Working paper

INFORMATIONAL ASYMMETRIES AS A MOTIVE FOR TRADE, TRADE POLICIES, AND INEFFICIENT TRADE AGREEMENTS[1]

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Abstract. We consider a general equilibrium model of international trade with two symmetric countries, two commodities and a terms-of-trade externality to which we append a two-layer informational problem. Informational asymmetries matter for the design of trade policies and trade agreements both within one country as the result of political pressure by domestic producers but also at the international level. In the country that suffers from an internal informational problem, the government implements tariff barriers and "behind-the border" policies to protect national producers who have private information on their technology. At the international level, this government bargains with its trading partner over a trade agreement so as to increase worldwide welfare but retains private information on the exact political influence of domestic producers. That domestic firms have private information distorts production and the pattern of comparative advantages so that the information-sensitive good is now imported even if countries are otherwise symmetric. As a result, the domestic government now designs tariff barriers that depend on the political weight of inefficient producers in its objective function. This parameter is private information and it may be manipulated by the domestic government to reach a higher welfare gain in trade negotiations with the uninformed trading partner. We characterize the optimal packages of trade and "behind-the border" policies that might come out of such negotiation. We discuss the feasibility of free-trade in an environment so informationally-constrained and characterize second-best agreements that emerges from this double-edged incentive problem.

Keywords. Asymmetric information, double-edged incentives, tariff equilibrium, "behind-the-border" policies, trade negotiations.

1. INTRODUCTION

Governments design trade policies so as to achieve welfare gains. Due to trade interdependencies, such policy choices are most likely to be detrimental to their trading partners. Trade agreements might thus be highly desirable. Those agreements are negotiated to achieve mutual welfare gains by comparison to a playing field where countries would non-cooperatively design their own trade policies

Starting with the seminal work of Johnson (1953), the design of trade policies, the characterization of tariff equilibria and the feasibility of trade agreements have thus become major pillars of the development of the modern Theory of International Trade. Relying on a two-country, two-commodity international trade model, Johnson studied tariff equilibrium and *"to reassert the proposition that a country may gain by imposing a tariff, even if other countries retaliate"* (Johnson, 1953, p.142). Yet, the bulk of the ensuing

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literature has been developed under the extreme assumption of complete information.[1] In sharp contrast, practitioners and scholars have long advocated the view that asymmetric information is actually a major impediment to efficient trade policy design.[2]

That informational asymmetries impact on policy-making is a tenet of the modern theory of Regulatory Economics.[3] This literature has forcefully argued that optimal regulatory policies should always balance efficiency goals with redistributive concerns in such contexts. Yet in an international trade contexts, informational asymmetries, efficiency and redistributive concerns come with a vengeance. Efficiency considerations should be taken worldwide. Redistribution is not only intra-country but across countries. Last but not least, informational constraints bite both at a national level when imperfectly informed governments implement trade and domestic regulatory policies for privately informed producers but also, at the international level, when governments bargain over a trade agreement so as to increase worldwide welfare and keep private information on the internal political pressures.

The broad objective assigned to this paper is to understand how those two distinctive layers of informational asymmetries, within and across countries, when taken altogether modify not only the pattern of trade, but also the design of trade and regulation policies at the national level and how double-edged incentive problem may finally trigger inefficient negotiations of trade agreements.

Main elements of the model. We consider a general equilibrium model of international trade with two countries, two commodities and a terms-of-trade externality. We append to this otherwise standard setup a two-layer informational problem. To focus on the pure impact of informational asymmetries for trade, those two economies are supposed to be strictly identical, in terms of production technologies, factor endowments and preferences. The only difference comes from the fact that information is incomplete in the domestic economy. Domestic producers keep private information on their technology, while similar information remains common knowledge abroad.

This first layer of informational asymmetry thus impacts only *"domestic politics"* through the adequate design of domestic instruments aimed at fostering protection of home producers. Since there are two distortions, one concerning information available and one concerning the terms-of-trade externality, the domestic government is endowed with two

[1]This literature can be split into two main directions. The first strand has looked for various generalizations of Johnson (1953)'s framework allowing for different policy instruments (specific tariffs as in Horwell, 1966, or quotas with Rodriguez, 1974 and Tower, 1975), arbitrary numbers of countries and goods (Kuga, 1973), and alternative formulations of government's preferences (Bagwell and Staiger, 1999). The second direction has been more concerned by unveiling conditions under which international cooperation can improve countries' welfare. As already established by Johnson (1953), neither country can improve its welfare by a unilateral decision away from a tariff equilibrium; however a trade agreement could improve both countries' welfare by mutual tariff adjustment. Along those lines, Riezman (1982) and Dixit (1987) have studied the feasibility of such tariff agreements. Finally, Mayer (1981) has shown that starting from a tariff equilibrium, free trade may not always be feasible especially when countries are highly asymmetric, when negotiating countries adopt collusive behavior rules like tariff-cutting formulae or when domestic pressure groups are opposed to international trade.

[2]According to Maggi (1999), *"A particularly damaging criticism raised against strategic trade theory concerns the assumption that policymakers have complete information about the targeted market. Real governments are unlikely to meet the informational requirements assumed by the theory."* The importance of incomplete information for sound policy-making has been for instance repeatedly stressed in empirical studies on antidumping legislations (see Prusa and Vermulst, 2013, among others).

