A simple theory of deep trade integration*†

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Abstract

We consider a Ricardian trade model where countries set standards to solve the externalities associated with the consumption of goods. Countries differ in their regulatory preferences over these externalities and choose different standards under autarky. When opening to trade, countries can stick to their standard or accept the other country's standard (recognition). Countries benefit from trade if and only if the Ricardian gains arising from technological differences outweigh their asymmetric concerns over these externalities. With many countries and a continuum of industries, the model yields a structural gravity equation where bilateral resistance terms reflect countries' divergence in their regulatory preferences. In the absence of terms-of-trade effects, the purpose of a trade agreement is the coordination of countries on their standards (harmonization). In the presence of highly-dispersed regulatory preferences, the gains from a multilateral trade policy are small, which leads the emergence of socially optimal trade blocs.

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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 (Felbermayr and Larch, 2013). These agreements have at their core the dismantling of non-tariff barriers, implying a convergence or a mutual recognition of regulations and standards. These treaties raise 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 existing 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). Existing models see such cost reductions as unambiguously positive from a social planner's perspective and predict aggregate gains from trade liberalization. However, non-tariff barriers such as Sanitary and Phytosanitary (SPS) measures may also reflect a country's legitimate concern for negative health externalities. If trade liberalization means a recognition of foreign standards, the welfare effects of international trade may thus become more complex. In this light, our paper provides a new theoretical framework to analyze the welfare implications of removing non-tariff barriers in the presence of externalities.

To capture these issues, we consider a simple Ricardian trade model where one of the goods generates a local consumption externality.[1] To address this externality, each country sets a consumption tax and a product standard to maximize domestic welfare, where the product "standard" fixes the level of externality allowed per unit of good consumed.[2] The focus of our study is thus on *vertical* standards, and we assume that it is more costly to produce a good that generates less consumption externality.

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. In autarky, countries have to produce with their own technology and set their standard to maximize domestic welfare. Since different countries have different views about the externality, they adopt different standards in autarky. The autarky price of the externality-generating good depends on two components: (i) a Ricardian technology parameter, which makes a country more or less efficient given any standard, and (ii) the standard at which the country produces, with a more stringent standard associated with higher marginal costs

[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 4.3.

[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.

of production.

When opening to trade, countries still have the option to produce domestically but may prefer to import from a country with a more efficient technology. This usual Ricardian motive for trade however comes at the cost of accepting the standard of the other country, effectively giving up the possibility to set domestic standards at the importer's preferred level. While accepting the foreign standard comes at no cost if both countries have the same preference for the externality (they would make the same optimal choice), it makes trade less attractive if those preferences are very heterogeneous across countries. The benefits from trade thus depend positively on the heterogeneity in technology across countries, but negatively on the heterogeneity in the preference for the externality.

This trade-off generates a number of conclusions. First, differences in technology are a necessary but not a sufficient reason to trade, thereby adding a dimension to the traditional Ricardian logic. Second, comparing (consumer or producer) autarky prices is not sufficient to determine the patterns of trade. Instead, a country will import a foreign good only if the cost gain more than compensates for the divergence in values, and thus for the divergence in regulations. Third, trade occurs under a broader range of parameters between countries that put a similar weight on the externality, leading to the emergence of trade blocs based on "values". We confirm this intuition by extending our model in an Eaton and Kortum (2002) fashion, which generates a gravity equation where bilateral trade costs are replaced by a bilateral distance between the weights that countries put on the externality. Although both regulatory preferences and technology, are "monadic" in the Head and Mayer (2014) terminology, the former acts as a dyadic term. Along the technological dimension, all countries rank potential exporters in the same way. Instead, each country's preferred exporter depends on the distance between their regulatory preferences.

We neutralize the terms-of-trade effect by assuming that both countries always produce the good that does not generate externalities, thereby pining down the relative wages. Absent terms-of-trade effects, the purpose of a trade agreement in our framework boils down to the coordination between countries on an optimal production standard. Starting with two countries, we show that, conditional on trade being optimal, a social planner sets a standard between the exporter's standard and the one that the importer would set if it had access to the exporter's technology. Compared to the non-cooperative case, the optimal standard does not coincide with the exporter's preferred standard. If several goods generate externalities, and if one of the country does not have a comparative advantage in all of them, a trade agreement featuring standard harmonization is implementable through mutual concessions. Countries will agree to deviate from their preferred standard to obtain reciprocal concessions from their trade partner. In a setting with many countries, a multilateral agreement - setting one standard for all - is not necessarily optimal. The formation of trade blocs allows the social planner to reduce within-bloc heterogeneity and thereby the gap between each trade bloc member's preferred standard to the harmonized one. This improvement comes at the expense of allocating some of the worldwide production to countries that are not the most efficient. While the Ricardian motive for trade favors multilateralism, a divergence in values explains the emergence of trade blocs. It is worth pointing out that a model where countries have heterogeneous perceptions about local *production* externalities would yield very different results. In line with the pollution haven literature, and for a given technological efficiency, those countries that attach less importance to the production externalities would export the externality-generating good. In contrast to our setup with consumption externality, all countries would thus tend to import from partners that have a low concern for the production externality.

Our analysis also applies to goods which do not create an externality on others, but on 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.[4] While requiring a more paternalistic view of the world and a fair amount of faith in the ability of governments, this interpretation squares well with the debates on measures protecting the health of consumers such as the ban on hormone-fed beef, chlorine-washed chicken or the concentration of bacteria allowed in cheese. Different perceptions of the internality by different governments, or different degrees of paternalism, would effectively extend our analysis to such goods.

This paper is related to different strands of the literature. First and foremost, the literature has emphasized the role of non-tariff barriers as a protectionist instrument typically referred to as regulatory protectionnism (e.g. Baldwin (2000); Fischer and Serra (2000)). A number of papers (Ederington (2001), Bagwell and Staiger (2001) or Campolmi et al. (2014) among others) show that, when countries cannot use trade policy, they use policy tools meant to solve a domestic externality to affect terms of trade. Bagwell and Staiger (2001) show that even when countries differ in their preferences over domestic policies, the fundamental reason behind the strategic choice of their standards, and thereby trade agreements, is the manipulation of the terms of trade. This motive is also present in Mei (2017) who builds a quantitative trade model featuring monopolistic competition to assess the welfare impact of regulatory cooperation. Other rationales include coping with the excessive entry of low-quality firms (Macedoni and Weinberger (2018)) and asymmetric information (Disdier et al. (2018)). Instead, we restrict our attention to the legitimate rationale which can exist behind non-tariff measures.
Closer to our paper is Grossman et al. (2019): they consider the rationale for a "new" trade agreement when countries have different ideal *horizontal* standards which may lead to global efficiency loss due to foregone economies of scale. Instead, we focus on consumption externalities that may be curbed through the implementation of *vertical* standards with countries which differ in their concern over these externalities. Furthermore, in order to isolate the impact of regulatory harmonization, we consider a perfectly-competitive market structure.

[4] In particular, think of hyperbolic discounters. They would like the government to set a standard as a commitment not to buy a good that is damaging for them in the future.

We consider purposedly a Ricardian trade model where not all countries are fully specialized so as to rule out any protectionist incentive for a country in setting a production standard. In our framework, coping with a consumption externality is the only reason for countries to set their standards. and the only rationale for a trade agreement comes down to a coordination problem on the product standard, which can be implemented through mutual concessions over several industries. Costinot (2008) provides a formal treatment of the issue of mutual recognition and shares some resemblance to our question, but considers an oligopolistic setup with no hererogeneity in costs or in "values" across countries, where profit shifting plays a key role in the outcome. The interplay between countries' comparative advantage and their idiosyncratic preferences over domestic policies is to the best of our knowledge absent from the existing literature.

On the empirical front, there is an abundant literature investigating 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)).

We also speak to 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.

The rest of the paper is structured as follows. Section 2 describes the baseline Ricardian model with two countries and derives the necessary and sufficient conditions for trade to happen in equilibrium. It also details the purpose of a trade agreement Section 3 extends the model to the case of many countries and many industries. It shows how it can lead to a structural gravity equation where bilateral and multilateral resistance terms can be reinterpreted through regulatory divergence. It also questions the optimality of multilateralism in the presence of regulatory preferences heterogeneity. Section 4 shows the robustness of the model's insights to the number of policy instruments, destination-specific standards and production externalities. Section 5 concludes.

