac{1}{2}\kappa_1^2 - l_1(e_{11}) + \kappa_1 e_{10} \quad \text{s.t.} \quad l_1(e_{11}) - l_0(e_{10}) \geq 0$$

By allowing e_{10} to differ from e_{11}, country 1 captures some of the gains from trade. The standard it applies to its domestic firm (e_{11}) matters for the price that firm 0 can charge on its market, while e_{10} is the standard that actually matters for the level of externality that occurs if it imports. Country 1 wants to set the lowest possible e_{11} $\left(\frac{\gamma}{1+\gamma}E^M\right)$, while setting the highest possible e_{10} (E^M), to extract as much surplus 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 export under the same condition as the planner in our baseline model (8). Here again, relaxing the violation of national treatment mimics the allocation of the planner if the importer captures the full surplus, i.e. if the participation constraint of the exporter is binding. Such an efficiency result would however not hold when firms choose their core competence as in 4.2. In that case, discriminatory standards would distort the choice of core competence by the exporter.

5 Conclusion

This paper develops an imperfectly competitive trade model with Ricardian differences in technology, where the consumption of goods generates a local externality. Countries differ in their regulatory preferences over the externality and impose more or less stringent product standards accordingly. Tailoring products to a different standard is costly for firms, and trade is only beneficial if the Ricardian gains outweigh the asymmetric concerns over these externalities. In this context, we have derived a number of properties of deep trade integration, defined as cooperative standard setting. We have shown that deep trade integration is more beneficial under moderate differences in regulatory preferences. Deep trade agreements rely on mutual concessions on standards and can go deeper between countries that have strong comparative advantages in different externality-generating goods. We have also shown that gains from deep trade agreements are larger after a shallow trade liberalization. In a multi-country setting with highly-dispersed regulatory preferences, an optimal deep trade integration is characterized by the formation of regulatory blocs.

Our results stand in sharp contrast with models featuring *production* externalities. In this case, importers tend to look for producing countries that are less concerned by these externalities. Yet, we have not considered the possibility of a government's preference that would reflect a genuine concern for an import-driven production externality. For instance, it can be argued that the availability of consumption-based accounting of CO2 emissions (see Davis and Caldeira (2010)) may shape the social welfare function of countries whose imports are intensive in "dirty" goods. In this event, our baseline model with consumption externalities becomes isomorphic to a set-up with an other-regarding government concerned with production externalities generated abroad. An increase in the concern for these production externalities by an importing country is a channel through which trade blocs could emerge again against Ricardian trade patterns. Endogeneizing such a shift in the social welfare function is left for future research. Relatedly, we have abstracted throughout of politically-minded governments whose objective function may be subject to lobbyists pressure (see for instance Maggi and Ossa (2020), Maggi and Mrázová (2022) and Rebeyrol (2021)). This constitutes another avenue for future research where regulatory "preferences" may be endogeneized.

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6 Appendix

6.1 Proof of Lemma 1

Consider country 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 (21) shows that, for any n':

$$c_n - c_{n'} < \gamma(\kappa_{n'} - \kappa_n)\left(\frac{\kappa_{n'} + \kappa_n}{2} - \kappa_j\right) + f_{n'j} - f_{nj} \tag{40}$$

$$c_n - c_{n'} < \gamma(\kappa_{n'} - \kappa_n)\left(\frac{\kappa_{n'} + \kappa_n}{2} - \kappa_l\right) + f_{n'l} - f_{nl} \tag{41}$$

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 that f is small enough is equivalent to saying that the fixed cost of export does not change this result. Formally, it is straightforward that, if $n' = j$ or $n' = l$ or $n = k$, the result also holds without additional assumption on the size of f. If country n can sell at lower cost than the domestic producer in j, despite the fixed costs of exports, it is an even stronger signal about its relative productivity compared to the producer from j. Similarly, if $n = k$, it is easier to sell as it does not pay the fixed costs of exports. If $n = j$ or $n = l$ or $n' = k$, the fixed costs of exports make it more difficult to prove the result. 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.

6.2 Continuum of varieties

The optimal consumption standards under the planner in equation (15) maximize world welfare if the following second order conditions hold:

$$-(1+\gamma) + \gamma(\kappa_1 - \kappa_0)\frac{\partial \omega_1}{\partial e_0} < 0 \tag{42}$$

$$-(1+\gamma) + \gamma(\kappa_0 - \kappa_1)\frac{\partial \omega_0}{\partial e_1} < 0 \tag{43}$$

Totally differentiating the definition of ω_0 and of ω_1 in (10) and (11) gives:

$$-A'(\omega_0)d\omega_0 + \gamma(\kappa_0 - \kappa_1)de_1 = 0 \Leftrightarrow \frac{d\omega_0}{de_1} = \frac{\gamma(\kappa_0 - \kappa_1)}{A'(\omega_0)} \tag{44}$$

$$-A'(1-\omega_1)d\omega_1 + \gamma(\kappa_1 - \kappa_0)de_0 = 0 \Leftrightarrow \frac{d\omega_1}{de_0} = \frac{\gamma(\kappa_1 - \kappa_0)}{A'(1-\omega_1)} \tag{45}$$