[3]See Baron and Myerson (1982), Laffont and Tirole (1993) and Armstrong and Sappington (2007).

kinds of policies: a standard tariff but also other kinds of *"behind-the border"* policies, say credit subsidies, tax cuts, input regulations, competition policies, product standard and related domestic regulations... Domestic producers hold private information on some parameters of their cost function. Therefore, when designing optimal policies, the domestic government accounts for any possible information manipulation that those producers may engage in to increase protection. As a result of those informational asymmetries vis-à-vis home producers and to ease incentive compatibility constraints, "behind-the-border" policies reduce domestic supply on the international market.

The first important consequence of such pattern is that, now, the informationally sensitive sector becomes an import sector. It in turn justifies using a tariff to protect domestic producers and raises revenues. Protection policies must trade off the domestic efficiency gains of raising tariff barriers with the extra information rents that may be captured by the efficient producers who enjoy most of the gains of raising a tariff.[4] The terms of this rent-efficiency trade-off depend on the distribution of political weights and influence that producers may exert on the political process.

The second dimension of informational asymmetries then bites on the *"external game"* that countries play when negotiating a trade agreement. When joining the bargaining table, a country may indeed exaggerate the political influence of the least efficient domestic producers, looking thereby for more significant concessions from its trading partners. That extra layer of informational frictions makes it sometimes impossible to design efficient trade agreements. Another rent-efficiency trade-off now bites at the international level. To induce information revelation from importing countries on the domestic influence of producers may require to stack the deck towards the status quo, i.e., towards the noncooperative tariff equilibrium.[5]

Main results. There is more in the doubled-edged incentives problem that is analyzed in this paper than the simple addition of internal and external agency considerations. Indeed, and to put it in a nutshell, informational asymmetries are both the source of trade, the justification of domestic trade policies and the raison-d'être of a (possibly inefficient) trade agreement.

To see this in more details, let us now explain how those different elements are indeed combined and intertwined. First, observe that even if competition is perfect and both countries are strictly identical in terms of size, factors endowments, technology of production and consumption function, trade arises since autarkic relative prices are different in both countries. This difference in relative prices is due to asymmetric information in one country and its consequences on "behind-the-border" policies. By an argument which is familiar from regulatory economics,[6] giving up information rent to the most efficient producers who have private information on their technology is socially costly. Mitigating that cost requires to design "behind-the-border" policies that are less favorable to the least efficient producers, making thereby their own allocation less attractive to the most efficient ones so as to relax incentive compatibility. Those "behind-the-border" policies consist in a menu of options proposed by the government to domestic firms. Each option

[4] This rent-efficiency trade-off is familiar from the screening literature. See Laffont and Martimort (2002, Chapter 2) for an overview.

[5] This point is well-known from the bargaining literature under asymmetric information and especially from Myerson and Sattherwaite (1983).

[6] See Baron and Myerson (1982), Laffont and Tirole (1993), and Armstrong and Sappington (2007) among others.

specifies a level of supply for each local firm and an attached compensation.[7] Least efficient producers choose an option that contracts their production as a result of incentive compatibility. As a matter of fact the country that suffers from asymmetric information necessarily imports the good where producers have private information and exports the good which is not impacted by informational asymmetries.[8]

The fact that domestic producers have private information is thus the source of international trade in the first place. This source of trade is novel in the literature since international trade has been explained until now by differences in technologies, differences in factors endowments or in national demands, and imperfect competition (scale economies, taste for varieties not only on the demand side but also on the supply side).

Yet, because trade now occurs, the domestic government sets an import tariff: a familiar response for a large country to improve terms of trade.[9] While "behind-the-border" policies are implemented to ease the internal informational problem, a border policy is now needed to respond to the supply contraction induced by those "behind-the-border" policies. Optimal domestic and trade policies go hands in hands since they are just two facets of the same informational problem. In particular, the optimal tariff is greater when domestic supply is more contracted as the result of asymmetric information, which occurs when high-cost producers have a greater political weight so that the information rent left to low-cost ones is viewed as being more socially costly.

The tariff equilibrium so obtained is now the *status quo* that prevails in the absence of any trade agreement. We broadly understand such trade agreement as a simple forum of discussions between sovereign countries where mutual tariff adjustments are negotiated under the constraint that the agreement gives to each participant at least the level of welfare that it would get under the *status quo*. When negotiating such agreement, the domestic country is ready to give up tariff barriers and facilitate imports against some compensations. Following Feenstra and Lewis (1991) and Amador and Bagwell (2011), we assume that the domestic government has private information on the magnitude of political influence that high-cost producers exert, an assumption which sounds quite realistic.[10] In such framework, exaggerating this political influence is thus a way for the domestic country to increase compensations from its partners and tilt the agreement in its favor. Of course, such strategy has also consequences on domestic redistribution. Obtaining more concessions from partners, raises worldwide price and favors inefficient producers at home.

Although free trade would maximize worldwide welfare,[11] such efficient outcome cannot always be implemented under asymmetric information on the domestic country's political preferences. Revealing such information requires to give that privately informed country

[7]Such menus are exemplified by the rich options that Common Agricultural Policy offers to including agricultural price supports, direct payments to farmers, supply controls. For 2004 on, farmers must comply with environmental, animal welfare, food safety, and food-quality regulations in order to receive compensation. Evenett (2013) points to many "behind-the-border" policies adopted worlwide since the 2007-08 financial crisis like bail-out/ state aid measures, public procurement, "buy-national" policies, sanitary, phytosanitary and technical regulations; research-development subsidies.

[8]Martimort and Verdier (2012) make a similar point in a model à la Heckscher-Ohlin to which is appended a set of domestic regulation policies of intermediate sectors which are impacted by asymmetric information.