2 The baseline model

2.1 Closed economy

Consumer preferences The world consists of N countries, indexed by n. Each country has a unit mass of identical agents with quasi-linear preferences over 2 goods. The first good, indexed by 0, enters the utility linearly and has a price normalized to one. The second good, which is the focus of our study, enters the utility in a concave manner, but its consumption generates a negative externality. We first consider the case where the externality-generating good cannot be traded. The cost of the externality in terms of utility depends on a country-specific parameter κ_n, which captures how individuals in n are concerned with the externality. Consumer h in country n has utility:

$$\mathcal{U}_h(E) = x_{h0} + u(x_h) - \kappa_n E \int_{h' \in n} x_{h'} dh' \tag{1}$$

where x_{h0} represents the consumption of the numeraire good by individual h. $u()$ is strictly increasing, twice continuously differentiable and concave. The last term in the utility captures the externality, which depends on the total consumption of the externality-generating good by all agents in the country, with E denoting the externality per unit consumed. 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[5] that is localized in space (noise, emissions of nitrogen oxide, etc.). The heterogeneous κ's across countries can reflect pure differences in preferences, i.e. different perceptions of how bad pollution is. They can however also reflect differences in the true effect of this pollution across countries, e.g. the fact that more densely populated areas may be more severely affected by a given amount of pollution. Regardless of the interpretation, we consider these κ's as exogenously given in our model.

When maximizing her utilliy with respect to x_h, individual h in n does not take into account his effect on the aggregate consumption and sets

$$u'(x_h) = q_n, \tag{2}$$

where q_n denotes the consumer price of the externality-generating good in n, and where we assume that all agents do consume the numeraire good in equilibrium.

Production Each agent in n supplies inelastically I_n units of labor and is freely mobile across sectors. Both sectors produce using only labor under constant returns to scale and perfect competition. All countries produce

[5] 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, the objective of the government remains unchanged and equation (1) becomes $\mathcal{U}_h(E) = x_{h0} + u(x_h)$.

the numeraire good in equilibrium, using one unit of labor to produce one unit of the good, thereby pinning down the wage to one in all countries. The labor needed to produce y units of the good generating externality E in country n is given by:

$$l(c_n, y, E) = c_n m(E) y. \tag{3}$$

All firms producing the externality-generating good in n face the same exogenous technology parameter c_n, which scales the unit labor requirement in n. The unit labor requirements, $c_n m(E)$, also depend on how "clean" the good is. We assume that goods generating less externality are more expensive to produce, as well as some additional regularity conditions on the function $m()$ to simplify the analysis.

Assumption 1. *The function $m(E)$ has the following properties:*

$$m'(E) < 0, \quad m''(E) > 0, \quad \lim_{E \to 0} m'(E) = -\infty, \quad \lim_{E \to \infty} m'(E) = 0$$

Assumption 1 holds in the rest of the analysis.

In each country, the government has two policy instruments to address the externality. First, it can levy a consumption tax t per unit consumed, driving a wedge between the consumer price (q) and the producer price (p), with $q = (1+t)p$. The proceeds of the tax are redistributed to the agents in the country. Second, it sets the externality E allowed per unit produced on its market. A lower E is thus equivalent to the imposition of stricter standards, or more stringent regulations.

We now turn to deriving the social welfare function faced by the government in n. If agents in n consume a good produced with technology parameter c and generating an externality E, they face a producer price of

$$p(c, E) = cm(E) \tag{4}$$

by perfect competition, and a consumer price:

$$q(c, E, t) = (1+t)cm(E). \tag{5}$$

Given this consumer price, agents consume an amount $x^*(c, E, t)$ of the externality-generating good, defined by (2). Consumers spend their remaining income, equal to $I_n - p(c, E)x^*(c, E, t)$ on the numeraire good.[6] The government maximizes the total utility of its agents, given by the aggregation of (20):

$$\mathcal{W}_n(c, E, t) = I_n + u(x^*(c, E, t)) - (cm(E) + \kappa_n E)\, x^*(c, E, t). \tag{6}$$

[6] Note that what consumers pay in taxes ($tx^*(c, E, t)$) is redistributed and thus does not appear in the consumption of the numeraire good.

Optimization with respect to t given c and E gives:[7]

$$\frac{\partial \mathcal{W}_n(c,E,t)}{\partial t} = 0 \Rightarrow t_n^*(c,E) = \frac{\kappa_n}{c}\frac{E}{m(E)}, \tag{7}$$

which implies that:

$$q_n(c,E) = (1 + t_n^*(c,E))cm(E) = cm(E) + \kappa_n E. \tag{8}$$

In the absence of externalities (or, equivalently, if the government does not give any weight to these externalities), (7) shows that the optimal consumption tax is zero. Note that (7) implies that the consumption tax can be used as a substitute for a more stringent standard (lower E) and that the government resorts to a higher consumption tax for low-standard goods. We allow the government to use two instruments - a tax and a standard - to reach the first best consumption level given c. An equivalent alternative would be for governments to set a full tax schedule $t(E)$, i.e. announce a tax rate that depends on the strength of the consumption externality. While both options allow the government to reach its first best, we concentrate our exposition on the first case as it appears more common in practice.[8] Last, while it may seem heroic to consider that consumers do not internalize any of the social cost of the externality, Ex should be understood as the residual part of the externality that is not internalized by consumers hence targeted by government policy. Plugging t_n^* back in n's welfare gives our first lemma, which establishes that consumer prices are a sufficient statistic for social welfare.

Lemma 1: *A government's social welfare function at its optimal consumption tax is a monotonically decreasing function of the consumer price $cm(E) + \kappa E$.*

The proof follows from writing $\mathcal{W}_n(c,E,t_n^*(c,E))$, with $t_n^*(c,E)$ given by (7). From (8) and using the first order condition of individual agents (2), $\mathcal{W}_n$ can be rewritten as a function of q_n only: $\tilde{\mathcal{W}}(q_n) = u(x^*(q_n)) - q_n x^*(q_n)$, where q_n is itself a function of c and E. Differentiating $\tilde{\mathcal{W}}(q_n)$ gives $\tilde{\mathcal{W}}'(q_n) = (u'(x_n^*) - q_n)\frac{\partial x_n^*}{\partial q_n} - x_n^*$. Using (2) shows that it is negative.

Optimal standard Given its domestic technology c_n, country n sets its optimal standard E_n^* to minimize $q_n(c_n, E)$, i.e.:

$$\kappa_n + c_n m'(E_n^*) = 0. \tag{9}$$

The above defines a function $E^*(c_n, \kappa_n)$ giving the optimal standard in autarky, which we call E_n^* to simplify the notation. Since it can target the quantity consumed through a consumption tax, the optimal E does not

[7]For clarity, we present the problem of the government as a sequential decision of choosing t first, followed by E. In our setup, it is however equivalent to choosing t and E simultaneously.

[8]Some countries have introduced tax schedules which depend on the externality generated per unit consumed. For example, some countries levy higher taxes on cars with larger cylinder capacities; France has recently introduced a tax on soda that depends on its sugar content. These attempts are still relatively rare, present discontinuities but most importantly they remain imperfect proxies for the externality that goods generate.

depend on quantities but purely on the technology c_n and on the preference parameter on the externality κ_n. Under our assumptions on the shape of $m(E)$, it is immediate that the regulation is stricter (E^* is lower) for low-cost technologies and for more *concerned* governments:

$$\frac{\partial E_n^*}{\partial c_n} = -\frac{m'(E_n^*)}{c_n m''(E_n^*)} > 0, \qquad \frac{\partial E_n^*}{\partial \kappa_n} = -\frac{1}{c_n m''(E_n^*)} < 0. \tag{10}$$

2.2 Two countries in an open economy.

We now consider the case of an open economy where both goods can be freely traded at zero costs. Compared to the closed economy problem, each country now has the option to recognize[9] foreign standards and to allow their commercialization in its domestic market. A country i minimizes its consumer price by choosing either to produce the good with its own technology (c_i) and setting its preferred standard (E_i^*) or by importing the good at a given foreign technology c_n and standard E_n. In the case where it decides to import, the country gains access to a different technology but loses the ability to choose its standard. It can however still adjust the consumption tax as we explicitly show below.

We consider without loss of generality the case where n is a more efficient producer than i from a technological perspective, i.e. $c_n < c_i$. In that case, and regardless of the standard at which country i produces, country n would never import from country i as:

$$c_n m(E_n^*) + \kappa_n E_n^* \leq c_n m(E_i) + \kappa_n E_i < c_i m(E_i) + \kappa_n E_i, \tag{11}$$

where the first inequality follows from the definition of E_n^*. Country n will thus stick to its autarky standard in the open economy, regardless of whether it exports or not. The reason why the most efficient country sticks to its autarky standard is that welfare depends only on consumer prices, even in our open economy setting. Our partial equilibrium setting with perfect competition and with no additional policy instruments (e.g. no production subsidy) implies that countries have no incentives to manipulate their terms of trade. While we do not dispute the importance of terms-of-trade effects in practice, they have been extensively studied in the literature and we purposedly shut them down to highlight the novel contribution of our model. Since distorting the production decisions do not bring any benefits in our open economy setting, all countries maximize their welfare by minimizing their consumer price. Even if country n exports, it produces both goods in equilibrium by assumption. Our model is thus similar to a 2x2 Ricardian model with incomplete specialization. At any equilibrium, the exporting country is indifferent to trade as trade fosters a zero-sum reallocation of workers across its two sectors.

