# The Political Economy of International Regulatory Cooperation*

# WORKING PAPER VERSION

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**Abstract**

We examine international regulatory agreements that are negotiated under lobbying pressures from producer groups. The way in which lobbying influences the cooperative setting of regulatory policies, as well as the welfare impacts of international agreements, depend crucially on whether the interests of producers in different countries are aligned or in conflict. The former situation tends to occur for product standards, while the latter tends to occur for process standards. We find that, if producer lobbies are strong enough, agreements on product standards lead to excessive de-regulation and decrease welfare, while agreements on process standards tighten regulations and enhance welfare.

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# 1 Introduction

After decades of trade liberalization, tariffs have reached historically low levels, so there is limited scope for further tariff reductions. As a result, recent trade agreements largely revolve around non-tariff issues such as domestic regulations. For example, all the agreements signed by the US since the North American Free Trade Agreement (NAFTA) contain provisions on environmental and labor standards, and the same is true for most of the agreements signed by the EU, including the recent Comprehensive Economic and Trade Agreement (CETA) with Canada.[1] Furthermore, many recent agreements have established regulatory cooperation councils that aim to coordinate national regulatory agencies on an ongoing basis.[2]

International agreements whose scope extends to domestic policies are often referred to as "deep" agreements, in contrast with "shallow" agreements that focus only on border policies. Deep agreements have been very controversial, as evidenced for example by the massive protests against CETA and TTIP in Europe, which drew hundreds of thousands of people to the streets. While some opponents criticize any form of economic globalization, most object specifically to the deep integration elements. The overarching concern is that deep agreements may get hijacked by special interests. In particular, a common claim is that business groups exert disproportionate influence on regulatory cooperation bodies, thus undermining consumer safety and endangering the environment. A case in point was the public uproar against allowing the sale of chlorine-washed chicken in Europe, which had been banned earlier by the EU. An example of this kind of criticism is the following statement by the Institute for Agriculture and Trade Policy: "*Regulatory cooperation activities most often take place behind closed doors, with a corporate-directed deregulatory agenda, and with minimal participation by civil society or stakeholders outside of the regulated industries...*" (www.iatp.org/new-nafta-grp)

These concerns are shared by some academic economists. For example, Dani Rodrik (2018) argues informally that shallow integration is likely to enhance welfare because it empowers exporter lobbies and pits them against import-competing interests, but warns that deep integration may be bad for welfare because it empowers the "wrong" special interests.

[1] See for example ustr.gov/issue-areas/environment/bilateral-and-regional-trade-agreements and ec.europa.eu/trade/policy/policy-making/sustainable-development.

[2] Some well-known regulatory cooperation councils are CETA's Regulatory Cooperation Forum, the Canada-US Regulatory Cooperation Council and the US-Mexico High Level Regulatory Cooperation Council, and a similar council is part of the proposed Transatlantic Trade and Investment Partnership (TTIP) between the EU and the US.

Academic research on the impact of special interests on trade agreements has focused mostly on questions surrounding shallow integration, but has paid little attention to the political economy of deep agreements. In this paper we take a step in this direction, and in particular we focus on the question of how global welfare is impacted by international regulatory agreements when these are influenced by industrial lobbies.

The simple overarching idea underlying our theory can be described as follows. A key determinant of the welfare impact of politically-pressured agreements is whether lobbies have more influence when policies are set unilaterally or when they are set by international negotiations; in the former case, international negotiations *dilute* the influence of lobbies, and agreements tend to increase welfare; in the latter case, international negotiations *intensify* the influence of lobbies, so agreements may decrease welfare.[3] This depends critically on whether the interests of a country's lobbies are aligned or in conflict with those of foreign countries' lobbies: in the former case, international negotiations induce "co-lobbying"; in the latter, they induce "counter-lobbying."

Whether international negotiations induce co-lobbying or counter-lobbying in turn depends crucially on the nature of the policy on the negotiating table. Our theory emphasizes a distinction between two types of regulations: *product* standards (defined as restrictions on the characteristics of products sold in the local market) and *process* standards (defined as restrictions on production processes that take place on domestic soil). If a country loosens its product standards (in a non-discriminatory way), this benefits both domestic and foreign producers, so in this case there is co-lobbying. On the other hand, loosening process standards benefits domestic producers while hurting foreign producers, so in this case there is counter-lobbying. This intuition thus suggests that international cooperation is less benign when negotiations focus on product standards than when they focus on process standards.[4]

[3] The statement above is based on the notion that lobbying tends to be detrimental for welfare. In our setting this is always true if lobbies are sufficiently powerful, but may not be true if the power of lobbies is moderate. We will come back to this point below (see footnote 48).

[4] The reason we define product standards as restrictions on the characteristics of products sold in the local market is that we want to focus on policies that a government can directly and unilaterally enforce, and for product standards this is the case only if they are destination-specific, because government A cannot restrict characteristics of products that are sold in country B. Similarly, a government cannot directly restrict characteristics of a process that takes place in a different jurisdiction, and this is why we define process standards as restrictions that a government imposes on *local* production processes. Having said this, it is important to mention that in reality there is a category of standards that does not fit within our notions of product standards or process standards, and namely, restrictions on the sale of products that are produced with certain processes. Examples of such standards are bans on the sale of clothes that are produced with child labor, or of tuna caught with dolphin-unsafe nets. This type of standards may be motivated by cross-border externalities (e.g. global moral externalities in the case of child labor or dolphin-unsafe processes) and are often proposed as unilateral policies to address such externalities, but note that they are less efficient

In reality both product standards and process standards play an important role in international regulatory cooperation. Product standards have been quite central in recent agreements such as the CETA agreement and the proposed TTIP agreement. It is noteworthy that some of the most well-known controversies regarding deep integration (including the famous case of chlorine-washed chicken) have revolved around product standards. Also process standards, such as environmental regulations for factories and safety standards for workers, have been an important area of concern for many trade agreements in the last couple of decades, as mentioned at the outset.[5]

Interestingly, Young (2016, 2017) provides an anecdotal account of the CETA and TTIP negotiations that resonates with a key theme of our paper, namely the coordination of lobbies across borders in their efforts to influence the agreements. For example, Young documents that US and European business groups acted in a coordinated way both in supporting TTIP negotiations and in influencing the content of this agreement. He reports that "*...rather than being rivals, American and European business interests are allies, adopting common positions on what they want the agreement to look like.*" (Young, 2016, p. 345). According to this account, conflict across business groups was observed only in the agricultural sector, where no transatlantic alliances were formed.[6]

We now describe in more detail the main steps of our analysis and our main results.

To focus sharply on issues of deep integration we consider a setting where border measures are unavailable, and in particular, trade taxes are not available and standards cannot discriminate against imports. In a later section we will discuss how results are affected if trade taxes are available but partially restricted, for example by a prior "shallow" agreement.

We assume a continuum of perfectly competitive small countries. This allows us to put lobbying at the heart of international negotiations, as small countries have no ability to manipulate terms of trade,[7] but later we extend the model to allow for large countries.

than process standards imposed at the origin, so they are in a sense "third best" instruments.

[5] We note that not all labor standards can be included in our definition of process standards: for example, workplace safety standards do fall within our notion of process standards, but minimum wages do not.

[6] We note that the transatlantic business alliances documented by Young and the fact that they strongly influenced TTIP negotiations are consistent both with the notions of "co-lobbying" and "counter-lobbying" as defined in our theory. These notions refer to whether the interests of domestic and foreign producers are aligned or in conflict with respect to a country's standards. But regardless of whether these interests are aligned or in conflict, our theory suggests that there is scope for coordination among lobbies across the borders, and that lobbies will support the agreement if they are powerful enough, because a key role of the agreement is to internalize the externalities exerted by a country's standards on foreign producers.

[7] The feature that lobbying is key to the purpose of an international agreement is present also in some domestic-commitment models of trade agreements, e.g. Maggi and Rodriguez-Clare (1998) and Mitra (2002). But these papers make very different points from the present paper, and they do not address deep agreements.

We start by focusing on product standards. To provide a meaningful role for product standards, we allow consumption to generate a local negative externality. Products are vertically differentiated, with lower-quality products generating worse externalities (e.g. dirtier cars causing more pollution, or more hazardous toys causing worse health-cost externalities).[8] Governments can use product standards to address the consumption externality, but they do so under political pressure from producer lobbies.

We first examine the "positive" effects of international cooperation on product standards relative to the noncooperative equilibrium, and then we characterize its effects on global welfare. We find that international cooperation loosens product standards in all countries. The basic logic behind this result is that, if a group of countries loosen their product standards, this boosts demand in these countries and increases world prices, and this in turn generates two positive externalities on other countries: it reduces consumption and hence mitigates pollution (environmental externality), and it benefits producer lobbies (political externality).

At the normative level, we find that cooperation on product standards increases welfare if lobbying pressures are sufficiently weak, but decreases welfare if lobbies are powerful enough. The broad intuition for this result is that the interests of producers world-wide are aligned, because de-regulation in any given group of country benefits producers in the whole world, so international cooperation strengthens the overall influence of lobbies on the choice of standards. This is the notion of "co-lobbying" mentioned above. If lobbies are not very powerful, the welfare motivations for regulatory cooperation dominate political considerations, and thus the agreement enhances welfare, but if lobbies are sufficiently powerful then international cooperation leads to excessive de-regulation and damages welfare.[9]

These results may seem pessimistic, but it should be kept in mind that our model abstracts from potentially important considerations, such as the presence of trans-boundary pollution externalities, that may increase the potential welfare gains from an agreement. But aside from the *sign* of the welfare change from the agreement, the more general prediction is that the influence of producer lobbies tends to decrease the welfare gain, or increase the welfare loss, from an agreement on product standards.

It should also be kept in mind that many real-world trade agreements, including the

[8]In this paper we focus on vertical standards. An examination of horizontal standards, such as compatibility standards motivated by the presence of network externalities, would require a very different setup. We briefly discuss horizontal standards in the Conclusion.

[9]We also consider the possibility that governments may use both product standards and consumption taxes to address consumption externalities, and in this case the results are more pessimistic, in the sense that international agreements on product standards decrease welfare as long as there is any lobbying.

GATT/WTO, are concerned with preventing the use of regulatory policies as a way to discriminate against foreign producers. In principle, the long-standing "National Treatment" rule in the GATT/WTO does prohibit discriminatory product standards (as we assumed in our model), but in practice this is an unfinished job. Intuition suggests that, to the extent that an agreement tackles the issue of discrimination in standards, the influence of lobbies on the agreement is likely to be benign, because there should be counter-lobbying between import-competing producers, who benefit from discrimination against imports, and exporters, who are interested in removing any discrimination.

We next turn our attention to process standards. These include environmental standards imposed on factories and workplace safety standards. To introduce a role for process standards, we allow for local production externalities and suppose that production processes are vertically differentiated, with cheaper processes generating worse externalities. In analogy with the case of product standards, governments can use process standards to address production externalities, but they do so under pressure from producer lobbies.

Unlike the case of product standards, we find that international cooperation does not necessarily lead to de-regulation. If lobbying pressures are weak an international agreement does loosen process standards, but if lobbying is strong then the agreement tightens regulations. The reason is that the two international externalities mentioned above – environmental and political – now work in opposite directions. If a group of countries loosen their process standards, this boosts supply in these countries and depresses world prices. At the environmental level this is beneficial for other countries, because it reduces production and mitigates pollution, but at the political level this damages them, because it decreases their producer surplus. If lobbying is strong enough, the negative political externality dominates, and hence the agreement tightens process standards.

The welfare impacts of international cooperation on process standards are strikingly different from the case of product standards. We find that an international agreement on process standards increases welfare if the power of lobbies is either sufficiently large or sufficiently small, and can decrease welfare only for an intermediate range of lobbying powers. Intuitively, a key ingredient of this result is that international negotiations induce counter-lobbying, because each lobby would like a loosening of its domestic regulations and a tightening of regulations in foreign countries. This counter-lobbying effect implies that international negotiations tend to dilute the overall impact of lobbies on policy-making. But note one subtle aspect of the above-mentioned result: in spite of the countervailing-lobbying effect, an agreement may decrease welfare for an intermediate range of lobbying powers, and this is guaranteed to happen if countries are not too asymmetric.

Most of our analysis deals with two separate models, one focused only on product standards and one focused only on process standards. In Section 5 we consider an integrated model that allows for both types of regulations and for externalities both on the consumption side and on the production side. In this setting we find that most of our qualitative results hold, with two qualifications. At the positive level, the equilibrium agreement changes product standards and process standards in opposite directions, and in particular, if the strength of lobbying is above a certain threshold then product standards are loosened and process standards are tightened, while the opposite is true if the strength of lobbying is below such threshold. And at the normative level, we find that when lobbying pressures are strong, the agreement decreases welfare if the relative importance of production externalities versus consumption externalities is small – since in this case product standards play a dominant role relative to process standards – while it increases welfare in the opposite case.

We then extend our analysis to the case of large countries. Two additional effects emerge in this setting. The first one is best illustrated by focusing on the case in which countries are symmetric. In our competitive setting, if countries are symmetric they do not trade, but an individual country's choice of standards does affect world prices. In the case of product standards, this implies that the incidence of such standards falls not only on domestic consumers but also on domestic producers, so lobbying matters also in the noncooperative scenario. This contrasts with the small-country case, where the incidence of product standards falls only on consumers and thus lobbying does not matter in the noncooperative scenario. Nonetheless, the basic logic of co-lobbying highlighted in the small-country model is still present, and our main results go through: in particular, the agreement loosens product standards, and it decreases welfare if lobbying is strong enough. Similarly, in the case of process standards, the incidence is shared between producers and consumers, but the basic logic of counter-lobbying is still present, and our main results still hold: in particular, the agreement tightens process standards and increases welfare if lobbying is strong enough.

The second additional effect emerges when countries are asymmetric and trade in equilibrium. Now countries have incentives to manipulate the terms of trade: in the noncooperative scenario, each country has an incentive to tighten product standards and loosen process standards (other things equal) in sectors where it imports, in order to push down world prices, and vice-versa in sectors where it exports. An international agreement now addresses three issues: environmental externalities, political externalities and terms-of-trade manipulation. The presence of the terms-of-trade motive can affect the direction in which the agreement changes standards, but when lobbying is strong enough political externalities dominate and our key results go through.

Finally, our model highlights that the presence of restrictions on taxation instruments can create a motive for international agreements. As we discuss in Section 3.6, if governments could use an unrestricted set of trade taxes or domestic taxes, regulatory policies would be undistorted in the noncooperative scenario, and the only possible role for international agreements would be to address terms-of-trade manipulation by large countries, so there would be no rationale for agreements in a world of small countries. But if governments are (at least partially) restricted in their use of trade taxes and domestic taxes, governments will seek international regulatory agreements as a way to manipulate world prices and transfer income more effectively to their producer groups.

Before plunging into the analysis, we discuss briefly the related literature.

There is a sizable literature on shallow agreements in the presence of lobbying pressures. The pioneering models in this literature are Grossman and Helpman (1995a) and Bagwell and Staiger (1999, 2001). In these models governments can use unrestricted trade taxes and subsidies, thus as highlighted just above, international agreements do not have a true political-economy motive, but rather, their only role is to address terms-of-trade manipulation.

On the other hand, there are several models within this broad family where export subsidies are restricted, and as a consequence, at the international negotiating table exporter interests are pitted against import-competing interests, or in our language, there is counter-lobbying between these interest groups: see for example Grossman and Helpman (1995b), Levy (1999), Ornelas (2005, 2008), Bagwell and Staiger (2011), Ludema and Mayda (2016), Nicita et al (2018) and Lazarevski (2020). This type of counter-lobbying is reminiscent of Dani Rodrik's argument mentioned at the outset, but we note that most of the above models adopt the same government objective functions to predict and evaluate trade policy choices, thus they cannot address the question of whether trade agreements benefit special interests at the expense of society.[10] In Section 2 we examine this question through a model of shallow agreements that shares many features with the models mentioned above, except that we assume a continuum of small countries in order to abstract from terms of trade manipulation

[10] Notable exceptions are Grossman and Helpman (1995b) and Ornelas (2005, 2008), who discuss whether politically-viable regional trade agreements are likely to cause more trade diversion or creation, and thus whether they are likely to increase or reduce welfare.

motives and emphasize the role of lobbying in the shaping of trade agreements. We will show that a trade agreement increases global welfare relative to the noncooperative equilibrium, provided it does not lead to large import subsidies.

The literature on the political economy of deep integration is very thin, and we are not aware of any model that examines the welfare impacts of politically-pressured deep agreements. Nevertheless there are papers in the literature that have points of contact with our model of regulatory cooperation. For example, a recent paper by Grossman et al. (2021) considers the optimal design of international agreements in a setting where governments can choose product standards as well as trade and domestic taxes. The questions they address are very different from ours, however. Among other things, they focus on the tradeoff between harmonization and regulatory diversity in a setting of monopolistic competition and fixed costs of standards compliance, an issue that is not a focus of our paper.[11]

The paper proceeds as follows. Section 2 focuses on shallow agreements. Section 3 examines international agreements on product standards. Section 4 focuses on the case of process standards. Section 5 presents the integrated model with both types of regulations. Section 6 considers the case of large countries. Section 7 offers concluding comments. The Appendix provides all the proofs that are not contained in the main text.

# 2 Preliminaries: Shallow Integration

Before we get to international regulatory agreements, which is the main focus of our paper, it is useful to revisit a familiar political-economy model of shallow integration, with the objective of investigating whether trade agreements benefit special interests at the expense of society. To make our points in the most transparent way, we consider an economic setting that differs from the canonical terms-of-trade models (e.g. Grossman and Helpman, 1995a) only in one respect: we assume a continuum of small countries rather than two large countries, in order to focus more sharply on the role of lobbying in the shaping of trade agreements.

## 2.1 Setup

We consider a perfectly competitive world with a continuum of countries and $\mathcal{G}+1$ goods. Good 0 is the numeraire. Here and throughout, we normalize the mass of countries to one.

[11]Other papers that examine international regulatory agreements from a purely economic perspective are Costinot (2008), Mei (2021), Parenti and Vannoorenberge (2021), and Campolmi et al (2022). See also Maggi and Ossa (2021) for a survey that discusses this literature in more detail.

In each country $i$ there is a unit mass of citizens with the following quasi-linear preferences

$$U_i = c_{i0} + \sum_{g \in \mathcal{G}} u_{ig}(c_{ig}), \tag{1}$$

where $c_{i0}$ denotes country $i$'s consumption of the numeraire good, $c_{ig}$ denotes country $i$'s consumption of good $g$, and $u_{ig}(\cdot)$ satisfies the usual properties $u'_{ig}(\cdot) > 0$ and $u''_{ig}(\cdot) < 0$. Utility maximization implies $p_{ig} = u'_{ig}(c_{ig})$, which can be inverted to yield the demand function $c_{ig} = d_{ig}(p_{ig})$, where $p_{ig}$ is the price of good $g$ in country $i$. The indirect utility of country $i$ with income $Y_i$ is then given by $V_i = Y_i + \sum_{g \in \mathcal{G}} S_{ig}(p_{ig})$, where $S_{ig}(p_{ig}) \equiv u_{ig}(d_{ig}(p_{ig})) - p_{ig} d_{ig}(p_{ig})$ is consumer surplus.

The numeraire good is produced one-for-one from labor. We assume that in each country there is positive production of the numeraire good in equilibrium, so the wage is equal to one everywhere. Each non-numeraire good is produced from labor and a sector-specific input whose returns in country $i$ we denote by $\pi_{ig}$. Hotelling's lemma implies that $y_{ig}(p_{ig}) = \pi'_{ig}(p_{ig})$, where $y_{ig}$ is country $i$'s supply of good $g$.

Countries can impose specific tariffs $\tau_{ig}$ on imported non-numeraire goods and do not have access to export policies.[12] Also, in line with most political-economy models of trade policy (including the Grossman-Helpman model), we assume away production subsidies. There are no trade costs other than the tariffs governments impose. Finally, we assume that the numeraire good is freely traded.[13]

We denote the subset of countries which import good $g$ by $\mathcal{M}_g$ and the subset of countries which export good $g$ by $\mathcal{X}_g$. Since tariffs drive a wedge between local prices and world prices and there are no export policy instruments, local prices satisfy $p_{ig} = p_g + \tau_{ig}$ for all $i \in \mathcal{M}_g$ and $p_{ig} = p_g$ for all $i \in \mathcal{X}_g$, where $p_g$ is the world price of good $g$.

[12] Export subsidies were banned long ago by GATT, so the model can be thought of as applying to tariff negotiations that have occurred after the export subsidy ban. While the assumption that export subsidies are unavailable seems descriptively realistic, the export subsidy ban is hard to explain based on standard trade models (see Maggi, 2014, for a survey of the relevant literature), but this is not a focus of our paper, and we just take this as a fact of life. And as discussed in the Introduction, we share the no-export-subsidy assumption with a large number of mainstream models of trade agreements. We also note that in our model there is no reason for a government to use export taxes, so assuming away export taxes is not restrictive in our setting.

[13] The assumption that the numeraire good is untaxed would in itself be without loss of generality, but in conjunction with the no-export-subsidy assumption it is not innocuous (we owe this observation to Ivan Werning). If we allowed for trade taxes on all goods, the effects of export subsidies could be replicated by choosing appropriate import and export taxes. We have in mind a slightly richer (and we believe more realistic) model that would not be subject to this issue and is likely to deliver similar insights as our current model, and in particular, a model where (at least) one good is not tradable. In such a setting, the no-export-subsidy restriction in general would be binding. However, non-traded goods would introduce general-equilibrium effects that are currently absent, so some qualifications to our results might arise.

World prices are pinned down by world market clearing. Letting $m_{ig}(p_{ig}) = d_{ig}(p_{ig}) - y_{ig}(p_{ig})$ and $x_{ig}(p_{ig}) = y_{ig}(p_{ig}) - d_{ig}(p_{ig})$, we can express the world market clearing conditions as

$$\int_{i \in \mathcal{M}_g} m_{ig}(p_g + \tau_{ig}) = \int_{i \in \mathcal{X}_g} x_{ig}(p_g). \tag{2}$$

Total income in country $i$ consists of labor income, which is equal to one, producer surplus $\sum_{g \in \mathcal{G}} \pi_{ig}$, and tariff revenue $\sum_{g \in \mathcal{G}} R_{ig}$, thus indirect utility can be rewritten as $V_i = 1 + \sum_{g \in \mathcal{G}} (\pi_{ig} + S_{ig} + R_{ig})$. We can abstract from the first term in $V_i$ and simply define welfare as the familiar sum of producer surplus, consumer surplus, and tariff revenue:

$$W_i = \sum_{g \in \mathcal{G}} W_{ig} = \sum_{g \in \mathcal{G}} (\pi_{ig} + S_{ig} + R_{ig}). \tag{3}$$

Governments are subject to lobbying pressures, so their objective function does not coincide with welfare. In the same spirit as Grossman and Helpman (1994, 1995a), we assume lobbies represent the groups of specific-factor owners, and we capture the influence that lobbies have on the government by assuming that government $i$ attaches extra weights $\gamma_{ig} \geq 0$ to the producer surplus in the various sectors.[14] Thus government $i$ maximizes:

$$\Omega_i = \sum_{g \in \mathcal{G}} \Omega_{ig} = \sum_{g \in \mathcal{G}} \left[ \left(1 + \gamma_{ig}\right) \pi_{ig} + S_{ig} + R_{ig} \right]. \tag{4}$$

A remark is in order on the difference between our "positive" government objective (12) and our "normative" criterion (11). We have adopted a utilitarian definition of welfare (just as in the Grossman-Helpman model) because it is the simplest and most natural one in this transferrable-utility environment, but we have in mind a broader interpretation: if we assigned different Pareto weights to different groups in our welfare criterion, our government objective would reflect these welfare weights plus the "bias" $\gamma_{ig}$ introduced by lobbying. What really matters for our results is that producer groups get more weight in the government objective than in the welfare criterion.