[9]For a textbook exposition see Feenstra (2003, Chapter 7) for instance.

[10]This assumption is common in the literature studying international trade negotiations (see Milner and Rosendorff, 1996, for example).

[11]The notion of Pareto efficiency that we use follows Holmström and Myerson (1983) notion of *interim efficiency* which takes into account that domestic producers have private information.

a large compensation that might not be acceptable by its trading partner. The domestic government gets some information rent and free trade is reachable if and only if the gains from eliminating the deadweight-loss associated with the tariff go beyond that rent. An interesting illustration is that when imports are inelastic, tariffs are high and free trade is reachable while when imports are elastic, tariffs are small and informational rents are greater: free trade is not achieved. This may be an explanation of the deadlock of current WTO negotiations under the Doha Development Agenda. Tariffs are low at the beginning of the negotiation, particularly in industry. Gains that could be expected from the elimination of deadweight losses caused by the tariff are small while there are still significant informational rents related to the private information of governments which voluntarily put too much emphasis on the political importance of inefficient sectors of production in order to obtain a better outcome.

We then characterize the optimal design of second-best trade agreements when free trade is no longer achievable. Such agreements call for lower compensations and request world prices to be closer to those implemented in a tariff equilibrium. The domestic country's private information on internal political preferences amounts to a gain in bargaining power that stacks the deck in its favor.

Literature review. Understanding the design of trade agreements under various kinds of political, incentive, and transaction costs constraints especially in models where domestic politics interact with trade negotiations has indeed been high on the research agenda over recent years. In a complete information setting but explicitly considering the relationship between internal lobbying games and trade, Grossman and Helpman (1995) have for instance demonstrated that trade agreements still allow governments to escape the well-known terms of trade prisoners' dilemma even when those governments are subject to domestic political pressure. Turning to the precise rules of those agreements, Bagwell and Staiger (1997, 2002) have established that the principles of reciprocity and non-discrimination indeed act as commitments towards efficiency and that this result holds under a broad set of assumptions on the underlying domestic political economy games.[12] Trade agreements may also help to commit vis-à-vis domestic actors. In this respect, Maggi and Rodriguez-Clare (1998) have shown that a small country commits to free trade to avoid the distortion caused by a politically organized sector which overinvests in capital when it is imperfectly mobile.[13] Maggi and Rodriguez-Clare (2007) have pursued this line of research when both terms-of-trade externalities and time inconsistency justify trade agreements.[14]

Trade agreements might also help saving on contracting costs in an incomplete contracting environment as argued by Horn, Maggi and Staiger (2008). Those authors have developed a two-country model with consumption and production externalities, a full set of policy instruments available to governments both at home and on borders, uncertainty on externalities and on trade volumes and contracting costs which are increasing in the number of state variables and policies available. In such setting, the WTO national treatment clause is a means of saving on contracting costs. More recently, Limao and Maggi

[12] Bagwell and Staiger (2011) have also tested empirically a relationship between negotiated tariff levels and pre-negotiation data on tariffs, import volumes, prices, and trade elasticities).

[13] See also Limao and Tovar (2011) on the benefits of constraining tariff barriers with trade agreements.

[14] Time inconsistency was first introduced in the theory of trade policy by Staiger and Tabellini (1987). Those authors have analyzed how a benevolent government with redistributive objectives chooses excessive protection when unexpected trade policy has more impact.

(2013) have introduced uncertainty on a political parameter of a government's objective function. Trade agreements are then justified by an uncertainty-reducing motive.

While this literature offers solid theoretical foundations to understand trade policy and trade agreements, it might be criticized for relying on two short-cuts. A first possible criticism is that, in practice, governments do not only implement policies at the border (custom duties and export taxation/subsidies) but also design various sort of "behind-the-border" policies to help domestic producers. "Behind-the-border policies" have recently come at the forefront of the debate among practitioners and within international institutions, especially in view of the possible discrimination implied by practices which are potentially more harmful for developing countries.[15] Curiously, "behind-the-border" policies have not attracted much attention in the theoretical literature, an exception certainly being Horn, Maggi and Staiger (2008). Yet, "behind-the-border" policies offer a natural vehicle for the influence of domestic producers on policy-makers. They are part of full picture of the double-edged incentives arising when domestic pressures interact with trade negotiations.

The second research alley that has been overlooked by the existing literature on trade agreements is asymmetric information. This literature assumes that governments always have complete complete information both when designing domestic or trade policies but also when negotiating trade agreements. As forcefully argued not only by the whole body of literature in the field of regulatory economics but also by practitioners,[16] imperfect information is already a significant concern for a government designing trade and regulation policies for domestic producers.[17] That governments have private information over the extent of domestic political pressure is an important issue already recognized by Feenstra and Lewis (1999). Those authors have shown that the optimal incentive-compatible trade agreement is a negotiated trade restriction where the foreign country receives a share of the rent induced by such restriction. Although, we borrow from this paper the modeling a trade agreement as a bargaining procedure under asymmetric information, our paper goes beyond. By assuming a first-layer of information asymmetry within the domestic country, we obtain a *raison d'être* for trade between otherwise symmetric countries. This in turn justifies first domestic trade policies and then international trade agreements to internalize the terms of trade externality so induced. Recently, Amador and Bagwell (2011) have also introduced uncertainty and private information in a two-country trade model with terms-of-trade externality. As in our context, the domestic country maximizes the sum of consumer surplus, tariff revenue and profit in the import-competing sector where the profit weight is uncertain before the trade agreement, but then privately observed by the domestic government. They show that the optimal trade agreement is then a cap on tariff.[18]

[15]See the Part VI of Hoekman and Mattoo (2002), devoted to behind-the-border policies, but also Sadikov (2007, **references**).