[9] In reality, exporters could of course also adjust their production to the standard of their destination markets. We discuss this case in section 4.

Given that n's standard remains at its aurtarky level E_n^*, country i imports from n if and only if:

$$c_n m(E_n^*) + \kappa_i E_n^* < c_i m(E_i^*) + \kappa_i E_i^*. \tag{12}$$

The above inequality immediately gives the following proposition.

Proposition 1. *If $\kappa_n \neq \kappa_i$, differences in technology are a necessary but not sufficient condition for trade. Conditional on trade occurring, the standard of the most competitive country applies to the consumption of both countries.*

When countries have different concerns about consumption externalities, technological differences are no longer a sufficient reason for trade to be welfare enhancing. This is because the standards of the exporter may be too different from the optimal standard that the importer would choose. Compared to the Ricardian model, where autarky prices are sufficient to determine the patterns of trade, - the left-hand side of (12) corresponds to the autarky price in n augmented with $(\kappa_i - \kappa_n) E_n^*$, i.e. a measure of the difference in political concern over the consumption externality. Given $c_n < c_i$, the gains from trade for i are maximized if $\kappa_n = \kappa_i$. This has two implications. First, while technological differences are a necessary condition for trade, trade is more likely to happen between countries with *similar* concerns for consumption externalities. The maximum gains from trade that can be achieved result from pure technological differences. Second, contrary to the standard law of comparative advantage where producer prices are a sufficient statistic to predict trade, here, the *source* of the cross-countries price difference matters. When a country's low consumer price under autarky reflects its low concern for an externality, it is less likely to export that product to a country with a high concern for that externality. The following additional assumptions on $m()$ are sufficient to guarantee the existence of a range of parameters in which country i does not import from n, as established in Proposition 2 below.

Assumption 2. $\lim_{E\to 0} m(E) = \infty$ *and* $lim_{E\to\infty} m(E) = 0$

Proposition 2. *Assume that $c_n < c_i$ and that both Assumptions 1 and 2 hold. There exists an interval $\mathcal{K}_i(c_n) \equiv [\underline{\kappa}_i(c_n), \bar{\kappa}_i(c_n)]$ with $\kappa_i \in \mathcal{K}_i(c_n)$ such that i imports from n if and only if $\kappa_n \in \mathcal{K}_i(c_n)$. The gains from importing are maximized if $\kappa_n = \kappa_i$.*

Proof. *See Appendix*

Implementation. If country i finds it optimal to import from country n, i.e. if (12) holds, it must set its domestic standards to guarantee that consumers actually choose to consume the imported goods. In practice, i should impose a standard E on domestically produced goods such that $E < \tilde{E}_i$, where $\tilde{E}_i$ equalizes the price of the domestic and of the foreign good $(c_n m(E_n^*) = c_i m(\tilde{E}_i))$. If Assumption 2 holds, there is a range of values

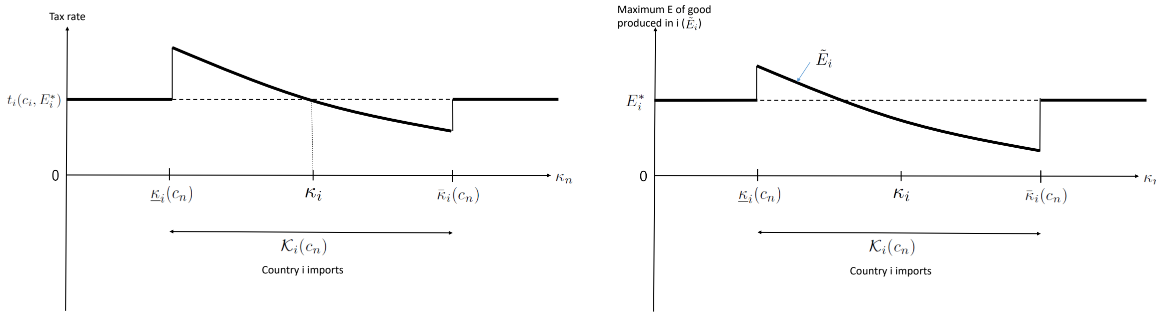

Figure 1: Standard and consumption taxes

of κ_n for which the country should optimally import, but for which consumers would not do so if producers in i were allowed to produce at the autarky standard E_i^*. If country n cares relatively much for the externality ($\kappa_i < \kappa_n < \bar{\kappa}_i(c_n)$), it imposes a stringent standard on its production. Country i may benefit from importing at n's superior technology ($c_n < c_i$ by assumption), even if the standard in n is too stringent from its perspective. Consumers however do not take the externality into account and may be tempted to still buy the good produced in i. Country i should thus raise its domestic standard to ensure that its domestic consumers prefer buying the foreign-produced good. We illustrate how $\tilde{E}_i$ depends on κ_n in Figure 1 and relegate all proofs to the appendix.

We have assumed that countries can adjust their consumption tax as a function of the c and the E of the goods that they consume. In other words, when a country decides to import, it reoptimizes its consumption tax to accommodate the different characteristics of the good that it consumes compared to the closed economy case. Figure 1 illustrates how the choice of the tax in country i depends on κ_n by plotting $t_i(c_n, E^*(\kappa_n, c_n))$ and comparing it to $t_i(c_i, E_i^*)$, the consumption tax with no trade. If country i imports from a country n with a low κ_n, it imports a cheaper good ($c_n < c_i$) and a relatively more polluting one than if it could choose the externality itself. Country i therefore sets a higher consumption tax than in autarky to limit the increase in the externality generated by consumption. Interestingly, we see that opening up to trade leads a high$-\kappa$ importer to raise its consumption tax. While this is observationally equivalent to a countervailing duty aiming to curb the rise in imports (the consumption tax applies to goods that are imported), it reflects in the present case a country's concern for an externality when it imports the good. The opposite reasoning applies to the case where κ_n is relatively high, with a tax set at a lower level than in the closed economy.

Asymmetric concerns over externalities. It is worth stressing that the above-results depart from the so-called second-best theory. While it is well known that trade might not be optimal under the presence of externalities, we are not comparing the outcome with or without externalities. Rather, we are comparing an equilibrium with and without trade when second-best policies are implemented through the joint use of a consumption tax and standard.

Our model emphasizes that it is the *asymmetry* in the preference for externalities that matters. To see this, consider the case of two perfectly symmetric countries which share the same preferences over consumption externalities κ but differ only technologically. In this event, the exporting country sets the standard at its first-best level, which would also be the first-best ot the importing country had it the same production possibilities, that is at a more stringent standard (lower E). Compared to autarky, the importing country then readjusts its consumption tax and necessarily gains from trade. In other words, when countries concerns over externalities are aligned, trade is *always* preferred regardless of the common concern over the externality κ. Trade is thus always preferred even though the consumption of the good which generates an externality has increased overall.

In the case where κ's are different across countries, it is worth emphasizing that the worldwide first-best is not reached without coordination. The reason is that in setting its standard, the exporter does not take into account the κ of the destination, hence the possibility of a welfare-increasing trade policy that we discuss in section 2.3.

Example. We now illustrate the main mechanisms that we described above with a parametric example where we assume:

$$m(E) = \frac{E^{-\delta}}{\delta} \text{ with } \delta \geq 1. \tag{M}$$

From (9), the optimal standard chosen by country n in autarky $E_n^* = \left(\frac{c_n}{\kappa_n}\right)^{\frac{1}{1+\delta}}$, which reflects the interplay between technology (c_n) and regulatory preferences (κ_n) in setting the optimal standard. The consumption tax is set at a level:

$$t_n^*(c, E) = \delta \frac{\kappa_n}{c} E^{1+\delta},$$

which implies a tax level in the closed economy equal to $t_n = \delta$, and a consumer price in autarky given by

$$q_n(c_n, E_n^*) = \frac{1+\delta}{\delta} c_n^{\frac{1}{1+\delta}} \kappa_n^{\frac{\delta}{1+\delta}}.$$

The consumer price is increasing with the unit labor requirements but also with the country's concern for the externality. The condition for i to import from n (Eq. (12)) becomes:

$$\left(\frac{\kappa_i^\delta c_i}{\kappa_n^\delta c_n}\right)^{\frac{1}{1+\delta}} \geq \frac{1+\delta\frac{\kappa_i}{\kappa_n}}{1+\delta}, \tag{13}$$

where the left hand side is the ratio of consumer prices (or producer prices) in autarky. In contrast to the standard version of the Ricardian model, comparing autarky prices is not sufficient to predict the patterns of trade. The condition for trade to arise boils down to comparing autarky prices if and only if $\kappa_i = \kappa_n$. In the knife-edge case where $c_i = c_n$, it can easily be verified that the above condition is violated as long $\kappa_i \neq \kappa_n$, i.e.

trade never arises based on differences in the concerns for externalities. On the contrary, the above condition is more likely to be violated the further away is κ_n from κ_i.