Next we compare the noncooperative equilibrium with the cooperative policy regime.

[14] This formulation of a government's objective is similar as in Baldwin (1987), and can be viewed as a reduced-form version of the government objectives in Grossman and Helpman (1994). In the latter model, $\gamma_{ig} = \frac{I_{ig} - \alpha_i^L}{a_i - \alpha_i^L}$, where $I_{ig}$ is a dummy that is equal to one if industry $i$ is politically organized, $\alpha_i^L$ is the share of the population represented by some lobby, and $a_i$ is government $i$'s valuation of welfare relative to campaign contributions. Also note that this model of lobbying implicitly assumes that labor-owners or consumers at large are not able to get politically organized, since these are large and dispersed economy-wide groups, so it is more difficult for them to overcome collective action problems.

## 2.2 Noncooperative equilibrium

In the noncooperative equilibrium, each importing country unilaterally sets tariffs to maximize $\Omega_i = \sum_{g \in \mathcal{G}} \Omega_{ig}$, taking world prices and other countries' tariffs as given. Since each country is small relative to the rest of the world, it takes world prices as given. This problem is separable across goods, so we can focus on a single good $g$:

$$\max_{\tau_{ig}} \Omega_{ig} = \left(1 + \gamma_{ig}\right) \pi_{ig}\left(p_g + \tau_{ig}\right) + S_{ig}\left(p_g + \tau_{ig}\right) + \tau_{ig} m_{ig}\left(p_g + \tau_{ig}\right), \quad i \in \mathcal{M}_g$$

We assume that $\Omega_{ig}$ is concave in $\tau_{ig}$ for all $i$, so we can rely on first-order conditions. It is direct to verify that the noncooperative tariffs and world price for good $g$ must satisfy:

$$\tau_{ig} = \frac{\gamma_{ig} y_{ig}\left(p_g + \tau_{ig}\right)}{-m'_{ig}\left(p_g + \tau_{ig}\right)}, \quad i \in \mathcal{M}_g \text{ and} \tag{5}$$

$$\int_{i \in \mathcal{M}_g} m_{ig}\left(p_g + \tau_{ig}\right) = \int_{i \in \mathcal{X}_g} x_{ig}\left(p_g\right) \tag{6}$$

We assume that the noncooperative equilibrium exists and is unique, meaning that there exists a unique solution to equations (5) and (6).

Notice that noncooperative tariffs are zero if $\gamma_{ig} = 0$, so lobbying is the only reason why governments deviate from free trade. And importantly, exporter interests are not taken into account in the noncooperative tariffs, since countries cannot unilaterally affect domestic prices in their exporting industries.

## 2.3 Cooperative tariffs

In the cooperative regime, countries set tariffs to maximize their joint payoff $\Omega \equiv \int_i \Omega_i = \sum_{g \in \mathcal{G}} \int_i \Omega_{ig}$ taking into account the impact of tariffs on world prices.[15] This problem is again separable across industries, so it suffices to maximize $\Omega_g$:

$$\max_{\{\tau_{ig}\}_{i \in \mathcal{M}_g}, p_g} \Omega_g = \int_i \left[\left(1 + \gamma_{ig}\right) \pi_{ig}\left(p_g + \tau_{ig}\right) + S_{ig}\left(p_g + \tau_{ig}\right) + \tau_{ig} m_{ig}\left(p_g + \tau_{ig}\right)\right]$$

$$\text{s.t.} \int_{i \in \mathcal{M}_g} m_{ig}\left(p_g + \tau_{ig}\right) = \int_{i \in \mathcal{X}_g} x_{ig}\left(p_g\right),$$

where we keep in mind that $\tau_{ig} = 0$ for $i \in \mathcal{X}_g$ in the expression above. In order to rely on a first-order-condition approach, we assume that $\Omega_g(\boldsymbol{\tau}_g, p_g(\boldsymbol{\tau}_g))$ is concave in the tariff vector

[15] We are implicitly assuming that countries have access to international transfers (in terms of the numeraire good). Given that governments have many ways to compensate each other in the context of trade negotiations, this assumption seems reasonable, but in any case it is not essential to our main qualitative results.

$\boldsymbol{\tau}_g$, where $p_g(\boldsymbol{\tau}_g)$ denotes the market-clearing price as a function of the tariffs (it is easy to show that this function is well-defined).

This problem can be solved with a standard Lagrangian approach. It is not hard to show that the cooperative tariffs and world price for good $g$ satisfy:

$$\tau_{ig} = \frac{\gamma_{ig} y_{ig}\left(p_g + \tau_{ig}\right)}{-m'_{ig}\left(p_g + \tau_{ig}\right)} - \frac{\int_{i \in \mathcal{X}_g} \gamma_{ig} y_{ig}\left(p_g + \tau_{ig}\right)}{\int_{i \in \mathcal{X}_g} x'_{ig}\left(p_g\right)}, \quad i \in \mathcal{M}_g \tag{7}$$

$$\int_{i \in \mathcal{M}_g} m_{ig}\left(p_g + \tau_{ig}\right) = \int_{i \in \mathcal{X}_g} x_{ig}\left(p_g\right) \tag{8}$$

We assume that a solution to the above system of equations exists (note that uniqueness is guaranteed by concavity of the objective function). The key difference between the noncooperative tariffs and the cooperative tariffs is the presence of the term $\frac{\int_{i \in \mathcal{X}_g} \gamma_{ig} y_{ig}}{\int_{i \in \mathcal{X}_g} x'_{ig}} > 0$ in equation (7). Notice that the numerator of this term captures the joint political power of exporters, since it integrates over all countries that are exporters of good $g$. This captures the idea that exporter interests are taken into account in the cooperative equilibrium, since countries can jointly increase world prices through tariff cuts.

## 2.4 What does the agreement do?

As we establish formally in the Appendix, under a mild regularity condition the trade agreement reduces all tariffs relative to the noncooperative equilibrium. Notice that this does not follow immediately from a comparison of equations (5) and (7), since they are evaluated at different world prices.[16]

The broad intuition for this result is that noncooperative tariffs reflect only the interests of import-competing producers, while cooperative tariffs also reflect the interests of exporters, who benefit from trade liberalization. But we can gain a deeper intuition for the tariff formula (7) by considering the international externalities exerted by tariffs through the world price. Suppose a positive measure of importing countries decreases their tariffs. This pushes up the world price by increasing import demand. How does this affect all other countries in the

[16] The regularity condition we need is a slight strengthening of the assumptions made above that there exists a unique noncooperative equilibrium and a unique solution to the first-order conditions of the cooperative problem. In particular, we assume that there exists a unique solution to the system of equations given by $\tau_{ig} = \frac{\gamma_{ig} y_{ig}(p_g + \tau_{ig})}{-m'_{ig}(p_g + \tau_{ig})} - \kappa_g$ and $\int_{i \in \mathcal{M}_g} m_{ig}\left(p_g + \tau_{ig}\right) = \int_{i \in \mathcal{X}_g} x_{ig}\left(p_g\right)$ for all $\kappa_g \in [0, \lambda_g]$, where $\lambda_g$ is the Lagrange multiplier of the cooperative problem. The assumptions already made above imply that this is true for $\kappa_g = 0$ and for $\kappa_g = \lambda_g$, so here we are extending the condition to intermediate values of $\kappa_g$. This assumption allows us to define a path that connects the noncooperative solution with the cooperative solution in the price-tariffs space, and evaluate how welfare changes along this path.

aggregate? Differentiating the joint payoff $\Omega_g$ with respect to the world price and evaluating at the noncooperative tariffs, we find:

$$\frac{\partial \Omega_g}{\partial p_g}|_{NE} = -\int_{i\in\mathcal{M}_g} m_{ig} + \int_{i\in\mathcal{X}_g} (\gamma_{ig} y_{ig} + x_{ig}) = \int_{i\in\mathcal{X}_g} \gamma_{ig} y_{ig} \tag{9}$$

The first term indicates that the externality of a decrease in tariffs on other importers is negative, since an increase in the world price is a deterioration of all importers' terms-of-trade. The second term shows that the externality on exporters is positive, for two reasons: it increases the political surplus for all exporters, and it improves their terms-of-trade. But the importers' aggregate terms-of-trade loss equals the exporters' aggregate terms-of-trade gain, so only the political externality $\int_{i\in\mathcal{X}_g} \gamma_{ig} y_{ig}$ remains. It is this externality that the trade agreement internalizes, as reflected in formula (7). Note that the net aggregate world-price externality does not include the political gain for importers ($\int_{i\in\mathcal{M}_g} \gamma_{ig} y_{ig}$), and the reason is that importers use tariffs optimally to benefit their domestic producers, whereas exporters lack policy instruments to do so.

While in our setting the purpose of a trade agreement is to deal with terms-of-trade externalities, there is a fundamental difference between the motives behind trade agreements in our model and in the standard terms-of-trade theory. In our model, the purpose of a trade agreement is not to prevent individual countries from manipulating terms-of-trade, because individual countries use tariffs only for political reasons, not to manipulate terms-of-trade. Rather, a trade agreement is motivated by lobbying pressures from exporters, given that export subsidies are restricted. It is useful to note that, if export subsidies were available, the externality (9) would be zero and hence noncooperative tariffs would be efficient, so there would be no scope for a trade agreement. And it is also apparent from (9) that there would be no need for an agreement if governments were welfare-maximizers.

We record the result above in the following proposition. The proofs of this and the next proposition are in Appendix A.

**Proposition 1** *The equilibrium trade agreement lowers all import tariffs relative to noncooperative levels, provided the aggregate political power of exporters is strictly positive.*

The model captures an often-heard "story" about the success of GATT/WTO negotiations that is quite different from the standard terms-of-trade theory: tariffs fell because the GATT/WTO changed the political calculus of policy makers, and lobbying pressures from exporter groups counter-balanced the pressures from import-competing groups, thus diluting the overall effect of lobbying on trade policy. The standard terms-of-trade story, on the other hand, is that tariffs fell because the agreement removed the individual countries' incentives to manipulate terms of trade.

### 2.5 Is it good for you?

Given that all tariffs fall as a result of the trade agreement, one might conjecture that it has positive welfare effects. This is not immediately obvious because we are allowing countries to be asymmetric in a number of dimensions, and we know from second-best theory that partial reductions of distortions (wedges) do not necessarily increase welfare. But we do confirm this conjecture, subject to the condition that the agreement not entail large import subsidies. We record this point with:

**Proposition 2** *The equilibrium trade agreement improves global welfare relative to the non-cooperative equilibrium, provided the agreement does not entail large import subsidies.*

This result suggests that we should not be excessively worried about the influence that producer lobbies have on shallow trade agreements. Intuitively, tariff negotiations trigger counter-lobbying between import-competing groups and exporting groups, hence diluting the overall effect of lobbying on trade policy relative to the non-cooperative equilibrium.

## 3 Product Standards

We now turn to the main question of our paper: what are the welfare effects of international regulatory cooperation when international negotiations are influenced by industrial lobbies?

The welfare implications of international regulatory agreements depend crucially on whether the agreement focuses on product standards or on process standards. To put these contrasting implications in sharp relief, we examine two separate models, one that focuses only on product standards and one that focuses only on process standards; we will later consider an integrated model that allows for both types of regulations.

To focus sharply on issues of deep integration, we assume that governments cannot impose border measures, and more specifically, trade taxes are not available and standards must be non-discriminatory (i.e. satisfy "national treatment"). As we will argue later, our main qualitative results are not an artifact of setting all trade taxes equal to zero, and would survive in a setting where tariffs or export subsidies are available but partially restricted.

As in the previous section, we assume away production subsidies.[17] In our basic model we also abstract from consumption taxes, but we will later extend the model to allow for this additional policy instrument.

We start by focusing on product standards, which are defined as restrictions on the characteristics of products sold in a given country. Examples include emissions standards for automobiles, safety standards for children's toys, or health standards for meat products. As mentioned in the Introduction, product standards have played a key role in a number of recent international negotiations, and have been at the center of some of the most well-known controversies regarding deep agreements.

## 3.1 Setup

We modify the economic structure of section 2 in two ways. First, we now assume that each non-numeraire good comes in a continuum of varieties, indexed by their "dirtiness" $e_g \in [0, \infty)$. For example, $e_g$ may index the amount of emissions generated by a car. Cleaner goods are more costly: in country $i$, producers have to incur an abatement cost $\phi_{ig}(e_g)$ in terms of the numeraire good for each unit of variety $e_g$ they produce. We assume $\phi_{ig}(e_g)$ is strictly positive for all $e_g$, decreasing and convex, with $\lim_{e_g \to \infty} \phi_{ig}(e_g) = 0$ and $\lim_{e_g \to 0} \phi_{ig}(e_g) = \infty$.[18]

Second, consuming a non-numeraire good generates a negative local externality, which is more severe if the good is dirtier ($e_g$ is higher). For concreteness we will focus on environmental externalities, but alternative interpretations are possible, for example health-care externalities caused by the consumption of unsafe products. The consumption externality will provide a potential welfare rationale for product standards. Each consumer is atomistic and ignores the impact of its consumption choices on the externality. Furthermore we assume that varieties are indistinguishable in the eyes of consumers.

In each country $i$ there is a unit mass of citizens with the following quasi-linear preferences:

$$U_i = c_{i0} + \sum_{g \in \mathcal{G}} [u_{ig}(c_{ig}) - E_{ig}], \tag{10}$$

where $c_{i0}$ denotes country $i$'s consumption of the numeraire good, $c_{ig}$ denotes country $i$'s consumption of good $g$, the subutility function $u_{ig}(\cdot)$ satisfies the usual properties $u'_{ig}(\cdot) > 0$

[17] If production subsidies were available, producer lobbies would focus their efforts on production subsidies, not on regulations, since the former are more efficient redistribution tools, thus it would be hard to explain the influence of lobbies on regulations, just as it would be hard to explain the influence of lobbies on trade policies.

[18] We note that our results go through also if $\phi_{ig}(0)$ is finite, as long as it is large enough.

and $u''_{ig}(\cdot) < 0$, and $E_{ig}$ is the consumption externality that the consumer takes as exogenous and which we will specify shortly.

Letting $p^c_{ig}$ denote the consumer price of good $g$ in country $i$, utility maximization implies $p^c_{ig} = u'_{ig}(c_{ig})$, which can be inverted to yield the demand function $c_{ig} = d_{ig}\left(p^c_{ig}\right)$.

The indirect utility implied by the utility function above is $V_i = Y_i + \sum_{g \in \mathcal{G}} \left[S_{ig}(p_{ig}) - E_{ig}\right]$, where $Y_i$ is income and $S_{ig}(p_{ig}) \equiv u_{ig}(d_{ig}(p_{ig})) - p_{ig} d_{ig}(p_{ig})$ is consumer surplus.

As will become clear below, in each country $i$ there will be a single variety of good $g$ that is consumed in equilibrium, say variety $e_{ig}$. Assuming that consuming one unit of variety $e_{ig}$ generates $e_{ig}$ units of pollution, the total amount of pollution is then $e_{ig} d_{ig}(p^c_{ig})$. In the case of cars, this would be the total amount of emissions from cars in country $i$. The disutility caused by a unit of pollution for the representative consumer in country $i$ is assumed to be constant and denoted by $a_{ig}$, so the local externality associated with consumption of variety $e_{ig}$ can be written as $E_{ig} = -a_{ig} e_{ig} d_{ig}(p^c_{ig})$. The parameter $a_{ig}$ can be interpreted as an environmental-preference parameter, capturing how strongly country $i$ feels against pollution.

Each government $i$ chooses emission standards $\{e_{ig}\}_{g \in \mathcal{G}}$ for products sold in its own market.[19] These can be interpreted as emission *caps*, because in this setting a cap is always binding, due to the fact that producing cleaner products is more costly and varieties are indistinguishable in the eyes of consumers.

Note that a product standard is a second-best policy, because given the variety $e_{ig}$ selected by the government, consumers do not internalize the consumption externality. One way to implement the first best is to combine a product standard with a consumption tax. At the end of this section we will argue that, if both instruments were available, our conclusions would get strengthened.

Since there are no trade costs, producer arbitrage ensures that producers get the same price net of abatement costs in any market where they sell. And since each individual country is small, its choice of standards cannot affect the net price received by its producers. Letting $p_g$ denote the producer price net of abatement costs, the price faced by consumers in country $i$ is therefore $p^c_{ig} = p_g + \phi_i(e_{ig})$. We will often refer to the net producer price $p_g$ as the "world" price.[20] Thus, if an individual country $i$ tightens its standards, the associated cost

[19] See footnote 4 for a discussion of our definition of product standards as "destination specific" restrictions.
[20] This is the net price that producers of each country can get if they sell anywhere in the world, and also the price that consumers of a country would pay if that country imposed no standard at all ($e_{ig} = \infty$).

falls entirely on its consumers.[21]

The feature that the incidence of product standards falls entirely on domestic consumers will make our results sharper, but it does not drive our main qualitative results: as we will show in section 6, if countries are large the incidence of product standards is shared between consumers and producers, but our key results continue to hold.

We can now write down an expression for welfare. Total income in country $i$ consists of labor income, which is equal to one, and producer surplus $\sum_{g\in\mathcal{G}}\pi_{ig}$, thus aggregate indirect utility can be written as $V_i = 1 + \sum_{g\in\mathcal{G}}(\pi_{ig} + S_{ig} - a_{ig}e_{ig}d_{ig})$. We can abstract from the first term in $V_i$ and define country $i$'s welfare as:

$$W_i = \sum_{g\in\mathcal{G}} W_{ig} = \sum_{g\in\mathcal{G}} \left[\pi_{ig}(p_g) + S_{ig}(p_g + \phi_i(e_{ig})) - a_{ig}e_{ig}d_{ig}(p_g + \phi_i(e_{ig}))\right]. \tag{11}$$

Governments are subject to lobbying pressures, so their objective function does not coincide with welfare. In the same spirit as Grossman and Helpman (1994, 1995a), we assume that lobbies represent the groups of specific-factor owners, and we capture the influence that lobbies have on the government by assuming that government $i$ attaches extra weights $\gamma_{ig} \geq 0$ to the producer surplus in the various sectors.[22] Thus government $i$ maximizes:

$$\Omega_i = W_i + \sum_{g\in\mathcal{G}} \gamma_{ig}\pi_{ig} \tag{12}$$

A remark is in order on the difference between our "positive" government objective (12) and our "normative" criterion (11). We have adopted a utilitarian definition of welfare (just as in the Grossman-Helpman model) because it is the simplest and most natural one in

[21] Note that, in our setting with constant returns, there is no cost in producing different varieties for different markets. In the Conclusion we will discuss how results might change if there are fixed costs of adapting a product to a country's local standard. At this juncture it is also worth highlighting the role of the assumption that abatement costs are paid in terms of the outside good. This feature is convenient because it implies that a product standard acts like a consumer tax (except that it affects the pollution level directly and does not generate revenue). An alternative assumption would be that the abatement cost is paid in terms of some non-numeraire good (possibly the same good that the standard is applied to), but this would lead to a less tractable model, because $e$ would then directly affect profits, and we would not be able to apply a simple arbitrage logic to link the prices of different varieties in different markets, and use a notion of "world price" to connect such prices. In other words, with our specification, if two countries choose two different standards, we can still think of the two varieties as the same good with different local prices. This convenient feature would be lost if abatement costs were paid in terms of some other good.

[22] This formulation of a government's objective is similar as in Baldwin (1987), and can be viewed as a reduced-form version of the government objectives in Grossman and Helpman's (1994) model. In this model, $\gamma_{ig}$ depends on government $i$'s valuation of welfare relative to campaign contributions and on the share of country $i$'s population that is represented by some lobby. Also note that this model of lobbying implicitly assumes that labor-owners or consumers at large are not able to get politically organized, since these are large and dispersed economy-wide groups, so it is more difficult for them to overcome collective action problems.

this transferrable-utility environment, but we have in mind a broader interpretation: if we assigned different Pareto weights to different groups in our welfare criterion, our government objective would reflect these welfare weights plus the "bias" $\gamma_{ig}$ introduced by lobbying. What really matters for our results is that producer groups get more weight in the government objective than in the welfare criterion.

## 3.2 Noncooperative product standards

In the noncooperative scenario, each government unilaterally chooses product standards to maximize $\Omega_i = \sum_{g\in\mathcal{G}} \Omega_{ig}$, taking world prices and other countries' standards as given. Since each country is small relative to the rest of the world, it takes world prices as given. This problem is separable across goods, so we can focus on a single good $g$. Thus each government $i$ solves:

$$\max_{e_{ig}} \Omega_{ig} = \left(1+\gamma_{ig}\right)\pi_{ig}\left(p_g\right) + S_{ig}\left(p_g + \phi_{ig}(e_{ig})\right) - a_{ig}e_{ig}d_{ig}\left(p_g + \phi_{ig}(e_{ig})\right).$$

To rely on a first-order approach we assume that the optimal unilateral standards are nonprohibitive. This is guaranteed as long as the externality parameters $a_{ig}$ are not too large.[23] Straightforward algebra reveals that the first-order condition implies:

$$e_{ig} = \frac{1}{\sigma_{ig}}\left(\frac{1}{a_{ig}} + \frac{1}{\phi'_{ig}}\right) \quad \text{for all } i, \tag{13}$$

where $\sigma_{ig} \equiv -\frac{d'_{ig}}{d_{ig}} > 0$ denotes the demand semi-elasticity.

The market clearing condition can be written as:

$$\int_i y_{ig}\left(p_g\right) = \int_i d_{ig}\left(p_g + \phi_{ig}(e_{ig})\right). \tag{14}$$

The noncooperative equilibrium product standards and world price for good $g$ solve equations (13) and (14). We assume that such solution exists and is unique, and denote it $\left(\{e^N_{ig}\}, p^N_g\right)$.[24]

[23] A prohibitive standard is one that chokes off consumption. Depending on whether the demand function has a choke price, the prohibitive level of the standard may be zero or positive. In either case, it is easy to see that the optimal level of $e_{ig}$ must be nonprohibitive if $a_{ig} = 0$, and by continuity the same is true if $a_{ig}$ is sufficiently small. Also note that $e_{ig} = \infty$ can never be optimal in our setting, as long as the $a_{ig}$ parameters are strictly positive, because this implies an infinite cost of the externality.

[24] As we show in Appendix B, a simple sufficient (but not necessary) condition on the fundamentals that guarantees the existence and uniqueness of the noncooperative equilibrium is that the demand semi-elasticities $\sigma_{ig}$ do not increase too much with the price.