[16]For instance, Creane and Miyagiwa (2008) state that *"Even if governments actually possess...[complete information about the economy], it still begs the question of how or from where they obtain such information. A natural candidate for the source of this information must be firms, but one may wonder if firms could ever have an incentive to share their information with the governments."*

[17]The study of incentive compatible strategic trade and "behind-the-border" policies has been investigated by Qiu (1994), Brainard and Martimort (1996), Kolev and Prusa (1999), Matschke (2003), Martimort and Verdier (2012) and Bouët and Cassagnard (2013) (among many others).

[18] Amador and Bagwell (2012) analyze a similar model with the weight of tariff revenue being uncertain and privately observed.

Organization of the paper. Section 2 describes the basic modeling assumptions. Section 3 analyzes "behind-the-border" policies under asymmetric information between domestic producers and their own government. Section 4 describes the autarky situation when those informational constraints are taken into account. After having argued that such domestic layer of asymmetric information is actually a source of trade between otherwise symmetric countries, Section 5 describes the tariff equilibrium that depends explicitly on the weight that high-cost producers have in the domestic political process. Section 6 characterizes trade mechanisms when those weights are unknown abroad. Conditions for the possibility of implementing a free-trade agreement are presented. Otherwise, second-best trade mechanisms and their properties are derived. Section 7 concludes. Proofs are relegated to an Appendix.

2. THE MODEL

Consider a stylized model of the world economy with two large countries E (domestic) and E^* (foreign). Those countries trade two final goods (resp. good 1 and 2) on the world market. Consumers' preferences and production technologies are the same in both countries. Those countries nevertheless differ in so far, producers of good 2 in country E have private information on their technology while such technologies are common knowledge in country E^*.

2.1. *Production Technologies.*

Good 1 is produced from a non-tradable input labor with a Leontieff one-to-one technology. Labor in country E is used as the numeraire. Given constant returns to scale and the fact that good 1 is traded on the world market, its price and wage in E^* can all be also normalized to one. Profits in that sector are zero.

In each country, there is a mass one of heterogenous firms producing good 2 under decreasing returns to scale.[19] Those firms differ with respect to their cost functions, $\theta C(y)$ where θ is an efficiency parameter capturing such heterogeneity (as described in more details below) and y the quantity of good 2 produced by that firm. The function $C(\cdot)$ is increasing and convex and, for simplicity, also satisfies the Inada condition $C'(0) = C(0) = 0$.

Denoting the marginal return on domestic production in country E by r, the profit for a firm with type θ can be written as: $\pi(\theta, r) = \max_y ry - \theta C(y)$. The type-dependent supply curve $y(\theta, r)$ of a firm with cost parameter θ is thus defined as: $r = \theta C'(y(\theta, r))$ or $y(\theta, r) = S\left(\frac{r}{\theta}\right)$ where $S = C'^{-1}$ is increasing.

In the sequel, we will distinguish the world price p^w from the domestic price p for good 2. Indeed, by imposing a positive tariff $t = p - p^w$ on that good, country E introduces a wedge between domestic and world price.

[19] Heteroegenity of firms is an important ingredient of modern trade theory as argued by Melitz (2003).

2.2. *Heterogeneity and Asymmetric Information*

The distributions of firms producing in sector 2 are identical in each country. Cost parameters are drawn on the discrete support $\Theta = \{\underline{\theta}, \bar{\theta}\}$ with respective probabilities ν and $1-\nu$ for each individual firm. Lower values of θ are meant for more efficient production technologies. Note that, by the law of large numbers, there is a fraction ν of efficient producers in each country. We denote by $E_\theta(\cdot)$ the expectation operator with respect to the distribution of θ. For further references, we also denote by $\theta^* = E_\theta(\theta)$ the average efficiency parameter, which is of course identical across countries.

Let $\Delta\theta = \bar{\theta} - \underline{\theta} > 0$ be the spread in the possible values of the firms' efficiency parameters. This parameter can be viewed as a measure of firms heterogeneity. To obtain tractable solutions to the analysis below, we will sometimes think of $\Delta\theta$ as being small enough. This assumption allows us to investigate how asymmetric information modifies trade patterns by means of Taylor expansions in the neighborhood of a complete information environment at θ^*.[20]

Ownership gives access to private information if any. Owners of a firm in sector 2 within country E have thus private information on its cost parameter θ. Instead, there is no such informational asymmetry in country E^* where cost parameters are common knowledge.

2.3. *Consumers*

There is a unit mass of consumers (indexed with the superscript $j \in [0,1]$) in each country. Each consumer is endowed with one unit of non-tradable labor. All consumers have identical quasi-linear utility functions.[21]

Consumer j in E owns a fraction $\beta_j(\theta)$ of shares of a θ-firm in sector 2. As we will see below, those firms only sell on the domestic market and thus make a profit $\pi(\theta, r)$ if r is the rate of return for good 2. Assuming that owners of a firm in sector 2 are all residents, we have $\int_j \beta_j(\theta)dj = 1$ for all θ. Observe in passing that the distribution of ownership for firms producing good 1 is irrelevant since those firms make zero profit because of constant returns to scale. These remarks allow us to write the utility of a consumer j in country E as:

$$\mathcal{U}(D(p)) - pD(p) + E_\theta(\beta_j(\theta)\pi(\theta,p)) + 1 + R(p_w, p).$$

This equation deserves some comments. First, $\mathcal{U}$ denotes the gross surplus function from consuming good 2. This surplus function is assumed to be increasing and concave (satisfying again the Inada condition $\mathcal{U}'(0) = +\infty$ to avoid corner solutions) and D denotes the corresponding (non-increasing) demand function. Second, consumers benefit from one unit of wealth associated with their individual labor endowment. For the sake of simplicity, this constant will be omitted in the sequel. Finally, the last term captures the (per capita) revenues $R(p_w, p)$ that country E raises by imposing an import tariff t.