2.3 Bilateral trade agreements

In this subsection, we take the perspective of a world social planner, which maximizes the joint welfare of all countries, defined as:

$$\sum_i F_i\left(\mathcal{W}_i(c, E, t)\right), \tag{14}$$

where $F_i()$ are monotonically increasing functions. The social planner can decide on the vector E and t for all countries in the world, as well as the assignment of source to destination countries.

We first note that, given a (c, E) tuple for country i, the choice of tax by the planner is the same as the decentralized choice of country i and is given by (7). In our setting, consumption externalities are country-specific and the tax policy in a given country does not create any externality on its trade partners. The problem of the planner therefore becomes:

$$\max_{i(n), E_n} \sum_i \tilde{F}_i\left(q_i(c_n, E_n)\right), \tag{15}$$

where $\tilde{F}_i()$ is strictly decreasing, where $q_i(c, E) = cm(E) + \kappa_i E$ and where $i(n)$ refers to the assignment of countries n producing to countries i consuming.

As before and without loss of generality, we assume that $c_n < c_i$. As in the uncooperative setting, the planner will never select an equilibrium with trade where the less efficient country (country n) exports. It is easy to see that such a situation would be dominated by country i buying from itself, i.e. with a better technology, and at its preferred standard. The planner thus either replicates the autarkic equilibrium or makes country i import from country n, in which case it picks a standard for country n's production such that:

$$c_n m'(E_n^P) + \lambda(c_n, E_n^P)\kappa_n + (1 - \lambda(c_n, E_n^P))\kappa_i = 0 \tag{16}$$

where $\lambda(c, E) \in [0, 1]$ is defined as:

$$\lambda(c, E) \equiv \frac{\tilde{F}_n'(q_n(c, E))}{\tilde{F}_n'(q_n(c, E)) + \tilde{F}_i'(q_i(c, E))}. \tag{17}$$

The standard that the planner chooses for the exporting country is the one that would be chosen by a country with a κ equal to an average between κ_i and κ_n. Consequently, when both countries matter for the planner ($0 < \lambda(c_n, E_n) < 1$), the planner sets an optimal standard which lies between the closed economy standard of the exporter ($\lambda = 1$) and the ideal standard of the importer, would it have access to the foreign technology[10]

[10] This argument depends on our assumption that the standard can take continuous values. If E could only take discrete values,

($\lambda = 0$). The planner wants i to import from n if and only if the welfare under trade is higher than in the closed economy, i.e. if:

$$\tilde{F}_i(c_n m(E_n^P) + \kappa_i E_n^P) + \tilde{F}_n(c_n m(E_n^P) + \kappa_n E_n^P) > \tilde{F}_i(c_i m(E_i^*) + \kappa_i E_i^*) + \tilde{F}_n(c_n m(E_n^*) + \kappa_n E_n^*) \tag{18}$$

We define the set of κ_n for which the above condition holds as $\mathcal{K}_i^P(c_n)$.

Proposition 3. *Compared to the Nash equilibrium, trade occurs under a broader range of regulatory preferences in the planner's solution (extensive margin), i.e.* $\mathcal{K}_i(c_n) \subset \mathcal{K}_i^P(c_n)$. *Given that there is international trade, the volume of trade in the planner's solution is higher than in the Nash equilibrium (intensive margin).*

If there is trade between both countries, the world welfare is higher under the social planner than under the Nash equilibrium, making trade profitable under a wider range of parameters. This result provides a simple rationale for an international standard. When considering both countries' welfare, the planner finds it optimal to deviate from the unilateral standard set by the exporter and to set a standard taking the importer's preferences into account. Compared to the Nash equilibrium, a marginal deviation leaves the exporter almost indifferent - marginal deviations at the maximizing standard are null by definition - while the importer stricly gains. The gains of the importer arise through a lower consumer price, thereby raising the volume of trade.

Implementation. Compared to the Nash equilibrium, the planner selects a solution where the exporter incurs small losses while the importer benefits from large gains. While the total welfare is higher, the policy is not a Pareto improvement, thereby raising questions about the practical implementation of such a policy. There are two ways through such a policy can be made agreeable to both parties. The importer could agree to transfer some of the numéraire good to the exporter, effectively making a transfer in exchange for a change in the exporter's standard. In a setup with more than one externality-generating good, on the other hand, it is likely that country i has a better technology than country n ($c_i < c_n$) for at least some goods. In that case, an agreement where both countries take the preferences of their partner when setting their standards of production would yield a Pareto improvement. If both countries are symmetric,[11] they can attain the planner's solution through mutual concessions on their standards on the set of goods that should optimally be traded.

the condition for the planner to strictly improve on the Nash situation would be a bit more restrictive.

[11] Symmetric here means that for each good ω, there is a good ω' such that $\kappa_{i\omega} = \kappa_{n\omega'}$, $\kappa_{n\omega} = \kappa_{i\omega'}$, $c_{i\omega} = c_{n\omega'}$ and $c_{n\omega} = c_{i\omega'}$.

3 Open economy: many countries.

3.1 Ranking exporters.

We now assume that there are $N > 2$ countries. Country i now has the choice between producing the good domestically or importing it from any of its partners. Country i will choose to import from the country such that $argmin_n\{c_n m(E_n^*) + \kappa_i E_n^*\}$, i.e. the country that will sell in i with the lowest consumer prices. If the cheapest source is i itself, then i optimally does not import. Generally, an importer i ranks potential exporters using iso-price curves denoted $\mathcal{C}_i(\kappa; q)$ for the level $q-$isoprice curve in the (κ, c) space. While none of the insights depends on a particular choice of functional form, we assume (M) in the following to simplify the exposition. Using that the final consumption price in i of a good produced in n is given by

$$q_{in} = \left(\frac{1}{\delta} + \frac{\kappa_i}{\kappa_n}\right) c_n^{\frac{1}{1+\delta}} \kappa_n^{\frac{\delta}{1+\delta}}. \tag{19}$$

We can define an iso-price curve at level q as follows:

$$\mathcal{C}_i(\kappa; q) = \left(\frac{\delta}{\kappa^{\frac{\delta}{\delta+1}}\left(1 + \delta\frac{\kappa_i}{\kappa}\right)} q\right)^{\delta+1}.$$

Condition (13) states that any country considers as an exporter any country below its closed-economy iso-price curve $\mathcal{C}_i(\kappa; q_{ii})$. Figure 2 depicts the position of 3 countries, i, n and n' in the (κ, c) space. We depict the closed-

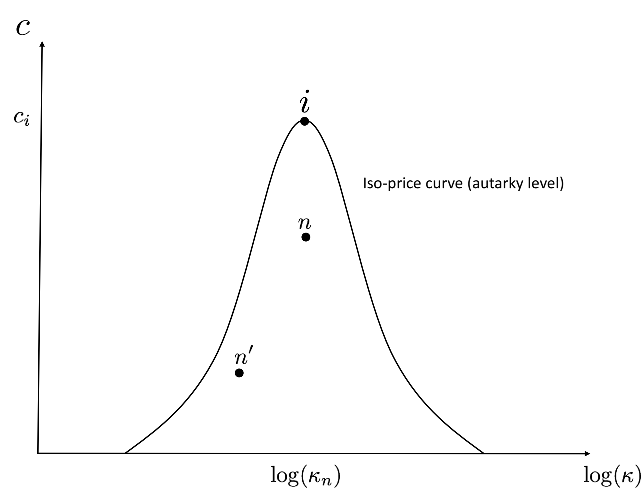

Figure 2: Iso-price curve in the closed economy

economy iso-price curve for $\delta = 1$ in the (κ, c) space. Country i is indifferent between producing domestically or importing from any country with a (κ, c) combination on the curve. The curve is bell-shaped with a maximum at κ_i, which shows the tension between the technological gap and the divergence in values. According to (13) the gains from trade are maximized the more asymmetric countries are technologically but the more symmetric they are are in terms of preferences. Country i prefers importing from any country below its autarky iso-price curve than producing domestically.

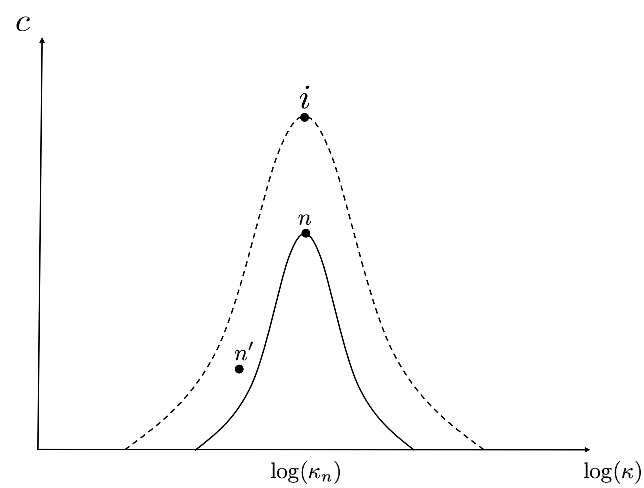

Figure 3: Ranking exporters

These conditions are verified for both countries n and n' in Figure 2. While n is perfectly aligned with i's concern for the externality, n' puts a lower weight on the externality and has the most efficient technology. As shown in Figure 3, i prefers importing from n than n' as the iso-price curve $\mathcal{C}_i(.;.)$ passing through n that leaves n' above.