Plugging back in the second order condition shows that the two first order conditions are indeed a best choice for all countries if and only if:

$$-(1+\gamma)+\frac{\gamma^2(\kappa_1-\kappa_0)^2}{A'(1-\omega_1)} < 0 \tag{46}$$

$$-(1+\gamma)+\frac{\gamma^2(\kappa_1-\kappa_0)^2}{A'(\omega_0)} < 0 \tag{47}$$

6.3 Appendix on trade costs

To simplify the exposition, we assume without loss of generality that $\Delta\kappa \equiv \kappa_1 - \kappa_0 > 0$, i.e. 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:

$$c_1 - c_0 - t_{01} + \frac{\gamma}{2}(e_1-\kappa_1)^2 - \frac{\gamma}{2}(e_1-\kappa_0)^2 \geq 0 \tag{48}$$

or:

$$c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2 - \gamma(e_1-\kappa_1)\Delta\kappa \geq 0 \tag{49}$$

Whether t_{01} is a transport cost of a tariff, the welfare of country 0 is:

$$\mathcal{W}_0 = \mathcal{V}_0 - c_0 + \max\left\{c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2 - \gamma(e_1-\kappa_1)\Delta\kappa\right\} \tag{50}$$

If t_{01} is a transport cost, the welfare of country 1 is

$$\mathcal{W}_1 = \mathcal{V}_1 - c_1 - \frac{1+\gamma}{2}(e_1-\kappa_1)^2 \tag{51}$$

while if it is a tariff, the welfare of country 1 becomes:

$$\mathcal{W}_1 = \begin{cases} \mathcal{V}_1 - c_1 - \frac{1+\gamma}{2}(e_1-\kappa_1)^2 & \text{if (49) does not hold (Country 1 does not import)} \\ \mathcal{V}_1 - c_1 - \frac{1+\gamma}{2}(e_1-\kappa_1)^2 + t_{01} & \text{if (49) holds (Country 1 imports),} \end{cases} \tag{52}$$

the difference coming from the tariff revenues that country 1 captures in the case of a tariff.

6.3.1 Transport costs

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:

$$\begin{array}{ll} \mathcal{V}_1 + \mathcal{V}_0 - c_0 - c_1 + \max\{c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2, 0\} & \text{if non-cooperative} \\ \mathcal{V}_1 + \mathcal{V}_0 - c_0 - c_1 + \max\{c_1 - c_0 - t_{01} - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2, 0\} & \text{under the planner} \end{array} \tag{53}$$

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:

$$\Delta\mathcal{W} = \begin{cases} \frac{1}{2}\frac{\gamma^2}{1+\gamma}\Delta\kappa^2 & \text{if } t_{01} < c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2 \\ c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 & \text{if } c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2 < t_{01} < c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 \\ 0 & \text{if } t_{01} > c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 \end{cases} \tag{54}$$

Decreasing transport costs weakly raises $\Delta\mathcal{W}$, making the planner more beneficial from a world persepctive. 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 $t_{01} < c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2$.

6.3.2 Tariffs

In the model with tariffs, the planner's problem is exactly the same as with no tariffs. The reason is that tariff revenues purely amount to a transfer from country 0 to country 1 and are neutral for the sum of world welfare. The planner's solution is thus to set $e_1 = \frac{\kappa_1 + \gamma\kappa_0}{1+\gamma}$, $e_0 = \kappa_0$ and that trade occurs when $c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 > 0$.

In case of a tariff, country 1's wefare is discontinuous when it starts importing due to the tariff revenue. In the non-cooperative situation, country 1 takes this into account and may affect its standard e_1 to incentivize country 0 to export. If it imports, it picks the e_1 which is closest to κ_1 such that country 0 exports, i.e. the e_1 such that:

$$e_1 - \kappa_1 = \min\left\{0, \frac{1}{\gamma}\frac{c_1 - c_0 - t_{01}}{\Delta\kappa} - \frac{1}{2}\Delta\kappa\right\}. \tag{55}$$

Under these conditions, the welfare of country 1 if it imports becomes:

$$\mathcal{W}_1 = \begin{cases} \mathcal{V}_1 - c_1 + t_{01} & \text{if: } t_{01} \leq c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2 \\ \mathcal{V}_1 - c_1 - \frac{1+\gamma}{2\gamma^2\Delta\kappa^2}\left(c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2\right)^2 + t_{01} & \text{if: } t_{01} > c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2 \end{cases} \tag{56}$$

Country 1 prefers importing if:

$$c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2 + \gamma\Delta\kappa\sqrt{\frac{2t_{01}}{1+\gamma}} > 0. \tag{57}$$