The formula for the noncooperative product standards in (13) is intuitive. A country's standard is tighter when the externality weight $a_{ig}$ is higher, as one would expect. When demand is more elastic (higher $\sigma_{ig}$), the price increase caused by a tighter standard leads to a larger reduction in consumption and hence pollution, thus the optimal standard is tighter. And it is also intuitive that, if the marginal abatement cost is lower (so that $\phi'_{ig}$ has a smaller negative value), the optimal standard is tighter.

Also note that the strength of lobbies ($\gamma_{ig}$) does not affect the noncooperative product standards. The reason is that the incidence of product standards is entirely on domestic consumers, so this instrument cannot be used to help domestic producers. This feature, which depends on the small-country assumption, is extreme and makes our results sharp, but does not drive our qualitative results, as will become clear later.

## 3.3 Cooperative product standards

In the cooperative regime, governments set standards to maximize their joint payoff $\Omega \equiv \int_i \Omega_i = \sum_{g\in\mathcal{G}} \int_i \Omega_{ig}$ taking into account the impact of product standards on world prices.[25] This problem is again separable across industries, so it suffices to maximize $\Omega_g$. Thus cooperative product standards solve:

$$\max_{\{e_{ig}\},p_g} \Omega_g = \int_i \left[ \left(1+\gamma_{ig}\right) \pi_{ig}\left(p_g\right) + S_{ig}\left(p_g + \phi_{ig}(e_{ig})\right) - a_{ig} e_{ig} d_{ig}\left(p_g + \phi_{ig}(e_{ig})\right) \right] \tag{15}$$

$$\text{s.t.} \quad \int_i y_{ig}\left(p_g\right) = \int_i d_{ig}\left(p_g + \phi_{ig}(e_{ig})\right)$$

As in the noncooperative scenario, we assume that the optimal standards are nonprohibitive (which again is ensured if the $a_{ig}$ parameters are not too large), so we can rely on a standard Lagrangian approach. Letting $\lambda_g$ denote the Lagrange multiplier, it is direct to verify that the cooperative standards and world price for good $g$ satisfy the following conditions (we suppress the arguments of all functions for simplicity):

$$e_{ig} = \frac{1}{\sigma_{ig}} \left( \frac{1}{a_{ig}} + \frac{1}{\phi'_{ig}} \right) + \frac{\lambda_g}{a_{ig}} \quad \text{for all } i \tag{16}$$

$$\lambda_g = \frac{\int_i \left(\gamma_{ig} y_{ig} + a_{ig} e_{ig} \sigma_{ig} d_{ig}\right)}{\int_i \left(\varepsilon_{ig} y_{ig} + \sigma_{ig} d_{ig}\right)} > 0$$

[25] We are implicitly assuming that countries have access to international transfers (in terms of the numeraire good). Given that governments have many ways to compensate each other in the context of trade negotiations, this assumption seems reasonable, but in any case it is not essential to our main qualitative results.

$$\int_i y_{ig} = \int_i d_{ig},$$

where $\varepsilon_{ig} \equiv \frac{y'_{ig}}{y_{ig}} > 0$ denotes the semi-elasticity of supply. We assume there exists a unique solution to the system of first order conditions above.[26]

The main difference between the noncooperative and cooperative product standards is the presence of the multiplier $\lambda_g$ in equation (16). Note that $\lambda_g > 0$ even if $\gamma_{ig} = 0$, thus the agreement changes standards for both political and environmental reasons, a finding that we explore more thoroughly below. For now, just notice that all producers have a common interest in loosening product standards, since they all benefit from the resulting increase in the world price.

Also note that, since the demand semi-elasticities $\sigma_{ig}$ in general depend on prices, and the agreement changes prices, we cannot immediately infer from equations (13) and (16) whether the agreement loosens or tightens standards.[27] We investigate this question next.

## 3.4 What does the agreement do?

We now examine how the agreement changes product standards relative to the noncooperative equilibrium. Here we take a heuristic approach, relegating the formal arguments to the appendix.

We start with a local argument. Let us consider the international externalities caused by a change in product standards starting from the noncooperative equilibrium. Suppose a positive measure of countries loosens their standards. This pushes up the world price by boosting

[26] It is natural to ask whether there are restrictions on the fundamentals that ensure the uniqueness of a stationary point. Addressing this question from an analytical standpoint is hard, so we turned to a numerical approach to investigate the shape of the objective function in a two-country world. More specifically, letting $p_g(\mathbf{e}_g)$ denote the market-clearing world price as a function of the standards, the objective function can be written as $\Omega_g(\mathbf{e}_g, p_g(\mathbf{e}_g))$. For the abatement cost function we considered a constant-elasticity specification, and for the demand and supply functions we considered three alternative specifications: constant semi-elasticity, constant elasticity, and linear. In each case we explored the shape of $\Omega_g(\mathbf{e}_g, p_g(\mathbf{e}_g))$ for a large number of parameter configurations. Consistent with our assumptions, we focused on parameter values such that the optimal standards are nonprohibitive (i.e. where the $a_{ig}$ parameters are not too large). For all parameter configurations we examined, we found the objective function to always have a unique interior maximum. A final observation is that, while the case of two countries is convenient because it allows for a visual inspection of the shape of the objective function, it seems reasonable to expect similar findings with a larger number of countries, because the cooperative objective function is the joint government payoff, and so its structure is similar regardless of the number of countries. This is clearly true, for example, if countries are symmetric, because in this case the joint payoff is the same regardless of the number of countries the world is divided into.

[27] To simplify some of the proofs, we make the technical assumptions that the semi-elasticities $\sigma_{ig}$ and $\varepsilon_{ig}$ are bounded above and bounded away from zero.

demand.[28] How does this affect the joint payoff of all governments? Differentiating the joint government payoff $\Omega_g$ with respect to the world price $p_g$ and evaluating the expression at the noncooperative standards (13), we obtain:

$$\frac{\partial \Omega_g}{\partial p_g}|_{NE} = \int_i \left(\gamma_{ig} y_{ig} + a_{ig} e_{ig}^N \sigma_{ig} d_{ig}\right) > 0 \tag{17}$$

The first term is positive and captures the beneficial effect of an increase in the world price for producers worldwide. The second term is also positive and is due to the fact that an increase in the world price reduces consumption and thereby mitigates the local environmental externality in all countries. Thus the aggregate international externality from loosening product standards is positive for two reasons, a political one and an environmental one. It is this externality that the international agreement internalizes, as reflected in formula (16).

Having argued that, when starting from the noncooperative equilibrium, the aggregate international externality from loosening product standards is positive, one can then show that the "best local agreement" entails increasing $e_{ig}$ for all countries, where the best local agreement is defined as the local change in product standards that achieves the steepest rate of improvement in the objective starting from noncooperative standards. Intuitively, if we marginally loosen standards in a group of countries starting from noncooperative levels, this causes a first-order positive externality on the other countries (as we argued above), while the loss for the countries loosening their standards is second-order, because they were starting from unilaterally-optimal levels, therefore the joint payoff $\Omega_g$ increases.

The next question is whether the local result above holds also globally. We can show that the globally optimal agreement loosens all product standards at least if one of the following sufficient conditions are satisfied: (i) demand semi-elasticities $\sigma_{ig}$ do not increase too much with the price, *or* (ii) countries are not too asymmetric, *or* (iii) lobbying pressures are sufficiently strong. We emphasize that these are three alternative sufficient conditions, and none of them is necessary.[29]

[28] To see this, differentiate the market clearing condition to get $dp_g = \frac{\int_i d'_{ig} \phi'_{ig} de_{ig}}{\int_i \left(y'_{ig} - d'_{ig}\right)}$. Noting that each term of the integral in the numerator has the same sign as $de_{ig}$, it follows that if any subset of countries loosens their standards, the world price goes up.

[29] To understand intuitively the role of the sufficient condition on $\sigma_{ig}$, compare the formulas for the noncooperative and cooperative standards, (13) and (16). Cooperation has a direct effect and an indirect effect on the standard levels. The direct effect is captured by the fact that the positive quantity $\lambda_g$ enters the latter formula but not the former. This pushes toward looser standards, which in turn pushes up the world price. This price change may have an indirect effect through $\sigma_{ig}$, but this is guaranteed not to outweigh the direct

Here and throughout the paper, we consider proportional changes in all political parameters $\gamma_{ig}$, by letting $\gamma_{ig} = \gamma_g \cdot \nu_{ig}$ (with $\nu_{ig} > 0$ for all $i, g$) and varying the scaling factor $\gamma_g$. So when we say that lobbying pressures are sufficiently strong we mean that $\gamma_g$ is sufficiently large.

The following proposition summarizes the positive effects of the equilibrium agreement. The proof of this and all subsequent propositions can be found in Appendix C.

**Proposition 3** *The equilibrium agreement loosens all product standards, at least if demand semi-elasticities $\sigma_{ig}$ do not increase too steeply with the price,* or *countries are not too asymmetric,* or *the strength of lobbying $\gamma_g$ is sufficiently high.*

Our model thus yields a sharp result: international cooperation on product standards leads to de-regulation. The intuition behind this result is that, if a group of countries loosen their product standards, the world price goes up because demand increases, and this in turn generates two externalities on other countries: it benefits producer lobbies (political externality) and it mitigates local pollution (environmental externality).

Note that, while in our setting the purpose of an international agreement is to deal with international externalities that travel through world prices, there is a fundamental difference between the motives behind an agreement in our model and in the standard terms-of-trade theory. In our model, the purpose of an agreement is not to prevent individual countries from manipulating world prices, because individual countries are small. Rather, the agreement is motivated by lobbying pressures and by environmental externalities. In Section 6 we will extend the model to the case of large countries, where terms-of-trade motivations for an agreement are also present.

## 3.5 Is it good for welfare?

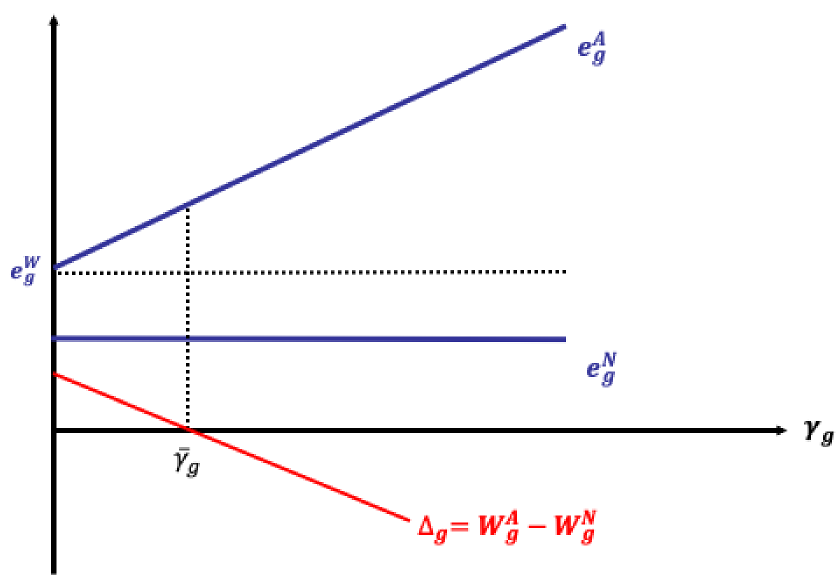
Recall from the discussion above that there are two motives for an agreement on product standards: a political reason and an environmental reason. Letting $\Delta_g \equiv W_g^A - W_g^N$ denote the (positive or negative) welfare change caused by the agreement relative to the noncooperative equilibrium, the political motive pushes $\Delta_g$ down, since lobbying pressures distort

effect if $\sigma_{ig}$ does not increase too steeply. Next notice that, as $\gamma_g$ becomes very large, so does $\lambda_g$, and this is an alternative way to guarantee that the indirect effect cannot undo the direct effect. Finally, if countries are symmetric, the cooperative problem becomes effectively one-dimensional (choosing a symmetric standard), and in this case the assumption that the cooperative objective is single-peaked is sufficient to ensure that the local result holds also globally.

product standards in the cooperative scenario but not in the noncooperative scenario. The environmental motive, on the other hand, pushes $\Delta_g$ up: intuitively, if lobbying pressures were absent the agreement would be motivated just by welfare considerations, and hence $\Delta_g$ would be positive.

We illustrate the welfare implications of the agreement intuitively by focusing on the case in which countries are symmetric, and later we extend the result to the case of asymmetric countries. The key argument for the case of symmetric countries can be illustrated with the help of Figure 1.[30]

**Figure 1: Product Standards**




This figure draws the noncooperative standards $e_g^N$ and the cooperative standards $e_g^A$ as functions of the political-economy parameter $\gamma_g$. It also shows the welfare-maximizing standards $e_g^W$ and the welfare gain from the agreement, $\Delta_g = W_g^A - W_g^N$.

First note that the noncooperative standards do not depend on $\gamma_g$ and are tighter than the welfare-maximizing standards ($e_g^N < e_g^W$).[31] Intuitively, starting from the noncooperative equilibrium, loosening standards in a group of countries has a positive welfare externality

[30] The key features of Figure 1 are proved in Appendix C, within the proof of Proposition 4. In what follows we provide an intuitive explanation.

[31] This is an immediate corollary of Proposition 3, since the welfare-maximizing standards coincide with the cooperative standards when $\gamma_g = 0$.

on other countries, because it increases the world price and in turn mitigates the local consumption externalities in other countries. As a consequence, noncooperative standards are too tight from the welfare point of view.

The cooperative standards $e_g^A$ coincide with $e_g^W$ for $\gamma_g = 0$ and are increasing in $\gamma_g$. Intuitively, stronger lobbying pressures lead to looser cooperative standards because producers worldwide benefit from a rise in the world price.

The welfare gain from the agreement ($\Delta_g$) is of course positive at $\gamma_g = 0$, but is decreasing in $\gamma_g$ and it becomes negative as $\gamma_g$ crosses a critical value $\bar{\gamma}_g$. Intuitively, as $\gamma_g$ increases, cooperative standards get looser and looser, and at some point the implied welfare distortion exceeds the welfare distortion in the over-tight noncooperative standards.

The result illustrated above for the case of symmetric countries extends to the case of asymmetric countries, albeit in a slightly weaker version. As before, we vary all political parameters proportionally by a scaling factor $\gamma_g$. In general it is not guaranteed that there is a unique value of $\gamma_g$ for which $\Delta_g = 0$ as in Figure 1, but we can prove the following:

**Proposition 4** *Cooperation on product standards increases global welfare if $\gamma_g$ is sufficiently low, and decreases global welfare if $\gamma_g$ is sufficiently high.*

In our model international cooperation on product standards leads to de-regulation. If lobbying pressures are weak, such de-regulation is mild and actually increases welfare, because non-cooperative standards are too tight from the welfare point of view, but if lobbying pressures are strong, the agreement leads to excessive de-regulation and damages welfare.

A key mechanism that underlies the result of Proposition 4 is that international cooperation induces "co-lobbying" by producers across countries: loosening product standards in any group of countries is in the interest of all producers world-wide, since they all share a common interest in boosting the world price. Because of this feature, international cooperation intensifies the impact of lobbying on regulations relative to the noncooperative scenario. In our small-country setting, this mechanism is made sharper by the fact that lobbying has zero impact in the noncooperative scenario, but as we will see in Section 6 the same logic applies in a large-country setting where lobbying has an impact also in the noncooperative scenario.[32]

[32] The logic of co-lobbying can be further understood with the following thought experiment. Suppose that, rather than increasing all the political parameters $\gamma_{ig}$, we increase them only for a group of countries (say group A), while holding constant the parameters of the remaining countries (group B), and think about how this affects cooperative standards. It is easy to show that increasing the strength of lobbying in group A leads

## 3.6 Product standards and taxation instruments

Our basic model abstracts from taxation instruments, and in particular consumption taxes and trade taxes. In this section we discuss how results would change if these instruments were available.

We start with a discussion of consumption taxes, which are a natural policy instrument to address consumption externalities. The first observation is that one way to implement the welfare optimum is to combine product standards with consumption taxes. To derive the optimal combination of product standards and consumption taxes, first note that such combination must be equivalent to the Pigouvian emission-contingent tax schedule $t_{ig}(e_{ig}) = a_{ig}e_{ig}$; this is the tax that internalizes the consumption externality for a given variety $e_{ig}$. Given this tax schedule, consumers will buy only the variety with the lowest consumer price. Since the incidence of abatement costs falls on consumers, the consumer price in the presence of the Pigouvian emission-contingent tax is $p_g + \phi_{ig}(e_{ig}) + a_{ig}e_{ig}$. Thus the variety that consumers will buy is defined by the first order condition $\phi'_{ig}(e_{ig}) = -a_{ig}$. This is the first-best variety. Thus the first best can be implemented by the product standard $e^{fb}_{ig} = \phi'^{-1}(-a_{ig})$ and the corresponding Pigouvian consumption tax $t^{fb}_{ig} = a_{ig}e^{fb}_{ig}$.

A key point is that, since countries are small, this combination of product standard and consumption tax $(e^{fb}_{ig}, t^{fb}_{ig})$ maximizes not only global welfare, but also unilateral welfare. And given that lobbying is immaterial for unilateral policies, since product standards and consumption taxes cannot affect local producer surplus, these are the noncooperative equilibrium policies regardless of the lobbying parameters $\gamma_{ig}$. It is then an immediate corollary that the cooperative policies must decrease welfare relative to the noncooperative policies.[33]

Thus the availability of consumption taxes makes the conclusion more pessimistic: international cooperation on product standards in this case is bad for welfare as long as there is any lobbying, and the welfare loss is worse if lobbying pressures are stronger. At the same time, however, it is important to keep in mind that our model abstracts from potentially

to looser cooperative standards not only for group A but also for group B, at least if the political parameters $\gamma_{ig}$ in group A become large enough. As we will see in the next section, this effect will be reversed in the case of process standards, which is characterized by counter-lobbying: there, increasing the strength of lobbying in group A will tend to loosen cooperative standards in group A while tightening those in group B.

[33] It is direct to verify that the cooperative taxes and standards are respectively given by $t^A_{ig} = a_{ig}\phi'^{-1}(-a_{ig}) - \frac{\int_i \gamma_{ig} y_{ig}}{\int_i \varepsilon_{ig} y_{ig}}$ and $e^A_{ig} = \phi'^{-1}(-a_{ig})$. Note that lobbying distorts only the consumption taxes (downwards), not the standards. The reason is that, conditional on consumption taxes and product standards being the only available instruments, lowering the consumption tax while keeping the variety $e_{ig}$ at the first-best level is the least distortionary way to increase the world price.

important motives for international agreements, such as the presence of trans-boundary pollution externalities, which can change the sign of the welfare effect of the agreement ($\Delta_g$). The result that is arguably more robust and we wish to emphasize is not about the sign of $\Delta_g$, but rather, the prediction that $\Delta_g$ tends to decrease with $\gamma_g$: increasing the power of lobbies tends to decrease the welfare gains, or increase the welfare losses, from the agreement.

Thus far we have abstracted from trade taxes, because our intention is to capture in a stylized way situations where trade taxes have been largely removed and the focus of international cooperation has shifted away from traditional trade policies. Nonetheless, it is important to understand how our results would be affected if trade taxes were available.

The main point will be that our results are not an artifact of setting all trade taxes/subsidies equal to zero. All we need is that *some* import tariffs or export subsidies are constrained below their optimal cooperative levels. There are several possible reasons – based on considerations outside of our model – why countries may face restrictions on tariffs or export subsidies. One reason is that export subsidies have been banned by GATT. Another possible reason is that past agreements may have imposed tariff caps that are costly to undo, and in the meantime economic/political conditions have changed, so the tariff caps inherited from the past may be below the ex-post optimal levels for some goods/countries.[34] And finally, one can think of a reason that is not linked to pre-existing trade agreements, and namely, there may be political costs associated with the use of subsidies in general, and therefore also of trade subsidies.

For concreteness here we focus on the case of small countries, but our conclusions extend to the case of large countries (with a couple of caveats that will be made below). Furthermore, we focus here on the case of product standards, but the same conclusion applies to the case of process standards.

In our baseline model of product standards with small countries, let $\tau_{ig}$ denote a non-discriminatory import tariff (respectively, export subsidy) chosen by country $i$ for an imported

[34] One can think of various reasons why pre-existing tariff commitments may be below the ex-post politically optimal levels. For example, the political power of certain producer groups may have grown over time. Another possibility might be that the initial tariff reductions were partly motivated by domestic commitment reasons à la Maggi and Rodriguez-Clare (1998, 2007), so that tariffs were reduced below their ex-post politically optimal levels, and perhaps domestic-commitment motives may not be as strong for regulatory cooperation as for tariff agreements. And finally, even though our model does not allow for discriminatory policies, it is relevant to observe that a significant share of tariff agreements in reality have taken the form of free trade areas and customs unions, which completely eliminate tariffs among member countries, and it is easy to imagine that zero tariffs may be below the ex-post politically optimal tariff levels, in part because of the constraints imposed by GATT Article XXIV.

(respectively, exported) good $g$. The government objective function $\Omega_{ig}$ can be written as:

$$\begin{aligned}\Omega_{ig} &= \left(1+\gamma_{ig}\right)\pi_{ig}\left(p_g+\tau_{ig}\right)+S_{ig}\left(p_g+\tau_{ig}+\phi_{ig}(e_{ig})\right) \\ &+\tau_{ig}\left[d_{ig}\left(p_g+\tau_{ig}+\phi_{ig}(e_{ig})\right)-y_{ig}\left(p_g+\tau_{ig}\right)\right] \\ &-a_{ig}e_{ig}d_{ig}\left(p_g+\tau_{ig}+\phi_{ig}(e_{ig})\right).\end{aligned} \tag{18}$$

Starting with the benchmark case where all policy instruments are unrestricted, it should be clear that in this small-country setting there is no scope for an international agreement, and if countries were large the agreement would implement the classic terms-of-trade-motivated tariff cuts and would not change standards. For future reference, we let $\tau_{ig}^N$ and $\tau_{ig}^C$ denote respectively the unconstrained noncooperative and cooperative levels of $\tau_{ig}$; in this small-country setting we have $\tau_{ig}^N=\tau_{ig}^C$, while if countries were large we would have $\tau_{ig}^N>\tau_{ig}^C$.

Let us now consider the case where some trade taxes/subsidies are restricted. We assume that for each good $g$ a subset of countries $\mathcal{C}_g$ faces a constraint $\tau_{ig}=\bar{\tau}_{ig}<\tau_{ig}^C$. For simplicity we write these as equality constraints, but they can be interpreted as caps. The remaining, "unconstrained" countries do not face a binding constraint on $\tau_{ig}$; this could be the case for example if a country imports good $g$ and the tariff cap inherited from the past is above its ex-post optimal level $\tau_{ig}^C$. Note that a special case of this setting is the one where export subsidies are banned, in which case $\mathcal{C}_g$ is the set of countries that export good $g$, and for these countries $\bar{\tau}_{ig}=0$.

We start with a preliminary consideration that is relatively straightforward but useful to keep in mind.