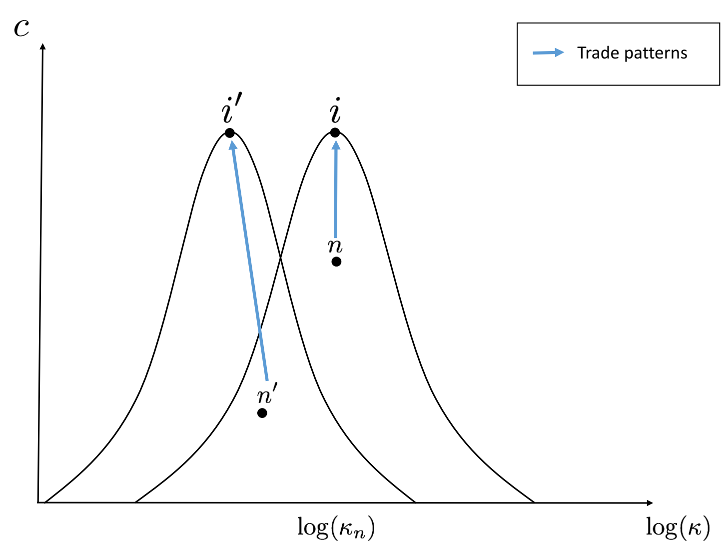

Figure 4: Trade blocs

Graphically, it is easy to see that taking into account countries asymmetries in values can generate trading blocs. In Figure 4, we consider a fourth country i' which has the same technology as i but a lower κ. i''s autarky iso-price curve then leaves n above so that i' strictly prefers to import from n' than n.

3.2 Gravity

We now show how our framework can be embedded in a multi-country-industry environment with bilateral trade costs à la Eaton and Kortum (2002). We extend our baseline model to a continuum of goods indexed by $\omega \in [0,1]$ and define an individual h's preferences in country i as:

$$\mathcal{U}_h(\mathbf{E}) = x_{h0} + \int_0^1 u(x_{h\omega})d\omega - \kappa_i \int_0^1 E_\omega \int_{h' \in n} x_{h'\omega} dh' d\omega. \tag{20}$$

The government maximizes the aggregate utility of its agents by choosing a good-specific consumption tax as well as a good-specific externality per unit consumed. The separability of the government's objective function guarantees that our previous results apply good by good. The consumer price of good ω in country i is, under the optimal consumption tax, $q_i(c_\omega, E_\omega) = c_\omega m(E_\omega) + \kappa_i E_\omega$. As in our baseline model, the optimal standard chosen by country i for good ω in autarky ($E^*_{i\omega}$) is given implicitly by $c_{i\omega} m'(E^*_{i\omega}) + \kappa_i = 0$, and i can import goods at a cost τ_{in} from other countries if it accepts their autarky standard.[12]

We make a number of parametric assumptions to make our setup amenable to an analysis à la Eaton Kortum (2002). We assume the functional form (M) for our cost function, $u(x) = \frac{x^\alpha}{\alpha}$ with $\alpha < 1$, and that country i draws independently for each good a technology parameter c_ω from a Weibull distribution such that:

$$\mathbb{P}_i\left(c_\omega \leq c\right) = 1 - e^{-T_i c^\theta} \tag{21}$$

Country i buys each good from the country which yields the lowest consumption price at home, i.e. it buys good ω from the country n with the minimum $\tau_{in} q_{in}$ where q_{in} is given by (19). We show in the Appendix 6.5 that the imports of country i from country n (M_{in}) as a fraction of the total imports of country i (M_i) are given by:

$$\frac{M_{in}}{M_i} = \frac{T_n \phi_{in}^{-\frac{\theta}{1+\delta}} \tau_{in}^{-\theta}}{\sum_{n'} T_{n'} \phi_{in'}^{-\frac{\theta}{1+\delta}} \tau_{in'}^{-\theta}}, \tag{22}$$

where

$$\phi_{in} = \left(\kappa_n / \kappa_i\right)^{\frac{\delta}{\delta+1}} + \delta \left(\kappa_i / \kappa_n\right)^{\frac{1}{1+\delta}}, \tag{23}$$

[12] In the spirit of Eaton - Kortum (2002), we assume here that the triangle inequality holds for *total* bilateral costs which include the usual bilateral trade costs as well as the dyadic terms which arise from divergence in regulatory preferences. Specifically, the following inequality is assumed to hold: $(\phi_{il}\phi_{ln})^{\frac{1}{1+\delta}} \tau_{il}\tau_{ln} > \phi_{in}^{\frac{1}{1+\delta}} \tau_{in}$. It means that countries will necessarily consume the good they export.

acts similarly to a trade friction between i and n. ϕ_{in} is minimized when $\kappa_n = \kappa_i$ and reflects the extent to which the concerns for the externality differ across both countries. The more the perceptions of the externality differ across countries, the less they trade together. Cross-country difference in concerns over externalities acts in a similar way as trade costs for the patterns of trade. Contrary to bilateral trade costs, these dyadic terms are entirely made of monadic terms, κ_n and κ_i. It is worth noting that ϕ_{in} is not separable into the two monadic terms because a country's concern for the externality does not - in itself - increase of decrease its import share from country n. It is the distance between κ_i and κ_n that matters for the bilateral trade between i and n.

In the previous section, we have shown that the dispersion in κ's naturally gives rise to trading blocs. The following proposition generalizes this insight in a multi-country multi-industry set-up *à la* Eaton-Kortum (2002):

Proposition 4. *The imports from n by country i, M_{in}, are log-supermodular in (κ_i, κ_n).*

Proof. *See Appendix 6.5*

In a an environment *à la* Eaton and Kortum (2002) world, there are no strict trade blocs as all countries trade with one another. However, the strong trade ties between countries with similar κ's implied by the log supermodularity is the smooth counterpart to the formation of trade blocs. Interestingly, our setup thus generates a Linder-like result through the optimal choice of standards by countries with different concerns for externalities.

3.3 Trade creation and trade diversion.

In 2.3, we have discussed the gains from standard harmonization in a two-country setting. We now revisit the impact of a bilateral agreement when the planner maximizes the joint welfare of i and n ignoring other countries in the world, affecting thereby third countries. We consider the case where $c_n < c_i$ and where $\kappa_n \in \mathcal{K}_i^P$, i.e. trade from n to i is optimal from the planner's perspective. Without loss of generality, consider the case where $\kappa_n > \kappa_i$, i.e. the exporting country n has a stronger concern about the externality than country i. The planner's solution is such that it implements a less stringent standard in n than in the closed economy, i.e. $E_n^P > E_n^*$. All other countries importing from n see their consumer price change between the Nash and the planner's solution in such a way that all countries i' with $\kappa_{i'} < \kappa_i$ importing from n benefit from the policy. Indeed, The consumer price in country i' if it imports from n at standart E is $c_n m(E) + \kappa_{i'} E$, which is minimized for E such that $c_n m'(E) + \kappa_i = 0$. If $\kappa_i' < \kappa_i$ and $\kappa_n \in \mathcal{K}_{i'}(c_n)$, the minimal consumer price obtains for an $E > E_n^P > E_n^*$ and the planner's policy reduces the consumer price in i' which imports (weakly) more from n (trade creation).

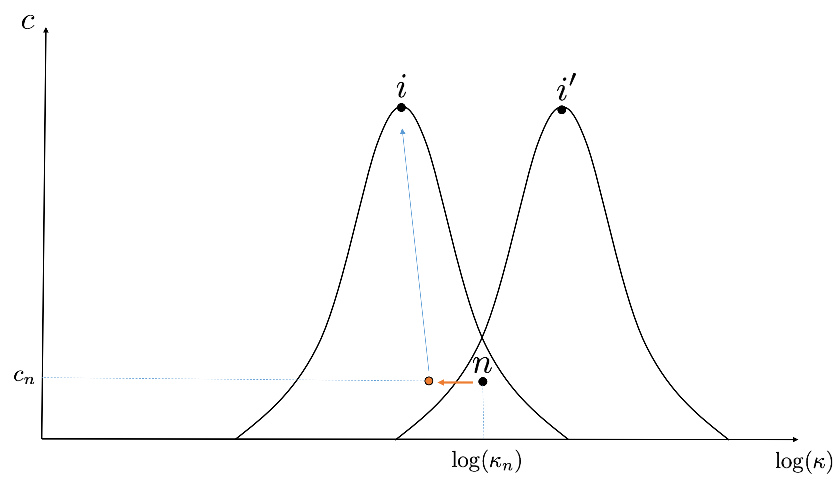

Figure 5: Trade diversion.