[20] Of course, the insights so obtained would carry over under a broader set of circumstances, especially when uncertainty is significant, but sometimes at the cost of a loss in tractability.

[21] The absence of any income effect allows us to import into our analysis all the tractability of partial equilibrium models that are familiar in the regulatory economics; an important ingredient to efficiently handle models with asymmetric information especially to bring them to general equilibrium.

2.4. *Welfare Functions*

Let w_j be the non-negative weight of consumer j in the social welfare function in country E (with the normalization $\int_j w_j dj = 1$). Formally, this social welfare function can be written as:

$$\mathcal{U}(D(p)) - pD(p) + E_\theta\left(\left(\int_j w_j\beta_j(\theta)dj\right)\pi(\theta,p)\right) + R(p_w,p).$$

To avoid that large lump-sum transfers between consumers with different ownership portfolios arbitrarily increase the value of this objective function, we shall assume that $E_\theta\left(\int_j w_j\beta_j(\theta)dj\right) = 1$. Equivalently, this amounts to assuming that there exists $\alpha \in [0, 1/\nu]$ such that:

$$\int_j w_j\beta_j(\underline{\theta})dj = \alpha \text{ and } \int_j w_j\beta_j(\bar{\theta})dj = \frac{1-\alpha\nu}{1-\nu}.$$

With those notations at hands, the welfare function at home can be written in a more compact form as:

$$\mathcal{U}(D(p)) - pD(p) + \alpha\nu\pi(\underline{\theta},p) + (1-\alpha\nu)\pi(\bar{\theta},p) + R(p_w,p). \tag{2.1}$$

Observe that, when $\alpha \leq 1$, this welfare function gives a lower weight to the profit of the most efficient producers. When $\alpha = 1$, all firms in sector 2 receive equal weights. The distribution of profit between low- and high-cost firms is then irrelevant. As we will see below, the equilibrium allocations are the same whether there is asymmetric or complete information in that case. Instead, when $\alpha < 1$; the high-cost producers are favored in the objective function. Under that scenario, our analysis will unveil an important trade-off between efficiency and redistribution that arises under asymmetric information.

The objective function in (2.1) is also consistent with more positive approaches. For instance, Baron (1989) views the choice of α as representing the preferences of a median-voter in Congress. Legislators may represent local interests in various districts which differ in terms of their shares of ownership in intermediate and final sectors. That the median belongs to a district which owns relatively more high-cost firms amounts to assuming that $\alpha < 1$. Beyond, political decision-makers may also have their own intrinsic preferences and allocate different weights to final and intermediate sectors depending on their respective lobbying power as in Bernheim and Whinston (1986) and Grossman and Helpman (1994).

In country E^*, production technologies are common knowledge. To avoid that large lump-sum transfers across firms with different efficiency parameters arbitrarily increases social welfare, social welfare function in E^* must necessarily give an equal weights to low- and high-cost producers:

$$\mathcal{U}(D(p_w)) - p_wD(p_w) + E_\theta(py(\theta,p) - \theta C(y(\theta,p))) - (p-p_w)E_\theta(y(\theta,p)). \tag{2.2}$$

In writing down this objective, we take care of the fact that producers in E^* are selling $E_\theta(y(\theta,p)) - D(p_w)$ units at price p on the export market in E and $D(p_w)$ units on the home market at price p_w. They have also to pay the tariff whose cost on E^*'s welfare is $(p-p_w)E_\theta(y(\theta,p))$.

Importantly, observe that asymmetric information allows a richer set of possible welfare functions. The difference comes from the fact that lump-sum transfers across firms with different efficiency parameters are not unbounded when they must respect incentive compatibility. This opens new possibilities for redistributing profits between firms even if they do not have the same political weight.

2.5. *Autarky Under Complete Information*

Because countries are symmetric both in terms of preferences and technologies, there is no reasons to trade between countries in the complete information scenario. *A fortiori*, there is no reason to impose a tariff. The autarky price p_a is thus equal to the world price and is defined as:

$$D(p_a) = E_\theta \left(S\left(\frac{p_a}{\theta}\right)\right).$$

This symmetric setting gives us an interesting benchmark with respect to which we can assess the pure impact that asymmetric information within country E has on trade.

When $\Delta\theta$ is small enough, simple Taylor expansions show that (up to terms of order magnitude greater than 2) the autarky price solves:

$$D(p_a) = S\left(\frac{p_a}{\theta^*}\right). \tag{2.3}$$

Of course, the equilibrium price will be modified under asymmetric information. Such changes will respond to demand and supply elasticities. For further references, we thus define those elasticities at the autarky price but also their ratio (an important parameter for the rest of our analysis below especially when we perform Taylor approximations) respectively as:

$$\varepsilon_D = \frac{-p_a D'(p_a)}{D(p_a)}, \quad \varepsilon_S = \frac{p_a S'\left(\frac{p_a}{\theta^*}\right)}{S\left(\frac{p_a}{\theta^*}\right)} \text{ and } \rho = \frac{\varepsilon_D}{\varepsilon_S}.$$

3. "BEHIND-THE-BORDER" MECHANISMS

Beyond imposing a tariff, country E may also complement its protection of domestic producers with various "behind-the-border" policies. Those policies stem for credit subsidies, tax cuts, input regulations, domestic regulations on product lines which are not sheltered from international competition, that may target specific importers.[22] Consistently with the idea that those policies are designed *"behind the border"* and have thus no commitment value to influence market equilibrium, we shall assume that those policies are designed taking as given the level of the import tariff t and the domestic price p, which will be simply obtained as a result of market equilibrium.