Let us examine the scope for an international agreement with the same heuristic approach as in the paper, by evaluating the externality that a change in the world price would have on the joint surplus of all countries starting from the Nash equilibrium. Letting the domestic producer price excluding abatement costs be denoted by $p_{ig}\equiv p_g+\tau_{ig}$ and substituting $\tau_{ig}=p_{ig}-p_g$ in (18), the following must hold at the Nash equilibrium:

$$\begin{aligned}\frac{\partial\Omega_{ig}}{\partial p_{ig}}|_{NE} &= 0\text{, for all } i\notin\mathcal{C}_g\text{, and} \\ \frac{\partial\Omega_{ig}}{\partial p_{ig}}|_{NE} &> 0\text{, for all } i\in\mathcal{C}_g.\end{aligned}$$

To evaluate the world-price externality at the Nash equilibrium, we write the joint objective function as $\Omega_g=\int_i\Omega_{ig}\left(p_{ig}(p_g),p_g,e_{ig}\right)$ and totally differentiate it with respect to $p_g$. First note that

$$\frac{d\Omega_g}{dp_g}=\int_i\frac{\partial\Omega_{ig}}{\partial p_{ig}}\frac{\partial p_{ig}}{\partial p_g}+\int_i\frac{\partial\Omega_{ig}}{\partial p_g}=\int_i\frac{\partial\Omega_{ig}}{\partial p_{ig}}+\int_i\frac{\partial\Omega_{ig}}{\partial p_g},$$

since $p_{ig} = p_g + \tau_{ig}$. Evaluating at the Nash equilibrium, we obtain

$$\begin{aligned}
\frac{d\Omega_g}{dp_g}|_{NE} &= \int_{i\in\mathcal{C}_g} \frac{\partial\Omega_{ig}}{\partial p_{ig}}|_{NE} + \int_i \frac{\partial\Omega_{ig}}{\partial p_g}, \text{ since } \int_{i\notin\mathcal{C}_g} \frac{\partial\Omega_{ig}}{\partial p_{ig}}|_{NE} = 0 \\
&= \int_{i\in\mathcal{C}_g} \frac{\partial\Omega_{ig}}{\partial p_{ig}}|_{NE}, \text{ since } \int_i \frac{\partial\Omega_{ig}}{\partial p_g} = 0 \\
&\geq 0, \text{ since } \frac{\partial\Omega_{ig}}{\partial p_{ig}}|_{NE} > 0 \text{ for all } i \in \mathcal{C}_g
\end{aligned}$$

The result used in the second-to-last line, $\int_i \frac{\partial\Omega_{ig}}{\partial p_g} = 0$, is due to the fact that, for given local prices, world price changes have zero net effect on world surplus, which is easy to verify using the trade balance condition.

Thus in our small-country setting there is scope for an international agreement in which countries jointly manage world prices as long as the set $\mathcal{C}_g$ is non-empty. In particular, it continues to be true that the 'best local agreement' as defined in our paper increases local prices by increasing world prices, just as in the baseline model without trade taxes. Intuitively, constrained countries are not able to unilaterally raise local prices as much as they would like given their political and environmental goals, so the agreement can help them by jointly managing world prices.

To examine *how* the agreement will raise world prices, we now derive formulas for the noncooperative and cooperative policies. We start with the noncooperative equilibrium.

Unconstrained countries choose $e_{ig}, \tau_{ig}$ to maximize $\Omega_{ig}$. Writing down the first-order conditions and manipulating, we obtain:

$$\begin{aligned}
e_{ig} &= \frac{1}{\sigma_{ig}}\left(\frac{1}{a_{ig}} + \frac{1}{\phi'_{ig}}\right)\left(1 + \frac{\sigma_{ig} d_{ig}}{\varepsilon_{ig} y_{ig}}\right) + \frac{\gamma_{ig}}{a_{ig}\varepsilon_{ig}}, \text{ for } i \notin \mathcal{C}_g \\
\tau_{ig} &= \frac{\gamma_{ig}}{\varepsilon_{ig}} + \frac{a_{ig} d_{ig}}{\varepsilon_{ig} y_{ig}}\left(\frac{1}{a_{ig}} + \frac{1}{\phi'_{ig}}\right), \text{ for } i \notin \mathcal{C}_g.
\end{aligned}$$

For constrained countries, the first-order conditions yield:

$$\begin{aligned}
e_{ig} &= \frac{1}{\sigma_{ig}}\left(\frac{1}{a_{ig}} + \frac{1}{\phi'_{ig}}\right) + \frac{\bar{\tau}_{ig}}{a_{ig}}, \text{ for } i \in \mathcal{C}_g \\
\tau_{ig} &= \bar{\tau}_{ig}, \text{ for } i \in \mathcal{C}_g.
\end{aligned}$$

We now turn to the cooperative problem. The Lagrangian can be written as:

$$
\begin{aligned}
\mathcal{L}_g \;=\; & \int_i (1+\gamma_{ig})\,\pi_{ig}(p_g+\tau_{ig}) + \int_i S_{ig}\left(p_g+\tau_{ig}+\phi_{ig}(e_{ig})\right) \\
& + \int_i \tau_{ig}\left[d_{ig}\left(p_g+\tau_{ig}+\phi_{ig}(e_{ig})\right) - y_{ig}(p_g+\tau_{ig})\right] \\
& - \int_i a_{ig}e_{ig}d_{ig}\left(p_g+\tau_{ig}+\phi_{ig}(e_{ig})\right) \\
& -\lambda_g \int_i \left[y_{ig}(p_g+\tau_{ig}) - d_{ig}\left(p_g+\tau_{ig}+\phi_{ig}(e_{ig})\right)\right].
\end{aligned}
$$

Maximizing the Lagrangian subject to the constraints $\tau_{ig} = \bar{\tau}_{ig}$ for all $i \in \mathcal{C}_g$ yields the following expressions for unconstrained countries:

$$
\begin{aligned}
e_{ig} &= \frac{1}{\sigma_{ig}}\left(\frac{1}{a_{ig}}+\frac{1}{\phi'_{ig}}\right)\left(1+\frac{\sigma_{ig}d_{ig}}{\varepsilon_{ig}y_{ig}}\right)+\frac{\gamma_{ig}}{a_{ig}\varepsilon_{ig}}, \text{ for } i \notin \mathcal{C}_g \\
\tau_{ig} &= \frac{\gamma_{ig}}{\varepsilon_{ig}}+\frac{a_{ig}d_{ig}}{\varepsilon_{ig}y_{ig}}\left(\frac{1}{a_{ig}}+\frac{1}{\phi'_{ig}}\right)-\lambda_g, \text{ for } i \notin \mathcal{C}_g
\end{aligned}
$$

and for constrained countries:

$$
\begin{aligned}
e_{ig} &= \frac{1}{\sigma_{ig}}\left(\frac{1}{a_{ig}}+\frac{1}{\phi'_{ig}}\right)+\frac{\bar{\tau}_{ig}}{a_{ig}}+\frac{\lambda_g}{a_{ig}}, \text{ for } i \in \mathcal{C}_g \\
\tau_{ig} &= \bar{\tau}_{ig}, \text{ for } i \in \mathcal{C}_g,
\end{aligned}
$$

where the Lagrange multiplier is given by:

$$
\lambda_g = \frac{\int_i \left[\gamma_{ig}y_{ig} + a_{ig}e_{ig}\sigma_{ig}d_{ig} - \tau_{ig}\left(\varepsilon_{ig}y_{ig}+\sigma_{ig}d_{ig}\right)\right]}{\int_i \left(\varepsilon_{ig}y_{ig}+\sigma_{ig}d_{ig}\right)}.
$$

It is not hard to show that $\bar{\tau}_{ig} < \tau^N_{ig}$ for $i \in \mathcal{C}_g$ implies $\lambda_g > 0$. Thus, comparing the noncooperative and cooperative expressions above, it seems clear that the agreement will lower import taxes/export subsidies in unconstrained countries and loosen product standards in constrained countries, at least under some regularity conditions.[35]

Note that in the special case where the only restriction is a ban on export subsidies, so that exporting countries face the constraint $\bar{\tau}_{ig} = 0$, the agreement will lower import tariffs and loosen standards in exporting countries.[36] Similarly, if only tariffs are constrained,

[35] Just as in our basic model without trade taxes, the expressions above define noncooperative and cooperative policies in implicit form, but the world price is different in the two scenarios, so regularity conditions may be needed to ensure that indirect effects through the world price do not outweigh the direct effects.

[36] Note that, if also import subsidies are restricted, perhaps because of political costs (see our discussion above), then if the political parameters $\gamma_{ig}$ are sufficiently high, at some point cooperative tariffs will hit zero and the agreement will loosen standards in all countries.

the agreement will loosen standards in importing countries and lower export subsidies in exporting countries. And if both export subsidies and tariffs are constrained, the agreement will loosen standards in all countries.

Finally, at the normative level, the analysis above suggests that if the political parameters $\gamma_{ig}$ are sufficiently high, the deregulation brought about by the agreement will be detrimental to global welfare, just as in our basic model without trade taxes.

The discussion above has focused on consumption taxes and trade taxes. As discussed at the outset of Section 3, we assumed away production subsidies, in line with most of the literature on the political economy of trade policy, but one point should be obvious: if production subsidies and consumption taxes were freely available, or in other words, if countries could use a complete set of domestic taxation instruments, there would be no motive for international agreements in our small-country setting, just as in the case where trade taxes are freely available.

As a final observation, and in light of our discussion above, our model suggests a new political-economy rationale for international agreements: if governments are restricted in their use of domestic and trade taxes, they are motivated to distort regulatory policies in order to transfer income to producer lobbies, and they can do so most effectively through international agreements. In our baseline model with small countries and product standards, this point is made sharper by the fact that a country cannot unilaterally affect domestic producer prices by changing its product standards, whereas countries can do so collectively. But as will become clear in the next two sections, this point holds also in settings where unilateral changes in standards do affect domestic producers, including settings where countries are large and where international cooperation focuses on process standards.

# 4 Process standards

We now turn our attention to international agreements on process standards, which are defined as restrictions on production processes that take place on domestic soil. Examples include environmental regulations for factories and safety standards for workers. As discussed above, process standards of this kind have been an important focus of many deep agreements in recent history.

To provide a welfare rationale for process standards we allow for local production externalities. To make our points in the most transparent way, in this section we focus on a setting where process standards are the only policy instruments and production externalities are the only market failures.

## 4.1 Setup

We now assume that each good $g$ is homogenous but can be produced with a continuum of technologies $z_g \in [0, \infty)$, indexed by their "dirtiness." Dirtier production processes are cheaper: producers in country $i$ incur a per-unit abatement cost $\varphi_{ig}(z_g)$ in terms of the numeraire good if they use technology $z_g$. We assume, in analogy with the case of product standards, that $\varphi_{ig}(z_g)$ is strictly positive for all $z_g$, decreasing and convex, with $\lim_{z_g \to \infty} \varphi_{ig}(z_g) = 0$ and $\lim_{z_g \to 0} \varphi_{ig}(z_g) = \infty$.[37]

From the point of view of an individual producer, aside from the abatement cost all technologies are identical.

Production generates a negative externality, which is worse for dirtier processes (higher $z_g$). For concreteness we will focus on pollution externalities as our running example. Since each producer is atomistic and hence does not take into account the pollution externality, the supply of good $g$ in country $i$ depends only on the local producer price $p_{ig}^p$, and will be denoted $y_{ig}(p_{ig}^p)$.

As will become clear, a single technology is used in equilibrium in each country $i$, say technology $z_{ig}$. Producing $y_{ig}$ units with technology $z_{ig}$ generates local pollution $z_{ig}y_{ig}$. This could be for example the amount of emissions from factories in country $i$. The disutility caused by a unit of pollution to the representative consumer of country $i$ is constant and denoted by $b_{ig}$, so the local externality is given by $-b_{ig}z_{ig}y_{ig}(p_{ig}^p)$.[38]

Each country $i$ chooses emission standards $\{z_{ig}\}_{g \in \mathcal{G}}$ for production activity that takes place on domestic soil. These can be interpreted as emission caps, since caps are always binding; recall that adopting a cleaner technology is costly and does not directly benefit an individual producer.

Due to consumer arbitrage, the consumer price is the same across the world, and we denote it by $p_g$. This can be interpreted as the "world" price in this setting. The producer price net of abatement costs, on the other hand, is $p_{ig}^p = p_g - \varphi_{ig}(z_{ig})$. Thus, if an individual country $i$ tightens its process standards, the associated cost falls entirely on its producers.

[37] Our results extend to the case in which $\varphi_{ig}(0)$ is finite, as long as it is large enough.

[38] As in the previous section, we are implicitly assuming that the disutility from pollution enters utility in a separable way.

Note the contrast with the case of product standards, where the cost of tighter standards falls on consumers.

Government $i$'s objective can be written as:

$$\Omega_i = \sum_{g \in \mathcal{G}} \left[ (1+\gamma_{ig})\pi_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right) + S_{ig}\left(p_g\right) - b_{ig} z_{ig} y_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right) \right],$$

Note that, just as in the case of product standards, process standards are second-best policies, because given the process $z_{ig}$ producers do not internalize the production externality.

## 4.2 Noncooperative process standards

In the noncooperative scenario, government $i$ chooses the process standard in sector $g$ according to:

$$\max_{z_{ig}} \Omega_{ig} = \left(1+\gamma_{ig}\right)\pi_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right) + S_{ig}\left(p_g\right) - b_{ig} z_{ig} y_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right) \tag{19}$$

As in the previous section, we assume that the optimal unilateral standards are nonprohibitive. This assumption is satisfied as long as the $b_{ig}$ parameters are not too large. It is easy to verify that the first-order conditions imply

$$z_{ig} = \frac{1}{\varepsilon_{ig}}\left(\frac{1+\gamma_{ig}}{b_{ig}} + \frac{1}{\varphi'_{ig}}\right) \quad \text{for all } i, \tag{20}$$

The market clearing condition can be written as:

$$\int_i y_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right) = \int_i d_{ig}\left(p_g\right). \tag{21}$$

The noncooperative equilibrium process standards and world price for good $g$ solve equations (20) and (21). We assume that the solution to this system of equations exists and is unique, and denote it $\left(\{z_{ig}^N\}, p_g^N\right)$.[39]

A key difference between product and process standards can already be noted from (20): unlike the case of product standards, unilateral process standards *are* influenced by lobbies. The reason is that the process standard adopted by country $i$ directly affects the local producer price, so to the extent that local producers have political power, they will push for

[39] A sufficient (but not necessary) condition on the fundamentals that guarantees the existence and uniqueness of the noncooperative equilibrium is that the supply semi-elasticities $\varepsilon_{ig}$ do not decrease too much with the price. This claim is proved in Appendix B.

looser standards.[40] Also note that, intuitively, a country's standards are tighter when the externality weights are higher, when the marginal abatement cost is lower and when supply is more elastic.

## 4.3 Cooperative process standards

In the cooperative scenario, governments maximize their joint payoff taking into account the effect of process standards on world prices. Thus cooperative process standards in sector $g$ solve:

$$\max_{\{z_{ig}\},p_g} \Omega_g = \int_i \left[ (1+\gamma_{ig}) \pi_{ig} \left( p_g - \varphi_{ig}(z_{ig}) \right) + S_{ig}(p_g) - b_{ig} z_{ig} y_{ig} \left( p_g - \varphi_{ig}(z_{ig}) \right) \right] \tag{22}$$

$$\text{s.t. } \int_i y_{ig} \left( p_g - \varphi_{ig}(z_{ig}) \right) = \int_i d_{ig}(p_g)$$

As in the noncooperative scenario, we assume that the optimal standards are nonprohibitive, so that we can rely on a standard Lagrangian approach.[41] It is easy to check that the cooperative process standards and world price for good $g$ satisfy the following conditions (omitting the arguments of the various functions for simplicity):

$$z_{ig} = \frac{1}{\varepsilon_{ig}} \left( \frac{1+\gamma_{ig}}{b_{ig}} + \frac{1}{\varphi'_{ig}} \right) - \frac{\lambda_g}{b_{ig}} \text{ for all } i \tag{23}$$

$$\lambda_g = \frac{\int_i y_{ig} \left( \gamma_{ig} - b_{ig} z_{ig} \varepsilon_{ig} \right)}{\int_i \varepsilon_{ig} y_{ig} + \int_i \sigma_{ig} d_{ig}}$$

$$\int_i y_{ig} = \int_i d_{ig},$$

[40] Note that, if we increase the local producers' power $\gamma_{ig}$ all else equal, $z_{ig}^N$ gets looser, but if we increase producer powers in all countries at the same time, the world price will go down, and this may in turn affect the supply elasticity $\varepsilon_{ig}$. This will dampen or reinforce the impact on $z_{ig}^N$, depending on whether $\varepsilon_{ig}$ increases or decreases with the price.

[41] Relative to the case of product standards, where standards can be prohibitive only if the externality weights are large, here there is an additional possibility that may give rise to prohibitive process standards, namely the presence of large cross-country asymmetries, especially in the political parameters $\gamma_{ig}$. To see this, suppose lobbying is very strong in a group of countries (say group A) and very weak in another (say group B). Then cooperative standards may be prohibitive for group B, because tightening standards in this group of countries raises the world price, so it benefits producers in group A at the expense of group B. This is a manifestation of "counter-lobbying" in international negotiations, which we discuss further below. A sufficient condition that rules out prohibitive process standards is that the $b_{ig}$ parameters are not too large and countries are not too asymmetric.

where $\lambda_g$ denotes the Lagrange multiplier. We assume there exists a unique solution to the system of first order conditions above.[42]

The key difference between noncooperative and cooperative process standards is the presence of the multiplier $\lambda_g$ in equation (23). Note that $\lambda_g$ is positive if $\gamma_{ig} > b_{ig} z_{ig} \varepsilon_{ig}$ for all $i$. This suggests that the agreement will tighten standards if lobbying pressures are sufficiently strong, and loosen standards if lobbying pressures are sufficiently weak. Intuitively, the agreement changes process standards for both political and environmental reasons, as in the case of product standards, but these two forces now push in opposite directions: the political motive pushes for a tightening of standards, because this would increase the world price and hence benefit all producers, while the environmental motive pushes for a loosening of standards, because this would decrease the world price and hence reduce production and pollution.

The intuition offered just above, however, does not take into account the fact that the expression for $\lambda_g$ depends on the optimal standards $z_{ig}$ themselves (as well as the supply elasticities, which in general depend on prices). Thus we need to go a bit deeper with the analysis.

## 4.4 What does the agreement do?

To examine how the agreement changes process standards, we start by considering the international externalities caused by a change in process standards when starting from the noncooperative equilibrium. If a positive measure of countries tightens their standards, this reduces supply and hence pushes up the world price.[43] How does this affect the joint payoff of all governments? Differentiating the joint government payoff $\Omega_g$ with respect to $p_g$ and evaluating at the noncooperative standards, we obtain:

$$\frac{\partial \Omega_g}{\partial p_g}|_{NE} = \int_i \left( \gamma_{ig} y_{ig} - b_{ig} z_{ig}^N \varepsilon_{ig} y_{ig} \right) \tag{24}$$

The first term of (24) is positive and is due to the political externality exerted by the increase in the world price. The second term is negative and is due to the fact that a higher

[42] As in the case of product standards, we used numerical methods to investigate under what conditions the objective function has a unique interior maximum, focusing on a two-country world. We followed an analogous approach to the one described in footnote 26, and again we restricted our attention to parameter values such that the optimal standards are nonprohibitive. For all parameter configurations we examined, the objective function always had a unique interior maximum.

[43] To see this, differentiate the market clearing condition to get $\frac{\int_i y'_{ig} \varphi'_{ig} dz_{ig}}{\int_i \left( y'_{ig} - d'_{ig} \right)}$. Noting that each term of the integral in the numerator has the opposite sign as $dz_{ig}$, it follows that if a positive measure of countries reduce their $z$'s, the world price goes up.

world price stimulates supply, thus increasing pollution world-wide. Intuitively, if lobbying pressures are sufficiently strong the net externality should be positive, thus the agreement should tighten standards relative to the noncooperative equilibrium, while if lobbying pressures are sufficiently weak, the net externality should be negative, so the agreement should loosen standards.

We can confirm this intuition, in the following sense. Consider a proportional change in the political parameters, by letting $\gamma_{ig} = \gamma_g \nu_{ig}$ and varying the scaling factor $\gamma_g$ (as in the previous section). First, it is obvious that if $\gamma_g$ is small enough then $\frac{\partial \Omega_g}{\partial p_g}|_{NE} < 0$. Next note that, in the limit as $\gamma_g \to \infty$, the problem becomes equivalent to maximizing $\int_i \nu_{ig}\pi_{ig}$, and the derivative of this function with respect to $p_g$ is clearly positive. It is then a small step to conclude, using a similar logic as in the previous section, that the best local agreement loosens all standards if $\gamma_g$ is sufficiently small and tightens all standards if $\gamma_g$ is sufficiently large.

If $\gamma_g$ is large, we are able to show that the local result above holds globally, without need for any additional condition. If $\gamma_g$ is small, we can show that the local result is guaranteed to hold globally if the supply semi-elasticities $\varepsilon_{ig}$ do not decrease too much with the price *or* countries are not too asymmetric (these are two alternative sufficient conditions, neither of which is necessary).[44] The following proposition summarizes:

**Proposition 5** *(i) The equilibrium agreement loosens all process standards for sufficiently small $\gamma_g$, at least if countries are not too asymmetric* or *the supply semi-elasticities $\varepsilon_{ig}$ do not decrease too much with the price; (ii) The equilibrium agreement tightens all process standards for sufficiently large $\gamma_g$.*

Thus the model predicts that international cooperation on process standards leads to deregulation if lobbying is weak, but tightens regulations if lobbying pressures are strong. One way to interpret this result is that, when lobbying is strong, the non-cooperative equilibrium entails a "race to the bottom," and the agreement acts to counter-balance this tendency. But note that what drives the cooperative tightening of standards is the influence of producer groups themselves.

It may also be interesting to note that, even though the nature of the international externalities exerted by process standards is quite different relative to the case of product

[44] The intuition behind these sufficient conditions is similar to the corresponding conditions for the case of product standards: see footnote 29.

standards examined in the previous section, if governments maximize welfare ($\gamma_g = 0$) then the agreement loosens standards in both cases. To understand this feature, note that (i) in the case of process standards the externality from an increase in the world price is negative, as can be seen from (24), while in the case of product standards it is positive, as can be seen from (17); but (ii) the world-price impact of tightening standards is also reversed: tightening product standards raises local consumer prices, hence reduces local demand and puts downward pressure on world prices; while tightening process standards reduces local producer prices, hence reduces local supply and puts upward pressure on world prices. Thus the sign of the overall international externality generated by a tightening of standards is the same in both cases. Formally (and with a slight abuse of notation) we can write the overall international externality in the case of process standards as $\frac{\partial \Omega}{\partial p}\frac{\partial p}{\partial z}$, where the change in $z$ applies to a positive measure of countries. Given the observations above, if $\gamma_g = 0$ then $\frac{\partial \Omega}{\partial p} < 0$ and $\frac{\partial p}{\partial z} < 0$, thus $\frac{\partial \Omega}{\partial p}\frac{\partial p}{\partial z} > 0$. In the case of product standards, on the other hand, $\frac{\partial \Omega}{\partial p} > 0$ and $\frac{\partial p}{\partial e} > 0$, thus $\frac{\partial \Omega}{\partial p}\frac{\partial p}{\partial e} > 0$.