The opposite holds for countries with $\kappa_{i'} > \kappa_n$. Figure 5 above illustrates the case of trade diversion when country i' doesn't even find it beneficial to import at all from n at the new harmonised standard. Graphically, a trade agreement with i such that $\kappa_i < \kappa_n$ leads the exporter n to move horizontally - along its technology level c_n - towards regulatory preferences $\kappa_i < \kappa_n$. It then produces at a new standard - the orange dot, a regulatory compromise between κ_i and κ_n - which is above country i''s iso-price curve.

Last, for countries with $\kappa_{i'} \in (\kappa_i, \kappa_n)$, the effect is ambiguous and more likely to be negative the closer their $\kappa_{i'}$ is to κ_n.

3.4 Multilateral trade agreements.

We now consider the problem of the planner as outlined in (15) with $N > 2$ countries when the planner internalizes third-country effects. The planner may decide on one or several bilateral, multilateral agreements. By design, all importing countries that participate to a multilateral agreement import at the same standard. The following propositions capture some of the most salient features of the planner's problem with many countries.

Proposition 5. *If countries differ sufficiently in their concern for the externality (i.e. if* $\max_i \kappa_i / \min_i \kappa_i$ *is large enough) and if the cost advantage of the least cost source is not too strong, there is more than one producing country in the first best.*

Proof. *See Appendix*

The number of producing countries is equal to the number of different standards that are available in the world. If the heterogeneity in the concern for the externality is strong, the planner caters to these different concerns by requiring many countries to produce at different standards. This however comes at a cost as it implies that not all countries buy from the least cost producer. The above proposition states this tradeoff formally and provides conditions under which different countries should buy goods of different standards. In particular, this proposition states that a multilateral trade policy aiming to harmonize standards throughout the world is not first best if concerns about the externalities are heterogeneous. The following proposition characterizes the optimal assignment of importers to exporters.

Proposition 6. *The first best solution is such that, if a source sells to countries 1 and 2 such that $\kappa_1 < \kappa_2$, it sells to all countries with $\kappa \in [\kappa_1, \kappa_2]$.*

Proof. *See Appendix*

The above proposition shows that a given source will always sell to countries within a given interval of κ. Countries with similar concerns about the externalities should thus buy from the same exporter, suggesting that importers can be ordered in blocs. Given the assumptions or our setup, the solution of the first best problem is such that the countries with the lowest costs c sell to different blocs of importers ordered by their externality concern κ, at a standard which corresponds to a weighted average of the κ's of that interval. Nothing however guarantees that the least cost producer will wish to buy from itself and the optimal solution may have that countries produce at a standard at which they do not want to consume.

4 Robustness

4.1 No consumption tax.

In our baseline model, the use of consumption tax allows governments to pass-on the social cost of the externality into consumer prices. In particular, this leads countries to reach their first-best in the closed economy. In this subsection, we show however that the main take-away of our baseline model remains even in the absence of this policy instrument. Specifically, we investigate the robustness of our results to the case where countries cannot use a consumption tax but can only pick the standard that they want to allow on their market. The first order condition for welfare with respect to E becomes:

$$cm'(E) + \kappa_n - \kappa_n \epsilon_q(c, E) \frac{m'(E)E}{m(E)} = 0 \tag{24}$$

where ϵ_q is absolute value of the price elasticity of demand. The additional effect reflects the fact that increasing E, by decreasing the price, raises the consumption of the good, thereby raising the externality. By taking this additional effect into account, the optimal choice of E will tend to be lower than when a tax is available. We consider for simplicity the case where the demand elasticity is constant ($u(x) = \frac{x^\alpha}{\alpha}$), for which $\epsilon_q = \frac{1}{1-\alpha}$. We also assume the functional form (M) for $m(E)$. The condition (24) becomes:

$$\kappa_n\left(1+\frac{\delta}{1-\alpha}\right)+cm'(E_n^{T*})=0. \tag{25}$$

The main difference with the previous analysis is that prices are not a sufficient statistics for welfare anymore. To derive the condition under which a country i wants to import from a country n with $c_i > c_n$, we therefore need to compute explicitly the condition for $\mathcal{W}_i(c_n^*, E_n^{T*}, 0) > \mathcal{W}_i(c_i^*, E_i^{T*}, 0)$. We show in the appendix 6.3 that the above condition boils down to:

$$\left(\frac{c_i\kappa_i^\delta}{c_n\kappa_n^\delta}\right)^{\frac{1}{1+\delta}} > \left(1+\frac{\delta\alpha\left(1-\frac{\kappa_i}{\kappa_n}\right)}{(1-\alpha)(1+\delta)}\right)^{\frac{\alpha-1}{\alpha}}, \tag{26}$$

which is the counterpart of (13) without consumption tax. We also show in the appendix that the above condition defines a range $\mathcal{K}_i^T(c_n) \equiv [\underline{\kappa}_i^T(c_n), \bar{\kappa}_i^T(c_n)]$ with $\kappa_i \in \mathcal{K}_i^T(c_n)$ such that i imports from n if and only if $\kappa_n \in \mathcal{K}_i^T(c_n)$. We further show in the appendix that $\mathcal{K}_i^T(c_n) \subset \mathcal{K}_i(c_n)$, i.e. the range of parameters for which i imports from n is strictly smaller than when a consumption tax is available.

4.2 Destination-specific standards

Our baseline model assumes that the importing country cannot choose the standard at which the imported good is produced. Trade is thus akin to sacrificing a policy instrument - the choice of the production standard - in order to benefit from the better technology of a country's trade partner. We now extend our model to the case where a country n can produce at different standards and tailor its production to the standard of a potential destination. We assume that the importer can decide the standard for the imported good, but that customizing the standard to the destination market comes at an additional cost for the exporting country. Specifically, we assume that supplying a good tailored to the standard E_i in country n, $c_n\mu(E_i, E_n)$ is given by:

$$c_n\mu(E_i, E_n) = c_n m(E_i) + \rho\mathcal{D}(E_i - E_n), \tag{27}$$

where $\mathcal{D}''(x) > 0$, and $\mathcal{D}(0) = \mathcal{D}'(0) = 0$. $\mathcal{D}(E_i - E_n)$ can thus be thought of as a measure of the distance between the two standards. The rationale for the above assumption is that producing at a different standard than the usual one is costly, and producing at a different standard is costlier the larger the distance between the two standards. Since exporting does not yield any additional surplus to producers under perfect competition, the optimal standard from the perspective of n remains at the closed-economy level $E_n = E_n^*$. For the importer

i however, E_i^D is implicitly defined by:

$$c_n m'(E_i^D) + \kappa_i + \rho \mathcal{D}'(E_i^D - E_n^*) = 0, \tag{28}$$

and verifies the following property, which follows from (28) and the assumption on the function $\mathcal{D}$:

$$E_i^D = \beta_{in} E_n^* + (1 - \beta_{in}) E^*(c_n, \kappa_i), \quad \text{with: } \beta_{in} \in [0, 1].$$

The optimal standard from the perspective of i is between the standard that it would optimally set if it had costless access to n's technology and the closed economy standard of country n. This reflects the fact that deviating from E_n^* entails a cost which depends on the distance between E_i^D and E_n^*. If $\rho = 0$, $\beta = 0$ and country i can use n's technology with no additional costs. If $\rho \to \infty$, however, it is infinitely costly to deviate from n's closed economy standard and $\beta = 1$. With destination-specific standards, the condition for country i to import from n given that $c_i > c_n$ becomes:

$$c_n m(E_i^D) + \rho \mathcal{D}(E_i^D - E_n^*) + \kappa_i E_i^D < c_i m(E_i^*) + \kappa_i E_i^*. \tag{29}$$

We show in the appendix 6.4 that the above condition, as well as Assumptions 1, defines a range $\mathcal{K}_i^D(c_n, \rho) \subseteq [0, \infty)$ with $\kappa_i \in \mathcal{K}_i^D(c_n, \rho)$ such that i imports from n if and only if $\kappa_n \in \mathcal{K}_i^D(c_n, \rho)$, where $\mathcal{K}_i(c_n) \subset \mathcal{K}_i^D(c_n, \rho)$ and where $\lim_{\rho \to \infty} \mathcal{K}_i^D(c_n, \rho) = \mathcal{K}_i^D(c_n, \rho)$. By having the ability to use n's technology but still keeping some margin on how to set the standard, the importing country benefits more from trade than in the baseline situation and trade occurs for a wider range of parameters. In the limit when $\rho = 0$, we are back in a standard Ricardian case where differences in technology $c_n < c_i$ are sufficient to determine trade patterns, regardless of any asymmetry in the concerns for the externality.

4.3 Production externalities

The importance of production externalities in international trade is well understood (e.g. Copeland and Taylor (1994)). Nethertheless, it is worth contrasting their implications with our current framework. We now assume instead that it is the production of the good in our baseline model which generates a per-unit externality E. The first-best in a closed-economy is unchanged and can be obtained through the use of a Pigouvian tax.