3.1. *Incentive compatibility*

We take here the most normative perspective and envision any "behind-the-border" policy as a (direct) mechanism $\{z(\hat\theta), y(\hat\theta)\}_{\hat\theta\in\Theta}$ that stipulates the firm's payment and supply requirement as a function of its claim $\hat\theta$ on its efficiency parameter θ. In other words, the decision-maker proposes a whole menu of options to firms in the import sector. Those firms self-select by choosing how much to supply on the market $y(\hat\theta)$ and a compensation $z(\hat\theta)$ within this menu. From the Revelation Principle (Myerson, 1982), considering such direct mechanisms is without loss of generality. Incentive compatibility

[22] We retain here a large acceptation for "behind-the-border" policies: it includes all domestic practices implemented by the domestic government, practices that imply a discrimination of foreign producers once their products have crossed the border. In particular it also includes measures of domestic support that may be particularly important in agriculture.

implies that the following condition now defines the firm's profit, conditionally on the marginal return on production r:

$$\pi(\theta, r) = \max_{\hat{\theta}\in\Theta} z(\hat{\theta}) + ry(\hat{\theta}) - \theta C(y(\hat{\theta})).$$

In the sequel, we shall repeatedly rely on a dual and more compact characterization of incentive compatibility by using the profit level $\pi(\theta, r)$ instead of the payment $z(\theta)$ together with a supply curve. Next Lemma provides such characterization.

LEMMA 1 *An allocation $(\pi(\theta, r), y(\theta))$ is incentive compatible if*

$$\pi(\underline{\theta}, r) - \pi(\bar{\theta}, r) \geq \Delta\theta C(y(\bar{\theta})), \tag{3.1}$$

and

$$y(\underline{\theta}) \geq y(\bar{\theta}). \tag{3.2}$$

From (3.1), it follows immediately that low-cost firms in sector 2 obtain lower profit levels. Indeed, by mimicking a less efficient type $\bar{\theta}$, a low-cost firm $\underline{\theta}$ can adopt the same supply curve but produce at a lower marginal cost. The gains from doing so is $\Delta\theta C(y(\bar{\theta}))$ which is found on the right-hand side of (3.1). As we will see below, relaxing the incentive compatibility constraint requires to reduce these gains.[23]

3.2. *Budget balance*

A budget of size B is allocated to "behind-the-border" policies targeted to the import sector. Those funds are raised through lump-sum taxation on consumers. Given our assumption of quasi-linear preferences, those taxes have thus no distortionary effects and no impact on the value of the social welfare function since any such tax ends up being pocketed by consumers as a shareholder of firms in the subsidized sector. Budget balance thus holds when:

$$E_\theta(z(\theta)) = B.$$

It will often be convenient to rewrite this constraint in terms of profits in the import sector as:

$$E_\theta(\pi(\theta, r)) = E_\theta(ry(\theta) - \theta C(y(\theta))) + B. \tag{3.3}$$

That condition simply states that the overall profit in sector 2 plus the subsidy is fully redistributed across firms within that sector.[24]

[23] It is standard in the screening literature (Laffont and Martimort, 2002, Chapter 2) to focus only on the low-cost firm' incentive constraint which is binding at the optimum under asymmetric information. Lemma 1 thus allows us to significantly simplify the analysis when looking for the optimal incentive compatible mechanism. Indeed, it suffices to consider a relaxed problem where only (3.1) matters and check that the monotonicity condition (3.2) holds at the optimum to ensure that the high-cost firms' incentive constraint is then automatically satisfied; a route that we will follow thereafter.

[24] To fix ideas and prepare for some of the results below, suppose that domestic importers are subject to a per unit tax $\tau = p - p_w$ so that they internalize the impact of their own production on tariff revenues and reduce output accordingly to increase tariff revenues. The corresponding payments write then as $z(\theta) = -\tau y(\theta)$ and $B = -\tau E_\theta(y(\theta))$.

3.3. *Optimal "Behind-The-Border" Policies*

Taking into account (3.3) to rewrite the social welfare function in E, the second-best optimization problem consists in finding a profile of profit $\pi(\cdot)$ and supply functions $y(\cdot)$ that altogether solve:

$$(\mathcal{P}): \quad \max_{\pi(\cdot),y(\cdot)} \mathcal{U}(D(p))-pD(p)+E_\theta(ry(\theta)-\theta C(y(\theta)))-\nu(1-\alpha)(\pi(\underline{\theta},r)-\pi(\bar{\theta},r))+R(p_w,p)$$

subject to (3.1).[25]

Observe that, when looking for optimal "behind-the-border" policies, prices are taken as given. We are not modeling a planned economy where a central Agency would dictate resources allocations. Instead, the Agency in charge of regulating "behind-the-border" policies let markets still allocate resources freely which is more consistent with the behavior of actual economies. This approach is also consistent with the idea that many dimensions of those policies are actually secret and have no commitment power to influence equilibrium prices.[26]

Fixing $\alpha \in [0,1]$, we now define the so-called *virtual cost parameter* as:

$$\tilde{\theta}(\alpha,\theta) = \begin{cases} \underline{\theta} & \text{if } \theta = \underline{\theta}, \\ \bar{\theta} + \frac{\nu(1-\alpha)}{1-\nu}\Delta\theta > \bar{\theta} & \text{if } \theta = \bar{\theta}. \end{cases}$$

As we will see below, those virtual cost parameters replace true costs as the relevant variables determining domestic supply under asymmetric information. Equipped with this definition, we now obtain a compact expression of second-best policies under asymmetric information.