The value of the left-hand side is maximized for

$$t_{01} = \frac{1}{2}\frac{\gamma^2}{1+\gamma}\Delta\kappa^2 \tag{58}$$

in which case (57) boils down to the condition for trade to occur under the planner. As long as $c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 > 0$, equation (57) generates an interval $[\underline{t}, \bar{t}]$ such that trade occurs for a tariff $t_{01} \in [\underline{t}, \bar{t}]$, with $\underline{t} = 0$ if $c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2 > 0$. In the non-cooperative equilibrium, we obtain that:

- For $t_{01} < \max\{c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2, \underline{t}\}$, $e_1^* = \kappa_1$. Country 1 imports if $\bar{t} = 0$ and no trade takes place if $\bar{t} > 0$.
- For $\max\{c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2, \underline{t}\} < t_{01} < \bar{t}$, $e_1^* = \kappa_1 + \frac{1}{\gamma\Delta\kappa}\left(c_1 - c_0 - t_{01} - \frac{\gamma}{2}\Delta\kappa^2\right)$ and country 0 exports.
- For $t_{01} > \bar{t}$, $e_1^* = \kappa_1$ and no trade takes place.

The sum of welfare in the non-cooperative world is:

$$\mathcal{W}_0 + \mathcal{W}_1 = \begin{cases} \mathcal{V}_1 + \mathcal{V}_0 - 2c_0 - \frac{\gamma}{2}\Delta\kappa^2 - \frac{1+\gamma}{2}(e_1^* - \kappa_1)^2 - \gamma(e_1^* - \kappa_1)\Delta\kappa & \text{if: } \underline{t} \leq t_{01} \leq \bar{t} \\ \mathcal{V}_1 + \mathcal{V}_0 - c_1 - c_0 & \text{otherwise} \end{cases} \tag{59}$$

Under the case that we focus on ($c_1 - c_0 - t_{01} - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 > 0$), there is trade in the planner's case and global welfare with a planner is:

$$\mathcal{W}_0(e_0^{*P}, e_1^{*P}) + \mathcal{W}_1(e_0^{*P}, e_1^{*P}) = \mathcal{V}_0 + \mathcal{V}_1 - 2c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 \tag{60}$$

The difference in world welfare between the planner's case and the non-cooperative equilibrium is thus given by:

$$\Delta\mathcal{W} = \begin{cases} \frac{1}{2}\frac{\gamma^2}{1+\gamma}\Delta\kappa^2 + \frac{1+\gamma}{2}(e_1^* - \kappa_1)^2 + \gamma(e_1^* - \kappa_1)\Delta\kappa & \text{if: } \underline{t} \leq t_{01} \leq \bar{t} \\ c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2 & \text{otherwise} \end{cases} \tag{61}$$

where, for $t_{01} < c_1 - c_0 - \frac{\gamma}{2}\Delta\kappa^2$, $e_1^* = \kappa_1$ and the difference in welfare is as in the case with no trade costs. It is immediate under the parameter restrictions we consider that:

$$\Delta\mathcal{W}|_{\underline{t} < t_{01} < \bar{t}} < \Delta\mathcal{W}|_{t_{01} \in [0, \underline{t}] \cup [\bar{t}, \infty)} \tag{62}$$

If $e_1^* = e_1^P$, which is the case for

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

$\Delta\mathcal{W}$ is minimized and equal to 0. Plugging $\tilde{t}_{01}$ into the condition for country 1 to import (57) further shows that it is

necessarily below $\bar{t}$:

$$c_1 - c_0 - \tilde{t}_{01} - \frac{\gamma}{2}\Delta\kappa^2 + \gamma\Delta\kappa\sqrt{\frac{2\tilde{t}_{01}}{1+\gamma}} = \gamma\Delta\kappa\left[-\frac{\gamma}{1+\gamma}\Delta\kappa^2 + \sqrt{\frac{\gamma^2}{(1+\gamma)^2}\Delta\kappa^2 + \frac{2}{1+\gamma}\left(c_1 - c_0 - \frac{1}{2}\frac{\gamma}{1+\gamma}\Delta\kappa^2\right)}\right] > 0 \tag{63}$$

We thus obtain that, in the case of a tariff, $\frac{\partial\Delta\mathcal{W}}{\partial t_{01}} \leq 0$ for $t_{01} < \tilde{t}_{01}$ and $\frac{\partial\Delta\mathcal{W}}{\partial t_{01}} \geq 0$ for $t_{01} > \tilde{t}_{01}$.

If country 1 were to choose the optimal tariff from its perspective in the non-cooperative equilibrium, it would choose the t_{01} that maximizes (56), i.e. $t_{01} = \tilde{t}_{01}$. Since country 1 would not have any incentive to set a $t_{01} > \tilde{t}_{01}$ in the first place, we focus on a shallow liberalization for $t_{01} \leq \tilde{t}_{01}$, in which case a decrease in tariffs raises the welfare benefits of moving to the planner's solution.