In an open-economy, Ricardian differences in technology are no longer necessary for the importer to gain from trade. At the country level, substituting its production with imports comes down to outsourcing the externality costs.

As for the exporter, under perfect competition and at the closed-economy standard, we know that social welfare arising from domestic consumption is maximized but there is now an increase in production externalities due to trade. Absent any terms-of-trade motive (we adopt the broad definition of Bagwell and Staiger (2012) which encompasses profit shifting, see Grossman (2016) for details), trade would lead to a welfare loss compared to the closed-economy case. We consider here a situation in which the exporting country may use an export tax to break even. In order to contrast our results with the benchmark case however, we assume away terms of trade manipulation i.e. the use of an export tax for profit shifting.[13] This is the case with the implementation of an export tax is $t^X := \kappa_n E_n$ so that the social cost of the externality is exactly internalized by foreign consumers i.e. $q_i = c_n m(E_n) + \kappa_n E_n$ and the exporting country is again indifferent to trade by construction.

In this event, the standard of the exporting country remains at its closed-economy level. The importing country aims at decreasing the final consumption price: it will gain from trade when the following condition is satisfied

$$c_n m(E_n) + \kappa_n E_n < c_i m(E_i) + \kappa_i E_i$$

Interestingly enough we are back to the standard law of comparative advatange - where closed-economy prices predict the direction of trade. It also implies that the impact of the concerns for production externalities have now the opposite impact on trade patterns. Indeed, a country's comparative advantage is now magnified when it has very little concern over production externalities. The importer on the other hand sees trade as a way to outsource the externality: *trade is more likely to take place between countries who differ in their regulatory preferences.*

5 Conclusion

We have developed a Ricardian trade model where countries set product standards to solve the externalities associated with the consumption of goods. We have shown that since countries differ in their regulatory preferences over these externalities, they choose different standards in a closed economy. In an open-economy, countries may recognize the standard of other countries, allowing thereby gains from importing. For these gains to materlialize however, it must be that technological differences outweigh countries' asymmetric concerns over these externalities. With many countries and a continuum of industries, the model yields a structural gravity equation where bilateral resistance terms reflect countries' divergence in their regulatory preferences. We have shown that countries tend to import disproportionately more from countries which share similar regulatory preferences. In the absence of terms-of-trade effects, the purpose of a trade agreement is the coordination of countries on their standards (harmonization). In the presence of highly-dispersed regulatory preferences, the gains from a multilateral trade policy are small, which leads the emergence of socially optimal trade blocs.

[13] This could also be rationalized by assuming that demand is infinitely elastic as in the textbook small open-economy case.

Our results stand in sharp contrast with models featuring *production* externalities. In this event, 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.

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6 Appendix (preliminary)

6.1 Proof of Proposition 2

We define G_{in} as the left hand side minus the right hand side of (12):

$$G_{in} \equiv c_n m(E_n^*) + \kappa_i E_n^* - c_i m(E_i^*) - \kappa_i E_i^*, \tag{30}$$

where i imports from n if $G_{in} < 0$. Differentiating with respect to κ_n gives:

$$\frac{\partial G_{in}}{\partial \kappa_n} = (c_n m'(E*_n) + \kappa_i)\frac{\partial E_n^*}{\partial \kappa_n} = (\kappa_i - \kappa_n)\frac{\partial E_n^*}{\partial \kappa_n}$$

where the second equality uses the first-order condition for E_n^* and where $\frac{\partial E_n^*}{\partial \kappa_n} < 0$. The value of G_{in} is thus minimized for $\kappa_n = \kappa_i$, in which case $G_{in} < 0$.

Under Assumptions 1 and 2:

$$\lim_{\kappa_n \to \infty} E_n^* = 0 \quad \text{and} \quad \lim_{\kappa_n \to \infty} m(E_n^*) = \infty, \quad \text{implying:} \quad \lim_{\kappa_n \to \infty} G_{in} = \infty$$

$$\lim_{\kappa_n \to 0} E_n^* = \infty \quad \text{and} \quad \lim_{\kappa_n \to 0} m(E_n^*) = 0, \quad \text{implying:} \quad \lim_{\kappa_n \to \infty} G_{in} = \infty$$

This proves that if κ_n is

6.2 Implementation in the baseline model

$$\frac{\partial t_i(c_n, E_n^*)}{\partial \kappa_n} = \frac{\kappa_i}{c_n}\frac{\partial E_n^*}{\partial \kappa_n}\frac{1}{m(E_n^*)}\left(1 - \frac{E_n^* m'(E_n^*)}{m(E_n^*)}\right) < 0 \tag{31}$$

Minimum standard: $\tilde{E}_i$ such that:

$$c_n m(E^*(\kappa_n, c_n)) = c_i m(\tilde{E}_i) \tag{32}$$

which implies:

$$\frac{\partial \tilde{E}_i}{\partial \kappa_n} = \frac{c_n}{c_i}\frac{m'(E_n^*)}{m'(\tilde{E})}\frac{\partial E_n^*}{\partial \kappa_n} < 0 \tag{33}$$

If κ_n is such that $E^*(\kappa_n, c_n) = E^*(\kappa_i, c_i)$, it is immediate that $G_{ni} < 0$. It implies that $E^*(\underline{\kappa}_i, c_n) > E^*(\kappa_i, c_i)$ and that $c_n m(E^*(\underline{\kappa}_i, c_n)) < c_i m(E^*(\kappa_i, c_i))$. Since at $\underline{\kappa}_i$:

$$c_n m(E^*(\underline{\kappa}_i, c_n))(1 + t_i(c_n, E^*(\underline{\kappa}_i, c_n))) = c_i m(E^*(\kappa_i, c_i))(1 + t_i(c_i, E^*(\kappa_i, c_i))), \tag{34}$$

it implies

$$t_i(c_n, E^*(\underline{\kappa}_i, c_n)) > t_i(c_i, E^*(\kappa_i, c_i)) \tag{35}$$

Define $\tilde{\kappa}_H$ as the κ_n such that $c_n E^*(\tilde{\kappa}, c_n) = c_i m(E^*(\kappa_i, c_i))$. It implies that $E^*(\tilde{\kappa}_H, c_n) < E^*(\kappa_i, c_i)$ and that $G_{ni}(\tilde{\kappa}_H) < 0$. It must therefore be the case that $c_n m(E^*(\underline{\kappa}_i, c_n)) > c_i m(E^*(\kappa_i, c_i))$ and that

$$t_i(c_n, E^*(\bar{\kappa}_i, c_n)) < t_i(c_i, E^*(\kappa_i, c_i)). \tag{36}$$

6.3 With no consumption tax

We consider the case where $u(x) = \frac{1}{\alpha}x^\alpha$, with $\alpha < 1$, which implies that $x^*(c, E, 0) = p(c, E)^{\frac{1}{\alpha-1}}$. $\mathcal{W}_n$ thus becomes:

$$\mathcal{W}_n(c, E, 0) = I_n + p(c, E)^{\frac{1}{\alpha-1}} \left(\frac{1-\alpha}{\alpha} p(c, E) - \kappa_n E \right) \tag{37}$$

where $p(c, E) = c\frac{E^{-\delta}}{\delta}$. We know that:

$$E_n^* = \left[\frac{c_n}{\kappa_n} \frac{1-\alpha}{1-\alpha+\delta} \right]^{\frac{1}{1+\delta}} \qquad \text{and:} \qquad p(c_n, E_n^*) = c_n^{\frac{1}{1+\delta}} \kappa_n^{\frac{\delta}{1+\delta}} \frac{1}{\delta} \left(\frac{1-\alpha+\delta}{1-\alpha} \right)^{\frac{\delta}{1+\delta}} \tag{38}$$

$$\mathcal{W}_n(c_n, E_n^*, 0) = \frac{(1-\alpha)(1+\delta)}{\alpha\delta} \delta^{\frac{1}{1-\alpha}} \left(\frac{1-\alpha}{1-\alpha+\delta} \right)^{\frac{1-\alpha+\delta}{(1+\delta)(1-\alpha)}} \left(c_n \kappa_n^\delta \right)^{\frac{\alpha}{(\alpha-1)(1+\delta)}} \tag{39}$$

$$\mathcal{W}_i(c_n, E_n^*, 0) = \left(\frac{1-\alpha+\delta}{\alpha\delta} - \frac{\kappa_i}{\kappa_n} \right) \delta^{\frac{1}{1-\alpha}} \left(\frac{1-\alpha}{1-\alpha+\delta} \right)^{\frac{1-\alpha+\delta}{(1+\delta)(1-\alpha)}} \left(c_n \kappa_n^\delta \right)^{\frac{\alpha}{(\alpha-1)(1+\delta)}} \tag{40}$$