PROPOSITION 1 *The optimal "behind-the-border" policy under asymmetric information in country E induces a supply function $y(\tilde{\theta}(\alpha,\theta),r)$ from a firm with type θ. Low-cost firms have thus the same supply function as under complete information while high-cost firms produce less:*

$$y(\tilde{\theta}(\alpha,\theta),r) \leq y(\theta,r) \quad \forall \theta \in \Theta. \tag{3.4}$$

To reduce the social cost of incentive compatibility, the allocation targeted towards high-cost firms should be made less attractive to low-cost ones. This is obtained by contracting the supply function of those high-cost firms below its complete information value. Yet, condition (3.4) keeps some strong similarity with the expression that would prevail under complete information. Under asymmetric information, everything indeed happens as if the efficiency parameter $\bar{\theta}$ of a high-cost firm is now replaced by a greater *virtual efficiency parameter* $\tilde{\theta}(\alpha,\bar{\theta})$. As a result, high-cost firms produce less. This in turn relaxes the incentive constraint (3.1). Asymmetric information creates now a wedge between price and marginal cost for the least efficient firms in country E.[27]

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[26] This important feature distinguishes our approach from the literature on strategic trade policies (Brander, 1995) that precisely stresses the commitment value that public policies may have.

[27] It is worth stressing that, although the distortions due to asymmetric information are akin to market power, they cannot be undone by using subsidies. We comment further on this issue below.

Finally observe that, as α decreases, high-cost firms get a greater weight in the social welfare function and exert more pressure on decisions. This makes their allocation more attractive for low-cost firms and second-best distortions are exacerbated. *A contrario*, when $\alpha = 1$, the social welfare function gives an equal weight to all producers in sector 2. The distribution of profits among those firms has no consequences and there is no distortion in supply functions compared to the case of complete information.

4. AUTARKY

This section analyzes the autarky outcome in country E in a context with asymmetric information. As we will see, asymmetric information has no consequence on the efficiency of market allocations when the notion of efficiency is properly defined to account for incentive compatibility. Instead, asymmetric information has of course some impact on prices.

4.1. *Equilibrium Price*

Under autarky, the equilibrium price $p_a(\alpha)$ is such that:

$$D(p_a(\alpha)) = Y(\alpha, p_a(\alpha))$$

where $Y(\alpha, p) = E_\theta(y(\tilde{\theta}(\alpha, \theta), p))$ is the aggregate supply in country E.

Taking stock of the results in Proposition 1 tells us how the equilibrium price changes under asymmetric information and what are its main properties.

Proposition 2 *Under autarky in country E, asymmetric information raises the price for the informationally-sensitive good (i.e., good 2):*

$$p_a(\alpha) \geq p_a \quad \forall \alpha.$$

Under asymmetric information, the supply curve of high-cost firms is reduced, which contracts aggregate supply. In response, the market price increases beyond its complete information level.

Small cost uncertainty. To get sharp comparative statics, we now consider the case of small cost uncertainty. To this end, let introduce the parameter $k = \frac{p_a \nu}{\theta^*}$ that repeatedly plays a role in the sequel.

Proposition Bis 1 *Up to terms of order of magnitude more than 2 in $\Delta\theta$, the autarky price admits the following Taylor approximation when $\Delta\theta$ is small enough:*

$$p_a(\alpha) = p_a + \frac{k}{1+\rho}(1-\alpha)\Delta\theta \geq p_a. \tag{4.1}$$

When α decreases, when $\Delta\theta$ increases, or when the fraction of low-cost firms in the economy ν increases, the cost of inducing incentive compatibility allocations increases. Supply is further contracted and the autarky price further increases at equilibrium. Of course, the price increases also more when the demand curve is less elastic (i.e., ε_D smaller) and/or when the supply curve is more elastic (i.e., ε_S bigger). ■

4.2. *Interim Efficiency*

The inefficiency induced by asymmetric information is not an artifact of our assumption that prices are taken as given when designing an optimal incentive "behind-the-border" mechanism. Indeed, it would not be possible find a Pareto improvement by intervening also on the market price (for instance by means of subsidies boosting production) while still preserving incentive compatibility. To see why, observe that any per unit of output subsidy s could be already included into a "behind-the-border" mechanism in the first place. To this end, it would be enough to already incorporate the extra payment sy into such "behind-the-border" mechanism provided that supply requirements also take into account the extra incentives to produce. Confirming this rough intuition, Proposition 3 below demonstrates that the market allocation is actually *interim-efficient* in the sense of Holmström and Myerson (1983). That is to say this allocation cannot be Pareto improved once incentive constraints are taken into account.[28]

Proposition 3 *Under autarky, the market allocation is interim efficient.*

A planner would choose not to intervene on the market price if he was able to dictate market conduct. There is no justification of a market intervention to reduce distortions induced by asymmetric information if such market intervention has also to respect incentive constraints. This is an important result in view of our findings in Section 5 below. Indeed, we shall show there that asymmetric information is a source of trade. Then, distorting trade by means of import tariffs becomes a valuable strategy but it is only driven by the decision-maker's concerns for improving terms of trade not by the possibility of improving allocative efficiency within borders.