We are now ready to address the question of how international cooperation on process standards affects global welfare.

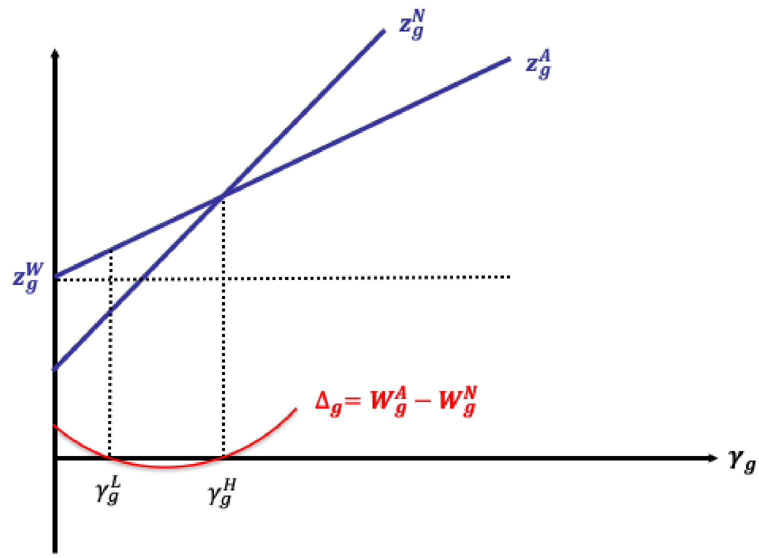
### 4.5 Is it good for welfare?

We start by describing briefly our main result and its underlying logic. We will show that the equilibrium agreement increases welfare if $\gamma_g$ is sufficiently small or sufficiently large, and may decrease welfare for intermediate values of $\gamma_g$. The starkest difference with respect to our earlier result for product standards is the fact that, when political pressures are strong ($\gamma_g$ large), a deep agreement is bad for welfare in the case of product standards, while it is good for welfare in the case of process standards. The fundamental reason for this difference is that the interests of producers around the world are no longer aligned when it comes to process standards, since each producer lobby prefers weak regulations at home and strict regulations abroad. As a result, the agreement now brings about counter-lobbying, thereby diluting the overall effect of lobbying on process standards.

We now illustrate in more detail the logic behind our result. We start by focusing on the special case in which countries are symmetric and the semi-elasticities of supply and demand are constant, and then we extend the result to the more general case. We illustrate our arguments with the help of Figure 2.[45]

[45] The key features of Figure 2 are proved in Appendix C, within the proof of Proposition 6.

**Figure 2: Process Standards**




This figure shows the noncooperative standards $z_g^N$, the cooperative standards $z_g^A$ and the welfare maximizing standards $z_g^W$ as functions of $\gamma_g$, as well as the welfare change from the agreement, $\Delta_g = W_g^A - W_g^N$.

Absent lobbying pressures ($\gamma_g = 0$), noncooperative process standards are too tight from the welfare point of view ($z_g^N < z_g^W$), since governments do not internalize the negative international externality caused by tightening standards. As $\gamma_g$ increases, noncooperative standards become looser, since loosening standards unilaterally benefits local producers. The cooperative standards $z_g^A$ coincide with the welfare-maximizing standards $z_g^W$ when $\gamma_g = 0$ and are also increasing in $\gamma_g$.[46] However, the $z_g^A$ schedule is flatter than the $z_g^N$ schedule, since in the cooperative scenario governments internalize the negative political terms-of-trade externality from loosening standards, and such externality becomes stronger as $\gamma_g$ increases. This captures the counter-lobbying intuition we mentioned earlier: looser domestic standards harm the interests of producers abroad, thus cooperation moderates the loosening of standards that is brought about by increases in lobbying pressures.[47]

[46] Recall that the equilibrium producer price given a symmetric standard $z_g$ is $p_g - \varphi_g(z_g)$. It is easy to show that the marginal effect of a change in $z_g$ on the world price $p_g$ is less than $\varphi_g'(z_g)$, thus a symmetric loosening of standards benefits producers.

[47] To further clarify the logic of counter-lobbying, consider the following thought experiment (analogously to the case of product standards, see footnote 32). Suppose we increase the strength of lobbying $\gamma_{ig}$ for a group of countries (group A), while holding them constant for the remaining countries (group B). It is easy to show that this now loosens cooperative standards for group A but tightens them for group B, at least in the limit when the political parameters $\gamma_{ig}$ in group A become very large.

The welfare change from the agreement ($\Delta_g$) is of course positive at $\gamma_g = 0$, but more interestingly, it must be positive again for $\gamma_g$ large enough. The latter statement follows from the fact that if $\gamma_g$ is large enough then $z_g^N > z_g^A > z_g^W$, together with the assumption that welfare has a unique stationary point (given by $z_g^W$). Furthermore, $\Delta_g$ must be negative for an intermediate range of $\gamma_g$ (in Figure 2 the interval between $\gamma_g^L$ and $\gamma_g^H$), because the noncooperative standards coincide with the welfare-maximizing standards for a critical value of $\gamma_g$. Thus the welfare change from the agreement is non-monotonic, being positive if lobbying pressures are low or high, but negative when lobbying pressures are intermediate.[48]

The result illustrated just above generalizes to the case of asymmetric countries and variable semi-elasticities, albeit in a slightly weaker version. The only change is that in general there may or may not be an intermediate range of $\gamma_g$ for which the agreement decreases welfare. In order to state the more general result, we consider as usual a proportional change in all political parameters $\gamma_{ig}$, with $\gamma_g$ denoting the scaling factor:

**Proposition 6** *Cooperation on process standards increases global welfare if $\gamma_g$ is sufficiently low or sufficiently high, and may decrease global welfare for intermediate values of $\gamma_g$.*

As discussed above, the result that the equilibrium agreement increases global welfare when lobbying is strong enough contrasts sharply with the case of product standards, and the basic reason is that international negotiations bring about counter-lobbying between the domestic producers of a given country and the producers in the remaining countries.

It is worth emphasizing a subtle aspect of the result in Proposition 6: in spite of the counter-lobbying effect, the agreement may decrease welfare for an intermediate range of lobbying pressures (and as noted above, this intermediate range of $\gamma_g$ is guaranteed to exist if countries are symmetric). The intuition is the following: if governments are welfare-maximizers ($\gamma_g = 0$), noncooperative standards are too tight, so a moderate amount of political pressures makes noncooperative standards more efficient, and there is a critical level of $\gamma_g$ that makes them exactly efficient ($z_g^N = z_g^W$ in Figure 2). Clearly, then, for $\gamma_g$ close to this critical level the agreement must be bad for welfare.

[48] Note that, while lobbying pressures are always detrimental for welfare if they are strong enough (both in the noncooperative and cooperative scenarios), a *moderate* amount of lobbying may increase welfare in the noncooperative scenario. This is clear from Figure 2: when $\gamma_g = 0$ non-cooperative standards are too tight from the welfare point of view, thus a moderate amount of lobbying pushes them closer to their efficient levels. This provides an important qualification to the general intuition that international agreements tend to increase welfare if they dilute the influence of lobbies on policy-making. See also footnote 3 above.

It is also interesting to compare the impact of the power of lobbies on the welfare change from the agreement ($\Delta_g$) with the case of product standards. Recall that, in the case of product standards, increasing the power of lobbies reduces $\Delta_g$ (see Figure 1). Here the answer is different and more subtle, as Figure 2 suggests: increasing the power of lobbies initially worsens the welfare impact of the agreement, but this effect is reversed as the power of lobbies becomes large.[49]

A final observation concerns the link between the notion of counter-lobbying and the welfare impact of the agreement. In our setting the presence of counter-lobbying plays a key role for the result that the agreement improves welfare when lobbying is strong, but this link is not automatic and may not hold in other policy settings. With reference to Figure 2, the presence of counterlobbying implies that the $z_g^A(\gamma_g)$ schedule increases more slowly than the $z_g^N(\gamma_g)$ schedule, but the $z_g^A(\gamma_g)$ schedule is still increasing, because a symmetric loosening of standards benefits all producers. In other words, increasing $\gamma_g$ affects the noncooperative and cooperative standards in the same direction. It is this feature, in conjunction with counterlobbying, that leads to the conclusion that the agreement increases welfare for $\gamma_g$ large enough. But it is not hard to imagine settings characterized by counter-lobbying where $\gamma_g$ has opposite effects on the noncooperative and cooperative policies, and if this is the case the agreement can decrease welfare when $\gamma_g$ is large. Thus our results should be interpreted as applying to settings where lobbying pressures affect the noncooperative and cooperative policies in the same direction.

# 5 Integrated Model

Thus far we have examined the implications of international cooperation on product and process standards with the aid of two separate models. We now consider the interactions between these two dimensions of deep integration in a setting where both consumption and production externalities are present, and governments can choose both product and process standards.

[49] The reader might wonder how our results on process standards would change if we allowed for production taxes (as a way to address more directly political and environmental concerns) or for trade taxes. First recall that if production subsidies (i.e. negative production taxes) were available, lobbies would focus only on production subsidies, thus the model would have nothing to say about the impact of lobbying on regulations. It is for this reason that we assumed away production taxes/subsidies, following most of the political-economy literature (see also footnote 17). And regarding the implications of trade taxes, the point we made in Section 3.6 applies also here: if trade taxes were unrestricted there would be no scope for international agreements, but if import tariffs and/or export subsidies are constrained below their noncooperative levels, our main qualitative results will go through.

We essentially merge the economic structures that we considered in sections 3 and 4, by allowing for a continuum of varieties and a continuum of technologies. If country $i$ imposes product standard $e_{ig}$ and process standard $z_{ig}$, international arbitrage ensures that the local consumer price is $p_g + \frac{1}{e_{ig}}$ and the local producer price is $p_g - \frac{1}{z_{ig}}$, where $p_g$ can be interpreted as the "world price," or alternatively, the price that producers and consumers of country $i$ would face if country $i$ imposed no standards ($e_{ig} = z_{ig} = \infty$). The local consumption and production externalities associated with these standards are respectively $-a_{ig}e_{ig}d_{ig}$ and $-b_{ig}z_{ig}y_{ig}$.

In the noncooperative scenario, government $i$ chooses standards in sector $g$ to solve the following problem:

$$\max_{\{e_{ig},z_{ig}\}} \Omega_{ig} = \left(1+\gamma_{ig}\right)\pi_{ig}\left(p_g - \frac{1}{z_{ig}}\right) + S_{ig}\left(p_g + \frac{1}{e_{ig}}\right) - a_{ig}e_{ig}d_{ig}\left(p_g + \frac{1}{e_{ig}}\right) - b_{ig}z_{ig}y_{ig}\left(p_g - \frac{1}{z_{ig}}\right).$$

Simple algebra reveals that the noncooperative standards and world price for good $g$ satisfy:

$$e_{ig} = -\frac{\sigma_{ig}}{2} + \sqrt{\left(\frac{\sigma_{ig}}{2}\right)^2 + \frac{1}{a_{ig}}} \text{ for all } i$$

$$z_{ig} = -\frac{\varepsilon_{ig}}{2} + \sqrt{\left(\frac{\varepsilon_{ig}}{2}\right)^2 + \frac{1}{b_{ig}}\left(1+\gamma_{ig}\right)} \text{ for all } i$$

$$\int_i y_{ig} = \int_i d_{ig}$$

In the cooperative scenario, on the other hand, the standards and world price for good $g$ solve:

$$\max_{\{e_{ig},z_{ig}\},p_g} \Omega_g = \int_i \{\left(1+\gamma_{ig}\right)\pi_{ig}\left(p_g - \frac{1}{z_{ig}}\right) + S_{ig}\left(p_g + \frac{1}{e_{ig}}\right) - a_{ig}e_{ig}d_{ig}\left(p_g + \frac{1}{e_{ig}}\right) - b_{ig}z_{ig}y_{ig}\left(p_g - \frac{1}{z_{ig}}\right)$$

$$\text{s.t.} \int_i y_{ig}\left(p_g - \frac{1}{z_{ig}}\right) = \int_i d_{ig}\left(p_g + \frac{1}{e_{ig}}\right)$$

It is easy to verify that the cooperative policies and world prices satisfy:

$$e_{ig} = -\frac{\sigma_{ig}}{2} + \sqrt{\left(\frac{\sigma_{ig}}{2}\right)^2 + \frac{1}{a_{ig}}\left(1+\sigma_{ig}\lambda_g\right)} \text{ for all } i$$

$$z_{ig} = -\frac{\varepsilon_{ig}}{2} + \sqrt{\left(\frac{\varepsilon_{ig}}{2}\right)^2 + \frac{1}{b_{ig}}\left(1+\gamma_{ig}-\varepsilon_{ig}\lambda_g\right)} \text{ for all } i$$

$$\lambda_g = \frac{\int_i \left(\gamma_{ig} y_{ig} + a_{ig} e_{ig} \sigma_{ig} d_{ig} - b_{ig} z_{ig} \varepsilon_{ig} y_{ig}\right)}{\int_i \left(\varepsilon_{ig} y_{ig} + \sigma_{ig} d_{ig}\right)}$$

$$\int_i y_{ig} = \int_i d_{ig},$$

where $\lambda_g$ as usual denotes the Lagrange multiplier. Note that $\lambda_g$ now reflects the effect of a change in the world price on the joint government payoff through three channels: the political channel, the consumption-externality channel and the production-externality channel.

We now examine how the agreement changes standards relative to the noncooperative equilibrium. Here we focus on the "local" agreement. As in the previous sections, the local results hold globally under certain sufficient conditions.

The first step is to understand how the local agreement changes the world price. This depends on how a small change in the world price affects the governments' joint payoff. It is immediate to verify that:

$$\frac{\partial \Omega_g}{\partial p_g}|_{NE} = \int_i \left(\gamma_{ig} y_{ig} + a_{ig} e^N_{ig} \sigma_{ig} d_{ig} - b_{ig} z^N_{ig} \varepsilon_{ig} y_{ig}\right) \tag{25}$$

The local agreement leads to an increase in the world price if and only if $\frac{\partial \Omega_g}{\partial p_g}|_{NE} > 0$. We can already make two observations. The first one is that, in each sector $g$, the local agreement loosens all product standards $e_{ig}$ and tightens all process standards $z_{ig}$ if $\frac{\partial \Omega_g}{\partial p_g}|_{NE} > 0$, and vice-versa if $\frac{\partial \Omega_g}{\partial p_g}|_{NE} < 0$. This is a consequence of the fact that loosening product standards increases $p_g$, while loosening process standards decreases $p_g$. Thus the local agreement always changes product standards and process standards in opposite directions.

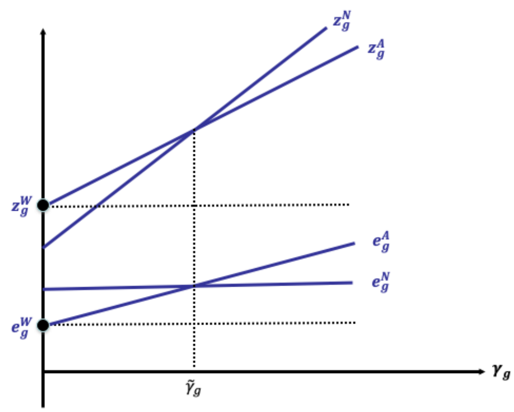
The second observation is that, if lobbying pressures are sufficiently strong, the local agreement loosens all product standards and tightens all process standards. It is easy to show, following a similar logic as in the previous section, that the positive term $\int_i \gamma_{ig} y_{ig}$ in (25) must outweigh the negative term $-\int_i b_{ig} z^N_{ig} \varepsilon_{ig} y_{ig}$ if the $\gamma_{ig}$ parameters are blown up sufficiently.

We can say something more if we impose symmetry across countries and constant semi-elasticities. First, in this case it is easy to show that the local results described just above are guaranteed to hold globally. Second, there exists a threshold $\tilde{\gamma}_g \geq 0$ such that the agreement tightens product standards and loosens process standards if $\gamma_g \in \left(0, \tilde{\gamma}_g\right)$ (with the range $\left(0, \tilde{\gamma}_g\right)$ possibly empty), and vice-versa if $\gamma_g > \tilde{\gamma}_g$.[50] The cooperative and noncooperative standards are depicted as functions of $\gamma_g$ in Figure 3, which focuses on the case where the

[50] To see this, first note from (25) that the agreement increases $e_g$ and decreases $z_g$ if $\gamma_g + a_g \sigma_g e^N_g - b_g \varepsilon_g z^N_g > 0$ (where we used $d_g = y_g$ from symmetry and market clearing), and vice-versa if $\gamma_g + a_g \sigma_g e^N_g - b_g \varepsilon_g z^N_g < 0$.

interval $(0, \tilde{\gamma}_g)$ is nonempty (the fact that we have drawn the $z_g$ schedules above the $e_g$ schedules has no significance).

**Figure 3: Product and Process Standards**




Note the two additional results that emerge relative to the previous sections, where product and process standards were analyzed separately. First, the agreement always changes product and process standards in opposite directions. And second, when lobbying pressures are weak, there are two new possibilities that could not arise when standards were considered in isolation: (i) the agreement may tighten product standards (if the interval $(0, \tilde{\gamma}_g)$ is nonempty, as in Figure 3), and (ii) the agreement may tighten process standards (if the interval $(0, \tilde{\gamma}_g)$ is empty, a case not considered in Figure 3).

Next we consider the welfare impacts of regulatory cooperation. We continue to focus on the case of symmetric countries and constant semi-elasticities.

For $\gamma_g = 0$, and hence for $\gamma_g$ small enough, the agreement is obviously good for welfare. The more interesting question is what happens for large $\gamma_g$. We can show that, when $\gamma_g$ is large, the agreement decreases global welfare if the production externality parameter $b_g$ is small enough (relative to the other parameters), while it increases global welfare if the consumption externality parameter $a_g$ is small enough (relative to the other parameters). Intuitively, if $b_g = 0$ then no process standards are imposed, either in the non-cooperative equilibrium or in the cooperative scenario, so the model essentially reduces to the product-standards-only setting of Section 3, where the agreement is bad for welfare if $\gamma_g$ is large; and

Next observe that there can be at most one value of $\gamma_g$ such that $\gamma_g + a_g \sigma_g e_g^N - b_g \varepsilon_g z_g^N = 0$. This is because $\frac{\partial(\gamma_g + a_g \sigma_g e_g^N)}{\partial \gamma_g} = 1$ (recalling that $e_g^N$ is independent of $\gamma_g$) and $b_g \varepsilon_g z_g^N$ is concave in $\gamma_g$, with $\frac{\partial(b_g \varepsilon_g z_g^N)}{\partial \gamma_g}|_{\gamma_g=0} < 1$. The claim follows immediately.

the same is true if $b_g$ is small enough. A similar intuition applies for the case in which the consumption externality parameter $a_g$ is small. Thus, when lobbying pressures are strong, the agreement is bad for welfare if the relative importance of production externalities versus consumption externalities is small, because in this case process standards play a small role relative to product standards, while it is good for welfare in the opposite case.

# 6 Large Countries

We now extend our analysis to the case of large countries. To this end, we replace our assumption that there is a continuum of small countries with the assumption that there are $N$ large countries; otherwise, we leave our setup unchanged. For simplicity we analyze separately the two models of product standards and process standards.

The key implication of this modification is that *individual* countries now have market power in world markets and are thus able to manipulate world prices. As one would expect, this shows up in the formulas for noncooperative standards but leaves the formulas for cooperative standards essentially unchanged. Note that countries were able to *jointly* control world prices even in our baseline model, and indeed this was the reason they pursued international agreements.

In what follows we summarize and discuss our results at an intuitive level, relegating the formal analysis to Appendix D.

We begin with the case of product standards. Defining imports $m_{ig} \equiv d_{ig} - y_{ig}$, it is easy to show that the formulas for noncooperative and cooperative product standards become respectively:

$$\begin{aligned} e_{ig}^N &= \frac{1}{\sigma_{ig}}\left(\frac{1}{a_{ig}} + \frac{1}{\phi_{ig}'}\right) + \frac{\lambda_{ig}^N}{a_{ig}} \text{ for all } i, \\ \text{where } \lambda_{ig}^N &= \frac{\gamma_{ig} y_{ig} + a_{ig} e_{ig}^N \sigma_{ig} d_{ig} - m_{ig}}{\sum_i \left(\varepsilon_{ig} y_{ig} + \sigma_{ig} d_{ig}\right)} \end{aligned} \tag{26}$$

and

$$\begin{aligned} e_{ig}^A &= \frac{1}{\sigma_{ig}}\left(\frac{1}{a_{ig}} + \frac{1}{\phi_{ig}'}\right) + \frac{\lambda_{g}^A}{a_{ig}} \text{ for all } i, \\ \text{where } \lambda_{g}^A &= \frac{\sum_i \left(\gamma_{ig} y_{ig} + a_{ig} e_{ig}^A \sigma_{ig} d_{ig}\right)}{\sum_i \left(\varepsilon_{ig} y_{ig} + \sigma_{ig} d_{ig}\right)}. \end{aligned} \tag{27}$$

The key difference relative to our baseline model is the Lagrange multiplier $\lambda_{ig}^N$ in the formula for noncooperative standards (26). Note that the Lagrange multiplier $\lambda_g^A$ in the formula for cooperative standards (27) is the sum of the noncooperative Lagrange multipliers, since $\sum_i m_{ig} = 0$, except that they are evaluated at different standards. This illustrates that individual countries now leverage their market power in a similar way as all countries do combined, with the key difference that individual countries only care about the effects of world price changes on their own economy.

It is instructive to begin the discussion by focusing on the special case of symmetric countries. In this case, there is no trade in equilibrium and thus no incentive to manipulate the terms-of-trade. This allows us to isolate a first new effect: since unilateral changes in standards now affect world prices, they now affect consumers *and* producers. Recall that in the baseline model, unilateral changes in product standards only affected consumers.

To understand the shared incidence of product standards, suppose a country unilaterally loosens its product standards. Just as in our baseline model, this reduces local consumer prices by reducing abatement costs. But now it also increases local (as well as foreign) producer prices, since the resulting boost to local consumption pushes up world prices. Hence, the incidence of a unilateral change in product standards is now shared between consumers and producers. In fact, if the world-price effect is strong, it is even possible that the incidence falls more on producers than on consumers. A key implication of this is that the strength of lobbies now does affect noncooperative product standards, as evidenced by the fact that the political parameter $\gamma_{ig}$ now enters the corresponding formula through $\lambda_{ig}^N$. Recall that in the baseline model there was no lobbying in the noncooperative equilibrium, since the incidence of unilateral changes in product standards was entirely on consumers.

In spite of the new effect just highlighted, in this symmetric case the main qualitative results of our baseline model are preserved, regardless of the way in which the incidence of product standards is shared between consumers and producers. In particular, at the positive level, the equilibrium agreement still loosens all product standards, and at the normative level, it is still true that the equilibrium agreement increases welfare if lobbying is sufficiently weak and decreases welfare if lobbying is strong enough.