The condition for i to import, $\mathcal{W}_i(c_n, E_n^*, 0) > \mathcal{W}_i(c_i, E_i^*, 0)$, becomes:

$$\left(\frac{c_i \kappa_i^\delta}{c_n \kappa_n^\delta} \right)^{\frac{1}{1+\delta}} > \left(1 + \frac{\delta\alpha \left(1 - \frac{\kappa_i}{\kappa_n} \right)}{(1-\alpha)(1+\delta)} \right)^{\frac{\alpha-1}{\alpha}} \tag{41}$$

6.4 Standard to destination

Proof of $\mathcal{K}_i(c_n) \subset \mathcal{K}_i^D(c_n, \rho)$: totally differentiating (28) shows that

$$\frac{\partial E_i^D}{\partial \kappa_n} = \frac{\partial E_n^*}{\partial \kappa_n} \frac{-\rho \frac{\partial^2 \mathcal{D}}{\partial E_n^* \partial E_i^D}}{c_n m''(E_i^D) + \rho \frac{\partial^2 (D)}{\partial^2 E_i^D}} \tag{42}$$

Since the distance function has the following properties:

$$\frac{\partial \mathcal{D}(E_i - E_n^*)}{\partial E_i} = -\frac{\partial \mathcal{D}(E_i - E_n^*)}{\partial E_n^*} \qquad \frac{\partial^2 \mathcal{D}}{\partial^2 E_i} = -\frac{\partial^2 \mathcal{D}}{\partial E_n^* \partial E_i} > 0, \tag{43}$$

we immediately obtain that:

$$0 > \frac{\partial E_i^D}{\partial \kappa_n} > \frac{\partial E_n^*}{\partial \kappa_n}. \tag{44}$$

We define G_{in}^D as the left hand side minus the right hand side of (29):

$$G_{in}^D \equiv c_n m(E_i^D) + \rho \mathcal{D}(E_i^D - E_n^*) + \kappa_i E_i^D - c_i m(E_i^*) - \kappa_i E_i^*. \tag{45}$$

We immediately note that if $\kappa_i = \kappa_n$, $G_{in} = G_{in}^D < 0$, so that i imports from n. Differentiating with respect to κ_n gives, by the envelope theorem:

$$\frac{\partial G_{in}^D}{\partial \kappa_n} = \rho \frac{\partial E_n^*}{\partial \kappa_n} \frac{\partial \mathcal{D}}{\partial E_n^*} = \frac{\partial E_n^*}{\partial \kappa_n} \left(c_n m'(E_i^D) + \kappa_i \right) \tag{46}$$

where the second equality uses the definition of E_i^D in (28) and the fact that $\frac{\partial \mathcal{D}(E_i^D - E_n^*)}{\partial E_n^*} = -\frac{\partial \mathcal{D}(E_i^D - E_n^*)}{\partial E_i^D}$. We thus obtain that:

$$\frac{\partial G_{in}^D}{\partial \kappa_n} = \frac{c_n m'(E_i^D) + \kappa_i}{c_n m'(E_n^*) + \kappa_i} \frac{\partial G_{in}}{\partial \kappa_n}. \tag{47}$$

Since $E_i^D > (<) E_n^*$ if $\kappa_n > (<) \kappa_i$ and $m''() > 0$, we immediately obtain that:

$$\left| \frac{\partial G_{in}^D}{\partial \kappa_n} \right| < \left| \frac{\partial G_{in}}{\partial \kappa_n} \right|,$$

which proves that $\mathcal{K}_i(c_n) \subset \mathcal{K}_i^D(c_n, \rho)$.

6.5 Derivation of (22) and proof of Proposition 4

Derivation of (22) To simplify the notation, we define $\mathsf{c} \equiv c^{\frac{1}{1+\delta}}$. c is drawn from a Fréchet distribution:

$$G_n(\mathsf{c}) = 1 - e^{-T_n \mathsf{c}^{-\theta}} \tag{48}$$

The probability that a good from country n with costs c has the lowest consumer price in i is given by the probability that all other sources are more expensive, i.e.:

$$G_{in}(\mathsf{c}) = \prod_{m \neq n} \left(1 - G_m \left(\mathsf{c} \left(\frac{\kappa_n}{\kappa_m} \right)^{\frac{\delta}{1+\delta}} \frac{\frac{1}{\delta} + \frac{\kappa_i}{\kappa_n}}{\frac{1}{\delta} + \frac{\kappa_i}{\kappa_m}} \right) \right)$$

The imports of i from n are given by:

$$M_{in} = \int_0^\infty \left(\left(\frac{1}{\delta} + \frac{\kappa_i}{\kappa_n} \right) \mathsf{c} \kappa_n^{\frac{\delta}{1+\delta}} \right)^{\frac{1}{\alpha-1}} G_{in}(\mathsf{c}) dG_n(\mathsf{c}) = T_n \theta \int_0^\infty \left(\kappa_n^{\frac{\delta}{1+\delta}} \left(\frac{1}{\delta} + \frac{\kappa_i}{\kappa_n} \right) \right)^{\frac{1}{\alpha-1}} \mathsf{c}^{\theta-1+\frac{1}{\alpha-1}} e^{-\sum_m T_m \left[\left(\frac{\kappa_n}{\kappa_m} \right)^{\frac{\delta}{1+\delta}} \frac{\frac{1}{\delta}+\frac{\kappa_i}{\kappa_n}}{\frac{1}{\delta}+\frac{\kappa_i}{\kappa_m}} \mathsf{c} \right]^\theta} d\mathsf{c}$$

Integrating by substitution and rearranging gives (22).

Proof of Proposition 4 Note that since

$$\left(\frac{M_{in}}{M_{i'n}} \frac{M_{i'n'}}{M_{in'}} \right) = \left(\frac{\phi_{in}}{\phi_{i'n}} \frac{\phi_{i'n'}}{\phi_{in'}} \right)^{-\theta}$$

we need to show that ϕ_{in} is log-supermodular in (κ_i, κ_n), i.e. that $\frac{\phi_{in}}{\phi_{i'n}} \frac{\phi_{i'n'}}{\phi_{in'}} < 1$ for $\kappa_i > \kappa_{i'}$ and $\kappa_n > \kappa_{n'}$.

That $\frac{\phi_{in}}{\phi_{i'n}} \frac{\phi_{i'n'}}{\phi_{in'}} < 1$ boils down to

$$\left((\kappa_n/\kappa_i)^{\frac{\delta}{\delta+1}} + \delta (\kappa_i/\kappa_n)^{\frac{1}{\delta+1}} \right) \left((\kappa_{n'}/\kappa_{i'})^{\frac{\delta}{\delta+1}} + \delta (\kappa_{i'}/\kappa_{n'})^{\frac{1}{\delta+1}} \right) < \left((\kappa_n/\kappa_{i'})^{\frac{\delta}{\delta+1}} + \delta (\kappa_{i'}/\kappa_n)^{\frac{1}{\delta+1}} \right) \left((\kappa_{n'}/\kappa_i)^{\frac{\delta}{\delta+1}} + \delta (\kappa_i/\kappa_{n'})^{\frac{1}{\delta+1}} \right)$$

Simplifying the above expression, we get that

$$(\kappa_i/\kappa_n)^{\frac{1}{\delta+1}} (\kappa_{n'}/\kappa_{i'})^{\frac{\delta}{\delta+1}} + (\kappa_n/\kappa_i)^{\frac{\delta}{\delta+1}} (\kappa_{i'}/\kappa_{n'})^{\frac{1}{\delta+1}} < (\kappa_i'/\kappa_n)^{\frac{1}{\delta+1}} (\kappa_{n'}/\kappa_i)^{\frac{\delta}{\delta+1}} + (\kappa_n/\kappa_{i'})^{\frac{\delta}{\delta+1}} (\kappa_i/\kappa_{n'})^{\frac{1}{\delta+1}}$$

which we can rearrange as follows

$$\left(\kappa_{n'}^{\frac{\delta}{\delta+1}} \kappa_n^{-\frac{1}{\delta+1}} \right) \left[\kappa_i^{\frac{1}{\delta+1}} \kappa_{i'}^{-\frac{\delta}{\delta+1}} - \kappa_{i'}^{\frac{1}{\delta+1}} \kappa_i^{-\frac{\delta}{\delta+1}} \right] < \left(\kappa_n^{\frac{\delta}{\delta+1}} \kappa_{n'}^{-\frac{1}{\delta+1}} \right) \left[\kappa_i^{\frac{1}{\delta+1}} \kappa_{i'}^{-\frac{\delta}{\delta+1}} - \kappa_{i'}^{\frac{1}{\delta+1}} \kappa_i^{-\frac{\delta}{\delta+1}} \right]$$

Using that $\kappa_i > \kappa_{i'}$, the above expression will be true if and only if

$$\kappa_{n'}^{\frac{\delta}{\delta+1}} \kappa_n^{-\frac{1}{\delta+1}} < \kappa_n^{\frac{\delta}{\delta+1}} \kappa_{n'}^{-\frac{1}{\delta+1}}$$

which is guaranteed by $\kappa_n > \kappa_{n'}$.