To gain intuition, consider the following local argument, in analogy to our discussion in Section 2. Suppose that, starting from the noncooperative equilibrium, country $i$ slightly loosens its standard $e_{ig}$. This pushes up the world price, and the implied change in the joint payoff of the remaining countries (denoted $\Omega_g^{-i}$) is easily shown to be:

$$\frac{\partial \Omega_g^{-i}}{\partial p_g}|_{NE} = (N-1)\left(\gamma_g y_g + a_g e_g^N \sigma_g d_g\right) > 0$$

Thus, just as in our baseline model, if countries are symmetric the international externality from loosening a standard is positive, because it is composed of a positive political externality and a positive environmental externality. In particular, the political externality is positive because loosening product standards in country $i$ benefits not only producers in country $i$ but also producers in the rest of the world, so the interests of all producer lobbies are aligned. As a consequence, the agreement leads to de-regulation. Furthermore, at the normative level, it is intuitive that if $\gamma_g$ is large enough such de-regulation is excessive and decreases welfare.

The case of symmetric large countries thus highlights that the main insights of our baseline model do not depend on the incidence of product standards, but rather on the feature that loosening product standards generates positive political and environmental externalities.[51]

We now turn to the case in which countries are asymmetric and trade in equilibrium. This introduces a second new effect, namely that unilateral changes in standards affect the terms-of-trade. As a result, import-competing countries now have an incentive to tighten product standards, other things equal, in order to reduce the world price and thus improve their terms-of-trade at the expense of exporting countries. Conversely, exporting countries now have an incentive to loosen product standards, other things equal, in order to increase the world price and thus improve their terms-of-trade at the expense of import-competing countries. The key implication is that the international agreement now also addresses the issue of terms-of-trade manipulation, in addition to the political and environmental world-price externalities familiar from the analysis above.

A local argument again goes a long way in illustrating the implications of the terms-of-trade motive. As above, suppose country $i$ loosens its standard ($e_{ig}$) starting from the noncooperative equilibrium. The increase in the world price caused by this change has the following impact on the joint payoff of the remaining countries:

$$\frac{\partial \Omega_g^{-i}}{\partial p_g}|_{NE} = \sum_{j \neq i} \left( \gamma_{jg} y_{jg} + a_{jg} e_{jg}^N \sigma_{jg} d_{jg} \right) + m_{ig} \tag{28}$$

The best local agreement loosens country $i$'s standard if and only if the expression above is positive. The sum on the right-hand side captures the political and environmental externalities familiar from the baseline model, which push toward a cooperative loosening of

[51] Note that the incidence of standards does matter for how lobbying affects noncooperative standards. For example, the feature that in the small-country model lobbying does not affect noncooperative product standards *is* due to the fact that the incidence of product standards falls entirely on consumers. But the direction in which the agreement changes standards relative to the noncooperative levels, as well as the associated welfare impact, does not.

product standards. The term $m_{ig}$ captures the terms-of-trade motive for the agreement: for importing countries, this reinforces the de-regulation brought about by the agreement, while for exporting countries it reduces de-regulation and may even overturn it, in which case the agreement tightens an exporting country's standards.

If lobbying forces are sufficiently strong, intuitively political motives swamp terms-of-trade motives. Indeed we can show that if the political parameters $\gamma_{ig}$ are sufficiently large, the globally optimal agreement loosens all product standards and damages welfare, just as in the small-country model. Thus the results of our baseline model are robust to the presence of large countries if political economy forces are strong enough.

We now turn to the model of process standards. In this large country setting, the noncooperative and cooperative process standards can be expressed respectively as:

$$\begin{aligned} z_{ig}^{N} &= \frac{1}{\varepsilon_{ig}}\left(\frac{1+\gamma_{ig}}{b_{ig}}+\frac{1}{\varphi_{ig}'}\right)-\frac{\lambda_{ig}^{N}}{b_{ig}} \text{ for all } i, \\ \text{where } \lambda_{ig}^{N} &= \frac{y_{ig}\left(\gamma_{ig}-b_{ig}z_{ig}^{N}\varepsilon_{ig}\right)-m_{ig}}{\sum_j\left(\varepsilon_{jg}y_{jg}+\sigma_{jg}d_{jg}\right)} \end{aligned} \tag{29}$$

and

$$\begin{aligned} z_{ig}^{A} &= \frac{1}{\varepsilon_{ig}}\left(\frac{1+\gamma_{ig}}{b_{ig}}+\frac{1}{\varphi_{ig}'}\right)-\frac{\lambda_{g}^{A}}{b_{ig}} \text{ for all } i, \\ \text{where } \lambda_{g}^{A} &= \frac{\sum_j y_{jg}\left(\gamma_{jg}-b_{jg}z_{jg}^{A}\varepsilon_{jg}\right)}{\sum_j\left(\varepsilon_{jg}y_{jg}+\sigma_{jg}d_{jg}\right)} \end{aligned} \tag{30}$$

Just as in the case of product standards, the key difference relative to our baseline model is the Lagrange multiplier in the formula for noncooperative standards, which captures the fact that individual countries now have market power in the world market.

First note how an individual country's influence on world prices changes the incidence of process standards. If country $i$ tightens its standards, domestic producers lose from the increase in abatement costs, but the world price increases as a consequence of the supply reduction, and this means that the incidence of the standard is now shared between consumers and producers: the stronger is the world-price effect, the more the incidence is shifted onto consumers. Also note how this changes the impact of lobbies on unilateral standards. Recall that lobbies already cared about unilateral changes in process standards in the small-country setting, but now they care less strongly, because the impact of a unilateral change in process standards on producers is now mitigated by the world-price effect.

Following a similar logic as above, it is easy to see that in the benchmark case of symmetric countries, the qualitative results of our baseline model are preserved, in spite of the changed incidence of process standards: in particular, if lobbying is strong enough, the equilibrium agreement tightens process standards and increases welfare. Intuitively this is because the basic logic of counter-lobbying highlighted in the small-country model is still present.

We next focus on the case in which countries are asymmetric and trade in equilibrium. Suppose country $i$ tightens its standard $(z_{ig})$ starting from the noncooperative equilibrium. This increases the world price and impacts the joint payoff of the remaining countries according to the following:

$$\frac{\partial \Omega_g^{-i}}{\partial p_g}|_{NE} = \sum_{j \neq i} y_{jg} \left( \gamma_{jg} - b_{jg} z_{jg}^N \varepsilon_{jg} \right) + m_{ig} \tag{31}$$

The best local agreement tightens country $i$'s process standard if and only if the expression above is positive. The sum on the right hand side captures the political and environmental externalities, which push in opposite directions, just as in the small-country case, and the term $m_{ig}$ captures the terms-of-trade motive for the agreement.

Focus first on the case in which lobbying pressures are weak, so the political parameters $\gamma_{ig}$ are small. In this case, recall that absent trade the agreement would loosen all process standards. But if there is trade, for exporting countries the terms-of-trade effect pushes in the same direction (toward de-regulation), while for importing countries it pushes in the opposite direction and may lead to a tightening of standards.

If the political pressure parameters $\gamma_{ig}$ are large enough, intuitively the political externality dominates and hence $\frac{\partial \Omega_g^{-i}}{\partial p_g}|_{NE} > 0$, thus the best local agreement tightens all process standards. We can show that, under a regularity condition, this local result holds also globally, and at the normative level the equilibrium agreement increases welfare, just as in our baseline model.[52]

# 7 Conclusion

In this paper we have examined the positive and normative effects of international regulatory agreements that are negotiated under lobbying pressures from producer groups. Our analysis

[52]The restriction under which we can show that the local result holds globally is that $\gamma_{ig}$ and $\varepsilon_{ig}$ are not too dissimilar across countries. Note that the key difference between the formulas for the noncooperative and cooperative standards, (29) and (30), lies in the difference between $\lambda_g^A$ and $\lambda_{ig}^N$. In Appendix D we show that the restriction mentioned above ensures that $\lambda_g^A > \lambda_{ig}^N$ when the $\gamma_{ig}$ parameters are sufficiently large.

suggests that these effects depend critically on whether the interests of producers in different countries are aligned or in conflict. The former situation tends to occur for product standards, while the latter tends to occur for process standards. We have shown that, if lobbying forces are strong enough, international cooperation on product standards leads to excessive deregulation and decreases welfare, while in the case of process standards it leads to tighter regulations and increases welfare.

There are several further extensions of our model that would be interesting to explore in future research.

Our model assumes perfect competition. While a competitive model seems like a natural place to start for exploring the questions we are interested in, the presence of imperfect competition may affect some of our qualitative results and may open up further interesting questions. One such question concerns the role of firm heterogeneity and how this might affect the alignment of producer interests across borders. For example, in our competitive setting all producers in the world benefit from a relaxation of (non-discriminatory) product standards in any given country, and this is true regardless of asymmetries in supply parameters, but this is no longer obvious in the presence of imperfect competition: in particular, it is conceivable that tightening a (non-discriminatory) standard may increase the profits of more productive firms at the expense of less productive ones, even though it increases abatement costs for all firms. Whether or not this is the case is likely to depend on the specifics of the market structure and on the extent of cross-firm differences in abatement cost elasticities, and it would be interesting to investigate the conditions under which this would happen.

We have abstracted from fixed costs of compliance with product standards. Such fixed costs are undoubtedly relevant in reality and often mentioned as a rationale for harmonization of standards. How the presence of such fixed costs might change the welfare impact of regulatory agreements that are negotiated under lobbying pressures is an important question, but again, this would require a model with imperfect competition, which is outside the scope of this paper. Second, we have not considered horizontal standards. Note that the notions of co-lobbying and counter-lobbying, which are central in our model, are intrinsically vertical notions (do lobbies agree on tightening versus loosening standards), so they would not apply to a setting of horizontal standards, and hence one would have to entirely revisit the question of whether lobbying has a more distortionary effect on cooperative policies or on unilateral policies.

Another important question that we have not addressed in this paper is the role of global supply chains. Intuitively, in the presence of global supply chains, the welfare effects of regulatory cooperation would depend on where regulations hit along the supply chain. For example, consider vertical product standards. The interests of producer lobbies around the world are likely to be aligned when it comes to standards on final products, so regulatory cooperation will strengthen the impact of lobbies on regulations. But this would not necessarily be true for standards on intermediate products, because in this case the interests of upstream and downstream lobbies worldwide would be in conflict, so an agreement may dilute the overall influence of lobbies.

In the debate on the welfare effects of deep integration, the role of multinational enterprises is often mentioned as one of the reasons for concern. A natural question therefore is whether or not the multinational nature of production tends to worsen the welfare impacts of deep integration. Our perfect-competition setting cannot speak to the role of multinational firms, since there is no meaningful notion of firms in such a setting, so this is another desirable direction of extension of our model.

We have focused on global agreements, but it would be interesting to explore the welfare impacts of regional agreements when such agreements are negotiated under lobbying pressures. While there is a large literature that examines the welfare impacts of regional agreements of the "shallow" kind, including a few models where such agreements are negotiated under political pressure (e.g. Grossman and Helpman, 1995b, and Ornelas, 2005), the literature has paid little attention so far to the welfare impacts of regional regulatory cooperation.

Finally, it would be important to examine the welfare impacts of international cooperation in other salient areas of deep integration, such as foreign investment and intellectual property rights. The cleavages between special interests across country borders are clearly issue-area specific, but our conjecture is that the basic logic outlined above will continue to apply – namely, that international negotiations tend to enhance welfare if the interests of lobbies around the world are aligned, while they tend to reduce welfare if the interests of lobbies across borders are in conflict, at least if lobbies are sufficiently powerful.

# 8 Appendix

## 8.1 Appendix A

### Proof of Proposition 1

Let $f_{ig}(p_g+\tau_{ig}) \equiv \frac{\gamma_{ig} y_{ig}(p_g+\tau_{ig})}{-m'_{ig}(p_g+\tau_{ig})}$ and let $(\{\hat{\tau}_{ig}(\kappa_g)\}_{i\in\mathcal{M}_g}, \hat{p}_g(\kappa_g))$ denote the solution to the following system:

$$\tau_{ig} = f_{ig}(p_g+\tau_{ig}) - \kappa_g, \quad i \in \mathcal{M}_g$$
$$\int_{i\in\mathcal{M}_g} m_{ig}(p_g+\tau_{ig}) = \int_{i\in\mathcal{X}_g} x_{ig}(p_g)$$

Note that $\kappa_g$ is a parameter that "connects" the noncooperative equilibrium with the cooperative solution. When $\kappa_g = 0$ the solution of the above system is the noncooperative equilibrium, and when $\kappa_g = \lambda_g$ the solution of the above system coincides with the cooperative solution.

It is not hard to see that, given the assumption that there exists a unique solution to the above system for any $\kappa_g \in [0, \lambda_g]$ (stated in footnote 16), we must have $f'_{ig} < 1$ for all $i$ when evaluated at the solution of the system. Differentiating the above system we obtain:

$$\begin{aligned} \frac{\partial\hat{\tau}_{ig}}{\partial\kappa_g} &= \frac{f'_{ig}}{1-f'_{ig}}\frac{\partial\hat{p}_g}{\partial\kappa_g} - \frac{1}{1-f'_{ig}} \\ \frac{\partial\hat{p}_g}{\partial\kappa_g} &= \frac{\int_{i\in\mathcal{M}_g} m'_{ig}\frac{\partial\hat{\tau}_{ig}}{\partial\kappa_g}}{\int_{i\in\mathcal{X}_g} x'_{ig} - \int_{i\in\mathcal{M}_g} m'_{ig}} \end{aligned}$$

This yields:

$$\begin{aligned} \frac{\partial\hat{\tau}_{ig}}{\partial\kappa_g} &= -\frac{1}{1-f'_{ig}}\frac{\int_{i\in\mathcal{X}_g} x'_{ig} - \left(1-f'_{ig}\right)\int_{i\in\mathcal{M}_g} m'_{ig}\frac{1}{1-f'_{ig}}}{\int_{i\in\mathcal{X}_g} x'_{ig} - \int_{i\in\mathcal{M}_g} m'_{ig}\frac{1}{1-f'_{ig}}} < 0 \\ \frac{\partial\hat{p}_g}{\partial\kappa_g} &= \frac{-\int_{i\in\mathcal{M}_g} m'_{ig}\frac{1}{1-f'_{ig}}}{\int_{i\in\mathcal{X}_g} x'_{ig} - \int_{i\in\mathcal{M}_g} m'_{ig}\frac{1}{1-f'_{ig}}} > 0 \end{aligned}$$

Thus, as we move from the noncooperative equilibrium to the cooperative equilibrium, $\hat{\tau}_{ig}$ decreases for all $i$, and $p_g$ increases. We can conclude that $\tau^A_{ig} < \tau^N_{ig}$ for all $i$. QED

### Proof of Proposition 2

We build on our proof of Proposition 1. First note that, using the expressions for $\frac{\partial\hat{\tau}_{ig}}{\partial\kappa_g}$ and $\frac{\partial\hat{p}_g}{\partial\kappa_g}$ obtained above yields:

$$\frac{\partial\left(\hat{p}_g+\hat{\tau}_{ig}\right)}{\partial\kappa_g} = -\frac{\frac{1}{1-f'_{ig}}\int_{i\in\mathcal{X}_g} x'_{ig}}{\int_{i\in\mathcal{X}_g} x'_{ig} - \int_{i\in\mathcal{M}_g} m'_{ig}\frac{1}{1-f'_{ig}}} < 0$$

Thus, as we move from the noncooperative equilibrium to the cooperative equilibrium, the domestic price decreases in each importing country.

We can now trace how global welfare changes as $\kappa_g$ changes. The global welfare associated with $\left(\{\hat{\tau}_{ig}(\kappa_g)\}_{i\in\mathcal{M}_g}, \hat{p}_g(\kappa_g)\right)$ can be written as:

$$\hat{W}_g(\kappa_g) = \int_i [\pi_{ig}(\hat{p}_g + \hat{\tau}_{ig}) + S_{ig}(\hat{p}_g + \hat{\tau}_{ig}) + \hat{\tau}_{ig} m_{ig}(\hat{p}_g + \hat{\tau}_{ig})],$$

where we keep in mind, here and below, that $\hat{p}_g$ and $\hat{\tau}_{ig}$ are functions of $\kappa_g$. Differentiating with respect to $\kappa_g$, we obtain:

$$\frac{\partial \hat{W}_g}{\partial \kappa_g} = \int_{i\in\mathcal{M}_g} \hat{\tau}_{ig} m'_{ig}(\hat{p}_g + \hat{\tau}_{ig}) \frac{\partial(\hat{p}_g + \hat{\tau}_{ig})}{\partial \kappa_g}$$

This implies that the welfare change caused by the agreement is:

$$W_g^A - W_g^N = \int_0^{\lambda_g} \left[\int_{i\in\mathcal{M}_g} \hat{\tau}_{ig} m'_{ig}(\hat{p}_g + \hat{\tau}_{ig}) \frac{\partial(\hat{p}_g + \hat{\tau}_{ig})}{\partial \kappa_g}\right] d\kappa_g$$

Recalling that $m'_{ig} < 0$, $\frac{\partial(\hat{p}_g + \hat{\tau}_{ig})}{\partial \kappa_g} < 0$, and $\hat{\tau}_{ig}$ goes from the noncooperative level to the cooperative level as $\kappa_g$ goes from 0 to $\lambda_g$, it follows that a sufficient condition for $W_g^A - W_g^N > 0$ is that cooperative tariffs are not too negative. QED

## 8.2 Appendix B

In this appendix we prove the claims made in the main text regarding the sufficient conditions for existence and uniqueness of the noncooperative equilibrium. We start with the model of product standards.

**Claim:** In the product-standards model, if $\sigma_{ig}$ does not increase too steeply with the price, then: (i) there exists a unique noncooperative equilibrium, and (ii) it satisfies the system (13)+(14).

**Proof:** We begin by showing that there exists a unique solution to the first-order condition $e_{ig} = \frac{1}{\sigma_{ig}\left(p_g + \phi_{ig}(e_{ig})\right)}\left(\frac{1}{a_{ig}} + \frac{1}{\phi'_{ig}(e_{ig})}\right)$ for any $p_g$, which must then correspond to the unique maximum of the associated objective function $\Omega_{ig}$ given that we assume away corner solutions. Recall that $\phi_{ig}$ is decreasing and convex, so $\phi'_{ig}$ is negative and increasing, hence $\frac{1}{\phi'_{ig}}$ is negative and decreasing. Also note that our assumptions imply $\frac{1}{\phi'_{ig}(0)} = 0$ and $\lim_{e_{ig}\to\infty} \frac{1}{\phi'_{ig}(e_{ig})} = -\infty$. Next note that, if $\sigma_{ig}$ is weakly decreasing in the price, it is weakly increasing in $e_{ig}$ and hence $\frac{1}{\sigma_{ig}\left(p_g + \phi_{ig}(e_{ig})\right)}$ is weakly decreasing in $e_{ig}$. So in this case the left-hand side of the equation above is a line with slope 1 and the right-hand side is a decreasing function that starts positive and goes to minus infinity, hence the equation above has a unique solution. Next note that, for the first-order condition to have a unique solution, it suffices that the right-hand side not increase in $e_{ig}$ with slope steeper than (or equal to) one, and this is satisfied as long as $\sigma_{ig}$ does not increase too steeply with the price, hence the claim.

Next we show that there exists a unique solution to the system (13)+(14), which must then correspond to the unique noncooperative equilibrium. The argument just above implies that the unilateral optimum given $p_g$ is a well defined function $e_{ig}(p_g)$. Plugging this into the market clearing condition gives $\int_i y_{ig}(p_g) = \int_i d_{ig}\left(p_g + \phi_{ig}(e_{ig}(p_g))\right)$. We now show that the consumer price $p_g^c \equiv p_g + \phi_{ig}(e_{ig}(p_g))$ increases weakly with $p_g$. Given this, the left-hand side is increasing in $p_g$ and the right-hand side is decreasing in $p_g$, so there is a unique solution.

Differentiating $p_g^c$ yields

$$\frac{dp_g^c}{dp_g} = 1 + \phi_{ig}' \frac{de_{ig}}{dp_g}$$

Differentiating the first order condition (13), it is direct to verify that

$$\frac{de_{ig}}{dp_g} = \frac{\frac{-\sigma_{ig}'}{\sigma_{ig}} e_{ig}}{1 + \frac{\phi_{ig}''}{\sigma_{ig}\phi_{ig}'^2} + \frac{\sigma_{ig}'\phi_{ig}' e_{ig}}{\sigma_{ig}}}$$

and hence

$$\frac{dp_g^c}{dp_g} = \frac{1 + \frac{\phi_{ig}''}{\sigma_{ig}\phi_{ig}'^2}}{1 + \frac{\phi_{ig}''}{\sigma_{ig}\phi_{ig}'^2} + \frac{\sigma_{ig}'\phi_{ig}' e_{ig}}{\sigma_{ig}}}$$

Since $\phi_{ig}' < 0$ and $\phi_{ig}'' > 0$ by assumption, $\frac{dp_g^c}{dp_g}$ is positive as long as $\sigma_{ig}'$ is not too large and positive, hence the claim. QED

Next we turn to the analogous claim for the model of process standards.

**Claim:** In the process-standards model, if $\varepsilon_i$ does not decrease too steeply with the price, then: (i) there exists a unique noncooperative equilibrium, and (ii) it satisfies the system (20)+(21).

**Proof:** We begin by showing that there exists a unique solution to the first-order condition $z_{ig} = \frac{1}{\varepsilon_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right)} \left( \frac{1+\gamma_{ig}}{b_{ig}} + \frac{1}{\varphi_{ig}'(z_{ig})} \right)$ for any $p_g$, which must then correspond to the unique maximum of the associated objective function $\Omega_{ig}$ given that we rule out corner solutions. Recall that $\varphi_{ig}'$ is decreasing and convex, so $\varphi_{ig}'$ is negative and increasing, hence $\frac{1}{\varphi'_{ig}}$ is negative and decreasing. Also note that our assumptions imply $\frac{1}{\varphi'_{ig}(0)} = 0$ and $\lim_{z_{ig}\to\infty} \frac{1}{\varphi'_{ig}(z_{ig})} = -\infty$. Next note that, if $\varepsilon_{ig}$ is weakly increasing in the price, it is weakly increasing in $z_{ig}$ and hence $\frac{1}{\varepsilon_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right)}$ is weakly decreasing in $z_{ig}$. So in this case the left-hand side of the equation above is a line with slope 1 and the right-hand side is a decreasing function that starts positive and goes to minus infinity, hence the equation above has a unique solution. Next note that, for the first-order condition to have a unique solution, it suffices that the right-hand side not increase in $z_{ig}$ with slope higher than (or equal to) one, and this is satisfied as long as $\varepsilon_{ig}$ does not decrease too steeply with the price, hence the claim.

Next we show that there exists a unique solution to the system (20)+(21), which must then correspond to the unique noncooperative equilibrium. The argument just above implies that the unilateral optimum given $p_g$ is a well defined function $z_{ig}(p_g)$. Plugging this into the market clearing condition gives $\int_i y_{ig}\left(p_g - \varphi_{ig}\left(z_{ig}\left(p_g\right)\right)\right) = \int_i d_{ig}\left(p_g\right)$. We now show that the producer price $p_g^p \equiv p_g - \varphi_{ig}\left(z_{ig}\left(p_g\right)\right)$ increases weakly with $p_g$. Given this, the left-hand side is increasing in $p_g$ and the right-hand side is decreasing in $p_g$, so there is a unique solution.

Differentiating $p_g^p$ yields

$$\frac{dp_g^p}{dp_g} = 1 - \varphi'_{ig}\frac{dz_{ig}}{dp_g}$$

Differentiating the first order condition (20), it is direct to verify that

$$\frac{dz_{ig}}{dp_g} = \frac{-\frac{\varepsilon'_{ig} z_{ig}}{\varepsilon_{ig}}}{1 + \frac{\varphi''_{ig}}{\varepsilon_{ig}\varphi'^2_{ig}} - \frac{\varepsilon'_{ig}\varphi'_{ig} z_{ig}}{\varepsilon_{ig}}}$$

and hence

$$\frac{dp_g^p}{dp_g} = \frac{1 + \frac{\varphi''_{ig}}{\varepsilon_{ig}\varphi'^2_{ig}}}{1 + \frac{\varphi''_{ig}}{\varepsilon_{ig}\varphi'^2_{ig}} - \frac{\varepsilon'_{ig}\varphi'_{ig} z_{ig}}{\varepsilon_{ig}}}$$

Since $\varphi'_{ig} < 0$ and $\varphi''_{ig} > 0$ by assumption, $\frac{dp_g^c}{dp_g}$ is positive as long as $\varepsilon'_{ig}$ is not too large and negative, hence the claim. QED

## 8.3 Appendix C

**Proof of Proposition 1**: We first establish that the best local agreement increases $e_{ig}$ for all $i$. This follows from two observations. The first one is that $\Omega_g$ is increasing in each $e_{ig}$

when evaluated at the noncooperative standards. To see this, differentiate $\Omega_g$ to get:

$$\begin{aligned} d\Omega_g &= \int_i \frac{\partial \Omega_{ig}}{\partial e_{ig}} de_{ig} + \frac{\partial \Omega_g}{\partial p_g} dp_g \\ &= \int_i \frac{\partial \Omega_{ig}}{\partial e_{ig}} de_{ig} - \frac{\partial \Omega_g}{\partial p_g} \int_i \frac{\sigma_{ig} d_{ig} \phi'_{ig}}{\int_j (\varepsilon_{jg} y_{jg} + \sigma_{jg} d_{jg})} de_{ig} \end{aligned}$$

where we have differentiated the market clearing condition to write down the expression for $dp_g$. Note that $\frac{\partial \Omega_{ig}}{\partial e_{ig}} = 0$ for all $i$ at the noncooperative equilibrium and recall from the main text that $\frac{\partial \Omega_g}{\partial p_g} > 0$ at the noncooperative equilibrium. Furthermore $-\int_i \frac{\sigma_{ig} d_{ig} \phi'_{ig}}{\int_j (\varepsilon_{jg} y_{jg} + \sigma_{jg} d_{jg})} de_{ig}$ has the same sign as $de_{ig}$, hence the claim. The second observation is that, since the gradient of $\Omega_g$ at the noncooperative standards $\mathbf{e}_g^N$ is positive for all standards, it follows that the direction of steepest ascent of the objective $\Omega_g$ starting from $\mathbf{e}_g^N$ entails loosening all of the standards.

Next we show that this local result holds globally if (i) countries are sufficiently close to symmetric, or (ii) demand semi-elasticities $\sigma_{ig}$ do not increase too much with the consumer price, or (iii) the political parameters $\gamma_{ig}$ are sufficiently large.

(i) Suppose countries are symmetric. Under our assumptions $\Omega_g(\mathbf{e}_g, p_g(\mathbf{e}_g))$ has a unique peak, which is symmetric. Letting $\Omega_g(e_g, p_g(e_g))$ denote the joint government payoff given a common standard $e_g$, also this function clearly has a single peak, which we denote $e_g^A$.

We know from the local argument in the main text that $\frac{d\Omega_g}{de_g}|_{NE} > 0$. Given that $\Omega_g(e_g, p(e_g))$ is single-peaked, it follows immediately that $e_g^A > e_g^N$, where $e_g^N$ is the symmetric noncooperative standard. A continuity argument can then be used to extend this result to the case where countries are sufficiently close to symmetric.

(ii) Let $(\hat{e}_{ig}(\kappa_g), \hat{p}_g(\kappa_g))$ denote the solution to the following system:

$$\begin{gathered} e_{ig} = \frac{1}{\sigma_{ig}\left(p_g + \phi_{ig}(e_{ig})\right)} \left( \frac{1}{a_{ig}} + \frac{1}{\phi'_{ig}(e_{ig})} \right) + \frac{\kappa_g}{a_{ig}} \text{ for all } i \\ \int_i y_{ig}(p_g) = \int_i d_{ig}\left(p_g + \phi_{ig}(e_{ig})\right) \end{gathered}$$

Note that $\kappa_g$ is a parameter that "connects" the noncooperative equilibrium with the cooperative solution: when $\kappa_g = 0$ the solution of the above system is the noncooperative equilibrium, and when $\kappa_g = \lambda_g > 0$ the solution of the above system coincides with the cooperative solution.

Given $\sigma_{ig}$, the first equation implicitly defines a unique value of $e_{ig}$, since the left-hand side is a line with slope one and the right-hand side is a decreasing function that starts positive and goes to minus infinity, given our assumptions on $\phi_{ig}(\cdot)$. We denote such solution by $e_{ig} = f_{ig}\left(\sigma_{ig}\left(p_g + \phi_{ig}(e_{ig})\right), \kappa_g\right)$ and rewrite the above system as:

$$\begin{aligned} e_{ig} &= f_{ig}\left(\sigma_{ig}\left(p_g + \phi_{ig}(e_{ig})\right), \kappa_g\right) \text{ for all } i \\ \int_i y_{ig}(p_g) &= \int_i d_{ig}\left(p_g + \phi_{ig}(e_{ig})\right) \end{aligned}$$

Recall from Appendix B that if $\kappa_g = 0$ then this system has a unique solution, provided $\sigma_{ig}$ does not increase too steeply. It is easy to show that the same is true for any $\kappa_g > 0$. Also, it is easy to verify that $\frac{\partial f_{ig}}{\partial \kappa_g} > 0$ and $\frac{\partial f_{ig}}{\partial \sigma_{ig}} < 0$. Differentiating the system we obtain:

$$\begin{aligned} \frac{d\hat{e}_{ig}}{d\kappa_g} &= \frac{\frac{\partial f_{ig}}{\partial \sigma_{ig}}\sigma'_{ig}}{1 - \frac{\partial f_{ig}}{\partial \sigma_{ig}}\sigma'_{ig}\phi'_{ig}}\frac{d\hat{p}_g}{d\kappa_g} + \frac{\frac{\partial f_{ig}}{\partial \kappa_g}}{1 - \frac{\partial f_{ig}}{\partial \sigma_{ig}}\sigma'_{ig}\phi'_{ig}} \\ \frac{d\hat{p}_g}{d\kappa_g} &= -\frac{\int_i \sigma_{ig} d_{ig} \phi'_{ig} \frac{d\hat{e}_{ig}}{d\kappa_g}}{\int_i \left(\varepsilon_{ig} y_{ig} + \sigma_{ig} d_{ig}\right)} \end{aligned}$$

Plugging the first equation into the second one and solving for $\frac{d\hat{p}_g}{d\kappa_g}$, this yields

$$\frac{d\hat{p}_g}{d\kappa_g} = -\frac{\int_i \sigma_{ig} d_{ig} \frac{\frac{\partial f_{ig}}{\partial \kappa_g}\phi'_{ig}}{1 - \frac{\partial f_{ig}}{\partial \sigma_{ig}}\sigma'_{ig}\phi'_{ig}}}{\int_i \varepsilon_{ig} y_{ig} + \int_i \sigma_{ig} d_{ig} \frac{1}{1 - \frac{\partial f_{ig}}{\partial \sigma_{ig}}\sigma'_{ig}\phi'_{ig}}}$$

Clearly, $\frac{d\hat{p}_g}{d\kappa_g} > 0$ as long as $\sigma_{ig}$ does not increase to steeply. This in turn immediately implies $\frac{d\hat{e}_{ig}}{d\kappa_g} > 0$. Thus, as we move from the noncooperative solution to the cooperative solution, $\hat{e}_{ig}$ increases for all $i$. We can conclude that $e^A_{ig} > e^N_{ig}$ for all $i$.

(iii) We first argue that, if $\gamma_g \to \infty$ for all $i$, then $e^A_{ig} \to \infty$ for all $i$. This follows from the fact that, in the limit as $\gamma_g \to \infty$ for all $i$, the cooperative standards must maximize $\int_i \nu_{ig}\pi_{ig}(p_g)$, and this implies $e^A_{ig} \to \infty$ for all $i$. More concretely, suppose by contradiction that, as $\gamma_g \to \infty$ for all $i$, the optimal standards $e^A_{ig}$ converge to some finite levels $\bar{e}_{ig}$ for a positive measure of countries. Then clearly there exist large enough values of $\gamma_g$ such that the optimal standards for these countries are looser than $\bar{e}_{ig}$.

Finally, recalling that $e^N_{ig}$ is independent of $\gamma_g$, we can conclude that the agreement loosens all standards if $\gamma_g$ is sufficiently large. QED

**Proof of Proposition 2**: Before proving the more general result stated in Proposition 2, we focus on the case of symmetric countries and prove the stronger result illustrated in Figure 1.

(i) We show that, if countries are symmetric, there exists a cutoff value $\bar{\gamma}_g$ such that $\Delta_g > 0$ for $\gamma_g < \bar{\gamma}_g$ and $\Delta_g < 0$ for $\gamma_g > \bar{\gamma}_g$.

We begin by characterizing $e_g^N$, $e_g^W$, and $e_g^A$ as functions of $\gamma_g$. It is immediate that $\frac{de_g^N}{d\gamma_g} = 0$, $\frac{de_g^W}{d\gamma_g} = 0$, and that $e_g^A = e_g^W$ for $\gamma_g = 0$.

Next we show that $e_g^A$ is increasing in $\gamma_g$. Let $\tilde{\Omega}_g(e_g, \gamma_g) \equiv \Omega_g \left(e_g, p\left(e_g\right), \gamma_g\right)$ (with a slight abuse of notation we have emphasized the dependence of $\Omega_g$ on $\gamma_g$), and note that $\frac{d^2\tilde{\Omega}_g}{de_g d\gamma_g} = \frac{y_g d'_g \phi'_g}{y'_g - d'_g} > 0$. Thus $\tilde{\Omega}_g$ is supermodular in $e_g$ and $\gamma_g$, and hence by standard supermodularity arguments it follows that $\frac{de_g^A}{d\gamma_g} > 0$.

We now turn to characterizing $W_g^N$ and $W_g^A$ as functions of $\gamma_g$. Note that $\frac{de_g^N}{d\gamma_g} = 0$ implies $\frac{dW_g^N}{d\gamma_g} = 0$ and $\frac{de_g^A}{d\gamma_g} > 0$ implies $\frac{dW_g^A}{d\gamma_g} < 0$, since $e_g^A$ maximizes welfare when $\gamma_g = 0$ and global welfare is single-peaked in $e_g$ by assumption. It follows that $\frac{d\Delta_g}{d\gamma_g} < 0$.

The final step is to show that $\Delta_g < 0$ for sufficiently large $\gamma_g$. Recalling from the proof of the previous proposition that $\lim_{\gamma_g \to \infty} e_{ig}^A = \infty$, it is clear that $\lim_{\gamma_g \to \infty} W_g^A = -\infty$, so there must exist some $\bar{\gamma}_g$ such that $\Delta_g < 0$ for $\gamma_g > \bar{\gamma}_g$.

(ii) We now allow for asymmetric countries. Recall that we define $\gamma_{ig} = \gamma_g \nu_{ig}$ and vary $\gamma_g$. With asymmetric countries, it is still trivially true that $\Delta_g > 0$ for $\gamma_g = 0$, and thus also for sufficiently low $\gamma_g$. Moreover, it is also still true that $\lim_{\gamma_g \to \infty} e_{ig}^A = \infty$ for all $i$ and thus $\Delta_g < 0$ for sufficiently large $\gamma_g$. What is no longer guaranteed in the case of asymmetric countries is that there exists a unique cutoff value $\bar{\gamma}_g$. QED

**Proof of Proposition 3**: In the main text we established that $\frac{\partial \Omega_g}{\partial p_g}|_{NE}$ is positive if $\gamma_g$ is large enough and negative if $\gamma_g$ is small enough. Using a similar argument as in the proof of Proposition 1, it is easy to argue that the best local agreement tightens all process standards if $\gamma_g$ is large enough and loosens all process standards if $\gamma_g$ is small enough.

Now we show that this local result holds globally under the conditions stated in Proposition 3.

($\text{i}_a$) Suppose countries are symmetric. Under our assumptions, $\Omega_g \left(\mathbf{z}_g, p_g\left(\mathbf{z}_g\right)\right)$ has a unique peak, which is symmetric. Let $z_g^A$ denote the symmetric cooperative standard. Let $\Omega_g \left(z_g, p_g\left(z_g\right)\right)$ denote the joint government payoff given a common standard $z_g$. Also this function clearly has a single peak at $z_g^A$.

We know from the local argument in the main text that $\frac{d\Omega_g}{dz_g}|_{NE} > 0$ for small enough $\gamma_g$. Given that $\Omega_g \left(z_g, p\left(z_g\right)\right)$ is single-peaked, it follows immediately that $z_g^A > z_g^N$ for small enough $\gamma_g$, where $z_g^N$ is the symmetric noncooperative standard. A continuity argument can then be used to extend this result to the case where countries are sufficiently close to symmetric.

($i_b$) We now show that the globally optimal agreement loosens all standards for small enough $\gamma_g$, as long as $\varepsilon_{ig}$ does not decrease too steeply.

It suffices to show the result for $\gamma_g = 0$. Note that in this case $\lambda_g < 0$.

Let $(\hat{z}_{ig}(\kappa_g), \hat{p}_g(\kappa_g))$ denote the solution to the following system:

$$z_{ig} = \frac{1}{\varepsilon_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right)}\left(\frac{1}{b_{ig}} + \frac{1}{\varphi'_{ig}(z_{ig})}\right) - \frac{\kappa_g}{b_{ig}}$$
$$\int_i y_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right) = \int_i d_{ig}(p_g)$$

As in the case of product standards, when $\kappa_g = 0$ the solution of the above system is the noncooperative equilibrium, and when $\kappa_g = \lambda_g < 0$ it coincides with the cooperative solution. Given $\varepsilon_{ig}$, the first equation implicitly defines a unique value of $z_{ig}$, since the left-hand side is a line with slope one and the right-hand side is a decreasing function that starts positive and goes to minus infinity, given our assumptions on $\varphi_{ig}(\cdot)$. We denote such solution by $z_{ig} = f_{ig}\left(\varepsilon_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right), \kappa_g\right)$ and rewrite the above system as:

$$\begin{aligned} z_{ig} &= f_{ig}\left(\varepsilon_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right), \kappa_g\right) \\ \int_i y_{ig}\left(p_g - \varphi_{ig}(z_{ig})\right) &= \int_i d_{ig}(p_g) \end{aligned}$$

Recall from Appendix B that if $\kappa_g = 0$ then this system has a unique solution, provided $\varepsilon_{ig}$ does not decrease too steeply. It is easy to show that the same is true for any $\kappa_g > 0$. Also, it is easy to verify that $\frac{\partial f_{ig}}{\partial \kappa_g} < 0$ and $\frac{\partial f_{ig}}{\partial \varepsilon_{ig}} < 0$. Differentiating the system we obtain:

$$\begin{aligned} \frac{d\hat{z}_{ig}}{d\kappa_g} &= \frac{\frac{\partial f_{ig}}{\partial \varepsilon_{ig}}\varepsilon'_{ig}}{1 + \frac{\partial f_{ig}}{\partial \varepsilon_{ig}}\varepsilon'_{ig}\varphi'_{ig}}\frac{d\hat{p}_g}{d\kappa_g} + \frac{\frac{\partial f_{ig}}{\partial \kappa_g}}{1 + \frac{\partial f_{ig}}{\partial \varepsilon_{ig}}\varepsilon'_{ig}\varphi'_{ig}} \\ \frac{d\hat{p}_g}{d\kappa_g} &= \frac{\int_i \varepsilon_{ig} y_{ig}\varphi'_{ig}\frac{d\hat{z}_{ig}}{d\kappa_g}}{\int_i\left(\varepsilon_{ig} y_{ig} + \sigma_{ig} d_{ig}\right)} \end{aligned}$$

Plugging the first equation into the second one and solving for $\frac{d\hat{p}_g}{d\kappa_g}$, this yields

$$\frac{d\hat{p}_g}{d\kappa_g} = \frac{\int_i \varepsilon_{ig} y_{ig}\varphi'_{ig}\frac{\frac{\partial f_{ig}}{\partial \kappa_g}}{1+\frac{\partial f_{ig}}{\partial \varepsilon_{ig}}\varepsilon'_{ig}\varphi'_{ig}}}{\int_i \sigma_{ig} d_{ig} + \int_i \varepsilon_{ig} y_{ig}\frac{1}{1+\frac{\partial f_{ig}}{\partial \varepsilon_{ig}}\varepsilon'_{ig}\varphi'_{ig}}}$$

Clearly, $\frac{d\hat{p}_g}{d\kappa_g} > 0$ as long as $\varepsilon_{ig}$ does not decrease too steeply with the price. This in turn immediately implies $\frac{d\hat{z}_{ig}}{d\kappa_g} < 0$. Thus, as we move from the noncooperative solution $(\kappa_g = 0)$

to the cooperative solution ($\kappa_g < 0$), $\hat{z}_{ig}$ increases for all $i$. We can conclude that $z_{ig}^A > z_{ig}^N$ for all $i$.

(ii) We now argue that the globally optimal agreement tightens all standards if $\gamma_g$ is large enough. In fact we will show a stronger result, namely that $z_{ig}^N - z_{ig}^A \to \infty$ as $\gamma_g \to \infty$ for all (except possibly a zero measure of) countries, a result that we will use in the next proof below.

First recall from equation (23) that $z_{ig}^A = \frac{1}{\varepsilon_{ig}}\left(\frac{1+\gamma_{ig}}{b_{ig}} + \frac{1}{\varphi'_{ig}\left(z_{ig}^A\right)}\right) - \frac{\lambda_g}{b_{ig}}$, where the multiplier is given by $\lambda_g = \frac{\int_i y_{ig}\left(\gamma_{ig} - b_{ig} z_{ig}^A \varepsilon_{ig}\right)}{\int_i \varepsilon_{ig} y_{ig} + \int_i \sigma_{ig} d_{ig}}$. Substituting the first equation into the second and rearranging yields

$$\lambda_g = -\frac{\int_i y_{ig}\left(1 + \frac{b_{ig}}{\varphi'_{ig}\left(z_{ig}^A\right)}\right)}{\int_i \sigma_{ig} d_{ig}}$$

Second, note that $\lim_{\gamma_g \to \infty} z_{ig}^N = \infty$. To see this, recall from (20) that $z_{ig}^N = \frac{1}{\varepsilon_{ig}}\left(\frac{1+\gamma_{ig}}{b_{ig}} + \frac{1}{\varphi'_{ig}(z_{ig}^N)}\right)$. Given the assumption that $\varepsilon_{ig}$ is bounded, the right hand side of the above expression goes to infinity as $\gamma_{ig} \to \infty$ , unless $\frac{1}{\varphi'_{ig}(z_{ig}^N)} \to -\infty$. But given our assumptions on the abatement cost function, the latter can happen only if $z_{ig}^N \to \infty$, thus the claim follows.

Now suppose by contradiction that $z_{ig}^N - z_{ig}^A$ stays bounded (or goes to $-\infty$) for a positive measure of countries, say group A. Then $\lim_{\gamma_g \to \infty} z_{ig}^A = \infty$ for group A, since $\lim_{\gamma_g \to \infty} z_{ig}^N = \infty$. This implies that $\varphi'_{ig}\left(z_{ig}^A\right) \to 0^-$ for group A. Also, for these countries $y_{ig}$ is clearly bounded away from zero, so $y_{ig}\left(1 + \frac{b_{ig}}{\varphi'_{ig}\left(z_{ig}^A\right)}\right) \to -\infty$ for group A. Furthermore, recalling the assumption that $\sigma_{ig}$ is bounded, $\int_i \sigma_{ig} d_{ig}$ stays bounded, and therefore $\lim_{\gamma_g \to \infty} \lambda_g = \infty$. Keeping in mind that $\lambda_g$ is the same for all countries, and using the formulas for the noncooperative standards (20) and cooperative standards (23), it is easy to see that $z_{ig}^N - z_{ig}^A$ must then go to infinity for all countries, thus contradicting the premise.

We can conclude that $z_{ig}^N - z_{ig}^A \to \infty$ as $\gamma_g \to \infty$ for all (except possibly a zero measure of) countries. QED

**Proof of Proposition 4**: We separate this proof into two parts. First, we focus on the case with symmetric countries and constant semi-elasticities and prove the result illustrated in Figure 2. Then we turn to the general case and prove the result stated in proposition 6.

(i) We first focus on the case of symmetric countries and constant semi-elasticities and prove the result illustrated in Figure 2, and namely that there exist critical levels $\gamma_g^L < \gamma_g^H$ such that the agreement increases welfare if $\gamma_g < \gamma_g^L$, decreases welfare if $\gamma_g \in \left(\gamma_g^L, \gamma_g^H\right)$, and increases welfare again if $\gamma_g > \gamma_g^H$.

We begin by showing that the schedules $z_g^N(\gamma_g)$ and $z_g^A(\gamma_g)$ are both increasing, and that $z_g^N(\gamma_g)$ crosses $z_g^A(\gamma_g)$ only once and from below. Differentiating equations (20) and (23) yields

$$\begin{aligned} \frac{dz_g^N}{d\gamma_g} &= \frac{1}{\varepsilon_g b_g}\left(1+\frac{\varphi_g''(z_g^N)}{\varepsilon_g \varphi_g'^2(z_g^N)}\right)^{-1} \\ \frac{dz_g^A}{d\gamma_g} &= \frac{1}{\varepsilon_g b_g}\left(1+\frac{\varphi_g''(z_g^A)}{\varepsilon_g \varphi_g'^2(z_g^A)}+\frac{\varphi_g''(z_g^A)}{\sigma_g \varphi_g'^2(z_g^A)}\right)^{-1} \end{aligned}$$

where we have used the fact that $y_g = d_g$ under symmetry. Since $\varphi_g'' > 0$, it follows that $\frac{dz_g^N}{d\gamma_g} > 0$ and $\frac{dz_g^A}{d\gamma_g} > 0$. Next recall from the previous proposition that $z_g^N(0) < z_g^A(0)$ and $z_g^N(\infty) > z_g^A(\infty)$, so $z_g^N(\gamma_g)$ must cross $z_g^A(\gamma_g)$ at least once and from below. Finally note that, at any point where the two schedules cross, it must be $z_g^A = z_g^N$, and hence using the expressions above $\frac{dz_g^N}{d\gamma_g} > \frac{dz_g^A}{d\gamma_g}$. This immediately implies that $z_g^N(\gamma_g)$ crosses $z_g^A(\gamma_g)$ only once and from below.

We are now ready to show that there exist cutoffs $\gamma_g^L < \gamma_g^H$ such that $\Delta_g > 0$ if $\gamma_g < \gamma_g^L$ or $\gamma_g > \gamma_g^H$ and $\Delta_g < 0$ if $\gamma_g \in \left(\gamma_g^L, \gamma_g^H\right)$.

With reference to Figure 2, let $\gamma_g^M$ denote the value of $\gamma_g$ such that the noncooperative standard is efficient, that is $z_g^N = z_g^W$, and let $\gamma_g^H$ denote the value of $\gamma_g$ such that $z_g^N = z_g^A$.

Clearly, we have $\Delta_g > 0$ at $\gamma_g = 0$, $\Delta_g < 0$ at $\gamma_g = \gamma_g^M$, and $\Delta_g = 0$ at $\gamma_g = \gamma_g^H$. Note also that $W_g$ is increasing in $z_g$ for all $z_g < z_g^W$ and decreasing in $z_g$ for all $z_g > z_g^W$, given that $z_g^W$ maximizes $W_g$ and $W_g$ is single-peaked in $z_g$.

For all $\gamma_g \in \left[0, \gamma_g^M\right)$, clearly $\frac{dW_g^A}{d\gamma_g} < 0$ and $\frac{dW_g^N}{d\gamma_g} > 0$, and hence $\frac{d\Delta_g}{d\gamma_g} < 0$, so there exists a critical value $\gamma_g^L$ between 0 and $\gamma_g^M$ such that $\Delta_g > 0$ for $\gamma_g \in \left[0, \gamma_g^L\right)$ and $\Delta_g < 0$ for $\gamma_g \in \left(\gamma_g^L, \gamma_g^M\right]$. Moreover, it is clear that $\Delta_g < 0$ for all $\gamma_g \in \left[\gamma_g^M, \gamma_g^H\right)$, given that $z_g^W \leq z_g^N \leq z_g^A$ and $W_g$ is increasing in $z_g$ for all $z_g < z_g^W$. And finally, $\Delta_g > 0$ for all $\gamma_g > \gamma_g^H$, given that $z_g^W \leq z_g^A \leq z_g^N$ and $W_g$ is decreasing in $z_g$ for all $z_g > z_g^W$.

(ii) We now turn to the general case allowing for asymmetric countries. Recall our scaling convention $\gamma_{ig} = \gamma_g \nu_{ig}$ and consider the limit cases $\gamma_g = 0$ and $\gamma_g \to \infty$. It is still (trivially) true that $\Delta_g > 0$ for $\gamma_g = 0$ and thus also for sufficiently low $\gamma_g$. What remains to be shown is that cooperation on process standards increases global welfare if $\gamma_g$ is sufficiently high.

From the expression for welfare, it follows immediately that

$$\lim_{\gamma_{g\to\infty}} W_g^N = \lim_{\gamma_{g\to\infty}} \int_i \left[\pi_{ig}\left(p_g^N - \varphi_{ig}\left(z_{ig}^N\right)\right) + S_{ig}\left(p_g^N\right) - b_{ig} z_{ig}^N y_{ig}\left(p_g^N - \varphi_{ig}\left(z_{ig}^N\right)\right)\right]$$

Recall from the proof of Proposition 3 that $\lim_{\gamma_{g\to\infty}} z_{ig}^N = \infty$ for all $i$. Note that therefore $\lim_{\gamma_{g\to\infty}} W_g^N = -\infty$, since $\pi_{ig}\left(p_g^N - \varphi_{ig}\left(z_{ig}^N\right)\right)$, $S_{ig}\left(p_g^N\right)$, and $y_{ig}\left(p_g^N - \varphi_{ig}\left(z_{ig}^N\right)\right)$ converge to some finite levels as $\gamma_g \to \infty$.

Similarly,

$$\lim_{\gamma_{g\to\infty}} W_g^A = \lim_{\gamma_{g\to\infty}} \int_i \left[\pi_{ig}\left(p_g^A - \varphi_{ig}\left(z_{ig}^A\right)\right) + S_{ig}\left(p_g^A\right) - b_{ig} z_{ig}^A y_{ig}\left(p_g^A - \varphi_{ig}\left(z_{ig}^A\right)\right)\right]$$

For each country, we need to consider two possibilities: $z_{ig}^A$ may go to infinity, or it may stay bounded (possibly at the prohibitive level). The latter possibility cannot be ruled out because there may be a group of countries with much lower $\nu_{ig}$ than other countries, and "counter-lobbying" by more powerful countries may push the standards in this group to get tighter. Letting $\mathcal{F}_g^B$ denote the (possibly empty) subset of countries for which $z_{ig}^A$ stays bounded as $\gamma_g \to \infty$, we can write

$$\begin{aligned}
\lim_{\gamma_{g\to\infty}} \Delta_g &\equiv \lim_{\gamma_{g\to\infty}} \left(W_g^A - W_g^N\right) \\
&= \lim_{\gamma_{g\to\infty}} \int_{i\in\mathcal{F}_g^B} \left(W_{ig}^A - W_{ig}^N\right) \\
&\quad + \lim_{\gamma_{g\to\infty}} \int_{i\notin\mathcal{F}_g^B} \left[\left(\pi_{ig}\left(p_g^A - \varphi_{ig}(z_{ig}^A)\right) + S_{ig}(p_g^A)\right) - \left(\pi_{ig}\left(p_g^N - \varphi_{ig}(z_{ig}^N)\right) + S_{ig}(p_g^N)\right)\right] \\
&\quad + \lim_{\gamma_{g\to\infty}} \int_{i\notin\mathcal{F}_g^B} \left[b_{ig} z_{ig}^N y_{ig}\left(p_g^N - \varphi_{ig}(z_{ig}^N)\right) - b_{ig} z_{ig}^A y_{ig}\left(p_g^A - \varphi_{ig}(z_{ig}^A)\right)\right]
\end{aligned}$$

The first term of the sum above goes to $\infty$, since $z_{ig}^A$ stays bounded for $i \in \mathcal{F}_g^B$ and hence $W_{ig}^A$ also stays bounded for these countries, while $\lim_{\gamma_{g\to\infty}} W_{ig}^N = -\infty$. The second term stays bounded, since clearly $p_g^A$ and $p_g^N$ both stay bounded. The third term goes to $\infty$ since $y_{ig}\left(p_g^N - \varphi_{ig}\left(z_{ig}^N\right)\right)$ and $y_{ig}\left(p_g^A - \varphi_{ig}\left(z_{ig}^A\right)\right)$ stay bounded and $\lim_{\gamma_g\to\infty}\left(z_{ig}^N - z_{ig}^A\right) = \infty$ as established in the proof of Proposition 3. We can conclude that $\lim_{\gamma_{g\to\infty}} \Delta_g = \infty$. QED.

## 8.4 Appendix D

In this appendix we extend our main results to the case of large countries.

We start with the model of product standards. We first prove the claims made in the main text about the positive effects of the globally optimal agreement:

**Proposition 1':** The equilibrium agreement loosens all product standards, provided that (i) countries are not too asymmetric, or (ii) the political parameters $\gamma_{ig}$ are sufficiently large.

**Proof:** Result (i) can be established following similar steps as in the proof of Proposition 1(i). The first step is to show that the best local agreement loosens standards. Next, if countries are symmetric the problem is effectively one-dimensional, and using the assumption that the objective function is single-peaked one can show that the local result holds globally. And finally, the result can be extended by continuity if countries are sufficiently close to symmetric.

Next we focus on result (ii). As usual, we let $\gamma_{ig} = \gamma_g \nu_{ig}$ and consider the limit as $\gamma_g \to \infty$. It is easy to check that the first-order conditions associated with the noncooperative and cooperative problems can be written as $f_{ig}(e_{ig}, \mathbf{e}_{-ig}) + \lambda_g^N(e_{ig}, \mathbf{e}_{-ig}) g_{ig}(e_{ig}, \mathbf{e}_{-ig}) = 0$ and $f_{ig}(e_{ig}, \mathbf{e}_{-ig}) + \lambda_g^A(e_{ig}, \mathbf{e}_{-ig}) g_{ig}(e_{ig}, \mathbf{e}_{-ig}) = 0$, where $f_{ig}(e_{ig}, \mathbf{e}_{-ig}) \equiv -d_{ig}\phi'_{ig} - a_{ig}d_{ig}\left(1 - e_{ig}\sigma_{ig}\phi'_{ig}\right)$ and $g_{ig}(e_{ig}, \mathbf{e}_{-ig}) \equiv -d_{ig}\sigma_{ig}\phi'_{ig}$, and the arguments $(e_{ig}, \mathbf{e}_{-ig})$ emphasize that all endogenous variables in general depend on all the standards. Note that, as we increase $e_{ig}$, the left-hand side has to cross zero once and from above in both cases, given our assumption that the noncooperative and cooperative problems each have a unique interior solution.

We first establish that $\lim_{\gamma_g \to \infty} e_{ig}^N = \infty$ and $\lim_{\gamma_g \to \infty} e_{ig}^A = \infty$ for all $i$. This follows immediately from the above first-order conditions combined with the fact that $\lambda_g^N(e_{ig}, \mathbf{e}_{-ig})$ and $\lambda_g^A(e_{ig}, \mathbf{e}_{-ig})$ are linearly increasing in $\gamma_g$ for given standards $(e_{ig}, \mathbf{e}_{-ig})$, as is easy to see from equations (26) and (27).

We now establish that $\lim_{\gamma_g \to \infty}\left(e_{ig}^A - e_{ig}^N\right) > 0$ for all $i$. This follows from two observations. First, $\lambda_g^A(e_{ig}, \mathbf{e}_{-ig}) - \lambda_{ig}^N(e_{ig}, \mathbf{e}_{-ig}) \to \infty$ for any $(e_{ig}, \mathbf{e}_{-ig})$ as $\gamma_g \to \infty$, as is easy to establish by combining the expressions for $\lambda_{ig}^N$ and $\lambda_g^A$ from equations (26) and (27) to $\lambda_g^A(e_{ig}, \mathbf{e}_{-ig}) - \lambda_{ig}^N(e_{ig}, \mathbf{e}_{-ig}) = \frac{\sum_{j \neq i}\left(\gamma_{jg}y_{jg} + a_{jg}e_{jg}\sigma_{jg}d_{jg}\right) + m_{ig}}{\sum_j(\varepsilon_{jg}y_{jg} + \sigma_{jg}d_{jg})}$. Second, as $\gamma_g$ becomes large and thus $e_{ig}^N$ and $e_{ig}^A$ become large, the standards of countries $j \neq i$ only have a negligible impact on the first-order conditions for country $i$, so we can write them as $f_{ig}(e_{ig}) + \lambda_g^N(e_{ig}) g_{ig}(e_{ig}) = 0$ and $f_{ig}(e_{ig}) + \lambda_g^A(e_{ig}) g_{ig}(e_{ig}) = 0$. To see this note that, as $e_{ig}^N$ and $e_{ig}^A$ become large, the equilibrium price and thus $d_{ig}$ and $y_{ig}$ converge to their unregulated levels, and recall the assumption that $\sigma_{ig}$ and $\varepsilon_{ig}$ are bounded above and bounded away from zero. These two observations together immediately imply the result. QED

Next we prove the claim made in the main text regarding the welfare impact of the equilibrium agreement on product standards:

**Proposition 2':** Suppose all political parameters are scaled by a factor $\gamma_g$. Cooperation on product standards increases global welfare if $\gamma_g$ is sufficiently low, and decreases global welfare if $\gamma_g$ is sufficiently high.

**Proof**: It is immediate that cooperation on product standards increases global welfare if $\gamma_g = 0$ and hence also if $\gamma_g$ is sufficiently low. We now show that the agreement decreases global welfare if $\gamma_g$ is sufficiently high.

From the expression for welfare, it follows immediately that

$$\begin{aligned} W_g^A - W_g^N &= \sum_i \left[\pi_{ig}\left(p_g^A\right) - \pi_{ig}\left(p_g^N\right)\right] \\ &+ \sum_i \left[S_{ig}\left(p_g^A + \phi_{ig}\left(e_{ig}^A\right)\right) - S_{ig}\left(p_g^N + \phi_{ig}\left(e_{ig}^N\right)\right)\right] \\ &- \sum_i a_{ig}\left[e_{ig}^A d_{ig}\left(p_g^A + \phi_{ig}\left(e_{ig}^A\right)\right) - e_{ig}^N d_{ig}\left(p_g^N + \phi_{ig}\left(e_{ig}^N\right)\right)\right] \end{aligned}$$

Recalling from the previous proof that $\lim_{\gamma_g \to \infty} e_{ig}^N = \infty$ and $\lim_{\gamma_g \to \infty} e_{ig}^A = \infty$, this implies

$$\begin{aligned} \lim_{\gamma_g \to \infty}\left(W_g^A - W_g^N\right) &= \sum_i \left[\pi_{ig}\left(\tilde{p}_g\right) - \pi_{ig}\left(\tilde{p}_g\right)\right] \\ &+ \sum_i \left[S_{ig}\left(\tilde{p}_g\right) - S_{ig}\left(\tilde{p}_g\right)\right] \\ &- \sum_i a_{ig} d_{ig}\left(\tilde{p}_g\right)\left(e_{ig}^A - e_{ig}^N\right) \\ &= -\sum_i a_{ig} d_{ig}\left(\tilde{p}_g\right)\left(e_{ig}^A - e_{ig}^N\right), \end{aligned}$$

where $\tilde{p}_g$ is the unregulated world price, i.e. the solution to $\sum_i y_{ig}\left(p_g\right) = \sum_i d_{ig}\left(p_g\right)$. Hence, $\lim_{\gamma_g \to \infty}\left(W_g^A - W_g^N\right) < 0$ if $e_{ig}^A > e_{ig}^N$ for all $i$, which is true for sufficiently large $\gamma_g$, as shown above. QED

We now turn to the model of process standards. We start by proving the claims made in the main text about the positive effects of the globally optimal agreement:

**Proposition 3':** (i) The equilibrium agreement loosens all process standards for sufficiently small $\gamma_g$, provided countries are sufficiently symmetric; (ii) The equilibrium agreement tightens all process standards for sufficiently large $\gamma_g$, as long as $\nu_{ig}$ and $\varepsilon_{ig}$ are not too dissimilar across countries.

**Proof:** Result (i) can be established following similar steps as in the proof of Proposition 3, part (i$_a$). We therefore focus on result (ii). As usual, we decompose $\gamma_{ig} = \gamma_g \nu_{ig}$ and consider the limit $\gamma_g \to \infty$.

It is easy to check that the first-order conditions associated with the noncooperative and cooperative problems can be written as $f_{ig}\left(z_{ig}, \mathbf{z}_{-ig}\right) + \left(\gamma_{ig} - \lambda_{ig}^N\left(z_{ig}, \mathbf{z}_{-ig}\right)\varepsilon_{ig}\right) g_{ig}\left(z_{ig}, \mathbf{z}_{-ig}\right) = 0$ and $f_{ig}\left(z_{ig}, \mathbf{z}_{-ig}\right) + \left(\gamma_{ig} - \lambda_g^A\left(z_{ig}, \mathbf{z}_{-ig}\right)\varepsilon_{ig}\right) g_{ig}\left(z_{ig}, \mathbf{z}_{-ig}\right) = 0$, where $f_{ig}\left(z_{ig}, \mathbf{z}_{-ig}\right) \equiv -y_{ig}\varphi_{ig}' - b_{ig} y_{ig}\left(1 - z_{ig}\varepsilon_{ig}\varphi_{ig}'\right)$, $g_{ig}\left(z_{ig}, \mathbf{z}_{-ig}\right) \equiv -y_{ig}\varphi_{ig}'$, and the arguments $\left(z_{ig}, \mathbf{z}_{-ig}\right)$ emphasize that all endogenous variables in general depend on all the standards. Note that, as we increase $z_{ig}$, the left-hand side has to cross zero once and from above in both cases, given our assumption that the noncooperative and cooperative problems each have a unique interior solution.

We first establish that $\lim_{\gamma_g \to \infty} z_{ig}^N = \infty$ for all $i$. This follows from the above first-order condition for noncooperative standards combined with the fact that the expression for $\gamma_{ig} - \lambda_{ig}^N (z_{ig}, \mathbf{z}_{-ig}) \varepsilon_{ig}$ is linearly increasing in $\gamma_g$ for given standards $(z_{ig}, \mathbf{z}_{-ig})$. To see this, note that we can use equation (29) to rewrite $\gamma_{ig} - \lambda_{ig}^N \varepsilon_{ig} = \gamma_{ig} \frac{\sum_{j \neq i} \varepsilon_{jg} y_{jg} + \sum_j \sigma_{jg} d_{jg}}{\sum_j (\varepsilon_{jg} y_{jg} + \sigma_{jg} d_{jg})} + \frac{b_{ig} z_{ig} \varepsilon_{ig} y_{ig} + m_{ig}}{\sum_j (\varepsilon_{jg} y_{jg} + \sigma_{jg} d_{jg})} \varepsilon_{ig}$.

We next show that $\lim_{\gamma_g \to \infty} z_{ig}^A = \infty$ for all $i$ provided that $\gamma_{ig}$ and $\varepsilon_{ig}$ are not too dissimilar across countries. This follows from the above first-order condition for cooperative standards combined with the fact that the expression for $\gamma_{ig} - \lambda_g^A (z_{ig}, \mathbf{z}_{-ig}) \varepsilon_{ig}$ is linearly increasing in $\gamma_g$ for given standards $(z_{ig}, \mathbf{z}_{-ig})$. To see this, note that we can use equation (30) to rewrite $\gamma_{ig} - \lambda_g^A \varepsilon_{ig} = \gamma_g \frac{\sum_j \sigma_{jg} d_{jg}}{\sum_j (\varepsilon_g y_{jg} + \sigma_{jg} d_{jg})} + \frac{\sum_j b_{jg} z_{jg} \varepsilon_g y_{jg}}{\sum_j (\varepsilon_g y_{jg} + \sigma_{jg} d_{jg})} \varepsilon_g$, upon imposing $\gamma_{ig} = \gamma_g$ and $\varepsilon_{ig} = \varepsilon_g$ for all $i$.

We now establish that $\lim_{\gamma_g \to \infty} \left( z_{ig}^N - z_{ig}^A \right) > 0$ for all $i$. This follows from two observations. First, $\lambda_g^A (z_{ig}, \mathbf{z}_{-ig}) - \lambda_{ig}^N (z_{ig}, \mathbf{z}_{-ig}) \to \infty$ for any $(z_{ig}, \mathbf{z}_{-ig})$ as $\gamma_g \to \infty$, as is easy to establish by combining the expressions for $\lambda_{ig}^N$ and $\lambda_g^A$ from equations (29) and (30) to $\lambda_g^A (z_{ig}, \mathbf{z}_{-ig}) - \lambda_{ig}^N (z_{ig}, \mathbf{z}_{-ig}) = \frac{\sum_{j \neq i} y_{jg} \left( \gamma_{jg} - b_{jg} z_{jg} \varepsilon_{jg} \right) + m_{ig}}{\sum_j (\varepsilon_{jg} y_{jg} + \sigma_{jg} d_{jg})}$. Second, as $\gamma_g$ becomes large and thus $z_{ig}^N$ and $z_{ig}^A$ become large, the standards of all countries $j \neq i$ only have a negligible impact on the first-order conditions of country $i$ so that we can write them as $f_{ig}(z_{ig}) + \left( \gamma_{ig} - \lambda_{ig}^N (z_{ig}) \varepsilon_{ig} \right) g_{ig}(z_{ig}) = 0$ and $f_{ig}(z_{ig}) + \left( \gamma_{ig} - \lambda_{ig}^A (z_{ig}) \varepsilon_{ig} \right) g_{ig}(z_{ig}) = 0$. To see this, note that the equilibrium price and thus $d_{ig}$ and $y_{ig}$ converge to their unregulated levels as $z_{ig}^A \to \infty$ and $z_{ig}^N \to \infty$, and recall the assumption that $\sigma_{ig}$ and $\varepsilon_{ig}$ are bounded above and away from zero. These two observations together immediately imply the result. QED

Finally, we prove the claim made in the main text regarding the welfare impact of the equilibrium agreement on process standards:

**Proposition 4':** Cooperation on process standards increases global welfare if $\gamma_g$ is sufficiently low. It also increases global welfare if $\gamma_g$ is sufficiently high, as long as $\nu_{ig}$ and $\varepsilon_{ig}$ are not too dissimilar across countries.

**Proof**: It is immediate that the agreement increases global welfare if $\gamma_g = 0$ and hence also if $\gamma_g$ is sufficiently low. We now show that the agreement increases global welfare also if $\gamma_g$ is sufficiently high, as long as $\nu_{ig}$ and $\varepsilon_{ig}$ are not too dissimilar across countries.

From the expression for welfare, it follows immediately that

$$\begin{aligned} W_g^A - W_g^N &= \sum_i \left[\pi_{ig}\left(p_g^A - \varphi_{ig}\left(z_{ig}^A\right)\right) - \pi_{ig}\left(p_g^N - \varphi_{ig}\left(z_{ig}^N\right)\right)\right] \\ &\quad + \sum_i \left[S_{ig}\left(p_g^A\right) - S_{ig}\left(p_g^N\right)\right] \\ &\quad - \sum_i b_{ig}\left[z_{ig}^A y_{ig}\left(p_g^A - \varphi_{ig}\left(z_{ig}^A\right)\right) - z_{ig}^N y_{ig}\left(p_g^N - \varphi_{ig}\left(z_{ig}^N\right)\right)\right] \end{aligned}$$

Recalling from the previous proof that $\lim_{\gamma_g \to \infty} z_{ig}^N = \infty$ and $\lim_{\gamma_g \to \infty} z_{ig}^A = \infty$ as long as the political parameters $\gamma_{ig}$ and the supply semi-elasticities $\varepsilon_{ig}$ are not too dissimilar across countries, this implies

$$\begin{aligned} \lim_{\gamma_g \to \infty}\left(W_g^A - W_g^N\right) &= \sum_i \left[\pi_{ig}\left(\tilde{p}_g\right) - \pi_{ig}\left(\tilde{p}_g\right)\right] \\ &\quad + \sum_i \left[S_{ig}\left(\tilde{p}_g\right) - S_{ig}\left(\tilde{p}_g\right)\right] \\ &\quad - \sum_i b_{ig} y_{ig}\left(\tilde{p}_g\right)\left(z_{ig}^A - z_{ig}^N\right) \\ &= - \sum_i b_{ig} y_{ig}\left(\tilde{p}_g\right)\left(z_{ig}^A - z_{ig}^N\right), \end{aligned}$$

where $\tilde{p}_g$ is the unregulated world price, i.e. the solution to $\sum_i y_{ig}\left(p_g\right) = \sum_i d_{ig}\left(p_g\right)$. Hence, $\lim_{\gamma_g \to \infty}\left(W_g^A - W_g^N\right) > 0$ if $z_{ig}^A < z_{ig}^N$ for all $i$, which is true for sufficiently large $\gamma_g$, as long as the political parameters $\gamma_{ig}$ and the supply semi-elasticities $\varepsilon_{ig}$ are not too dissimilar across countries, as follows from the previous proposition. QED

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