5. TARIFF EQUILIBRIUM UNDER ASYMMETRIC INFORMATION

This section first highlights how asymmetric information provides a new rationale for trade between otherwise identical countries. Then, we characterize the non-cooperative tariff equilibrium that arises when country E imposes an import tariff.

5.1. *Asymmetric Information as a Source of Trade*

Under asymmetric information, country E is comparatively less efficient at producing good 2 because it is now the comparison of *virtual costs* there with true costs in E^* that determines trade patterns.[29] E now imports good 2 which is impacted by asymmetric information while it exports good 1. Trade arises in this context only for pure informational reasons.

Proposition 4 *Country E which suffers from asymmetric information imports the informationally-sensitive good (i.e., good 2).*

[28] Holmström and Myerson (1983) argue that, under asymmetric information, different types of the same agent may receive different weights in the social welfare function when one wants to characterize the set of so-called *interim efficient allocations*. This approach fits with our specification of the social welfare function (2.1). Such objective is akin to those found in the Incentive Regulation literature although the later is concerned with the partial equilibrium impact of sectoral regulation. See for instance Baron and Myerson (1982), Laffont and Tirole (1993), and Armstrong and Sappington (2007).

[29] Martimort and Verdier (2012) develop a similar insight in the case of a small economy that trades with the rest of the world although in the absence of asymmetric information, trade may also arise in their model.

Given that country E imports good 2 and raises revenues from doing so, "behind-the-border" policies should be optimally designed so that home producers internalize the impact of their own production on those tariff revenues. To do so, it must be that the net benefit of each extra unit of home production is worth $r = p - (p - p_w) = p_w$ where p is the marginal return on producers' profits and $p - p^w$ the marginal return on tariff revenues. "Behind-the-border" policies should thus induce home producers to produce at price p_w. The results of Proposition 1 then apply with that specific value of r. In particular, domestic supply in country E amounts to $Y(\alpha, p_w) = E_\theta(y(\tilde{\theta}(\alpha,\theta), p_w)$. Instead, $Y^*(p) = E_\theta(y(\theta, p))$ represents country E^*'s supply when it exports part of this production on the domestic market E at price p.

In practice, incentive compatibility and re

Of course, without any "behind-the-border" intervention, the domestic government would not have any possibility to internalize the impact of domestic production on tariff revenues.

5.2. *Free Trade and Worldwide Interim-Efficiency*

Consider now the case of an open economy with country E maybe imposing an import tariff. The world price $p_w = P_w(\alpha, p)$ is now fully determined by the equilibrium condition:

$$D(p) - Y(\alpha, P_w(\alpha, p)) = Y^*(p) - D(P_w(\alpha, p)). \tag{5.1}$$

The function $P_w(\alpha, p)$ is non-increasing in both p and α. In other words, a greater domestic price reduces world price; a usual term of trade externality. More specially to our context, more political pressure by high-cost firms in the import sector (i.e., α lower) also raises the domestic price and reduces imports.

Opening borders to foreign exports, country E is now able to raise domestic revenues by charging a tariff $t = p - p_w$ on imports:

$$R(P_w(\alpha, p), p) = (p - P_w(\alpha, p))(D(p) - Y(\alpha, P_w(\alpha, p)).$$

Once tariff revenues are included, country E's welfare as defined from (2.1) becomes:

$$\mathcal{W}(\alpha, p) = \mathcal{U}(D(p)) - P_w(\alpha, p)D(p) + P_w(\alpha, p)Y(\alpha, P_w(\alpha, p)) - E_\theta(\tilde{\theta}(\alpha,\theta)C(y(\tilde{\theta}(\alpha,\theta), P_w(\alpha, p))). \tag{5.2}$$

Once the cost of paying a tariff on its exports is taken into account, welfare in E^*, namely $\mathcal{W}^*(p)$ as defined from (2.2), writes as:

$$\mathcal{W}^*(p) = \mathcal{U}(D(P_w(\alpha, p)) - P_w(\alpha, p)D(P_w(\alpha, p)) + P_w(\alpha, p)Y^*(p) - E_\theta(\theta C(y(\theta, p))).$$

To account for the fact that we are now considering an open economy, we now extend the concept of interim efficiency used in Section 4.2 worldwide. Because preferences are quasi-linear in each country and tariff revenues thus transfer wealth from one country to the other, we define a worldwide interim-efficient (domestic) price as now maximizing the sum of welfares in both countries, namely $\mathcal{W}_w(\alpha, p) \equiv \mathcal{W}(\alpha, p) + \mathcal{W}^*(p)$. Of course, this expression also takes care of the political preferences that prevail in country E.

Differentiating the expression of worldwide welfare with respect to p yields:

$$\frac{\partial \mathcal{W}_w}{\partial p}(\alpha, p) = (p - P_w(\alpha, p))(D'(p) - Y^{*'}(p)). \tag{5.3}$$

The facts that $p - P_w(\alpha, p)$ is increasing in p and that $D'(p) - Y^{*\prime}(p) < 0$ altogether show that $\mathcal{W}_w(\alpha, p)$ is quasi-concave in p. The first-order (necessary and sufficient) condition for the above maximization problem immediately yields:

Proposition 5 *The free-trade price $p_w(\alpha)$ defined implicitly as the solution to*

$$p_w(\alpha) = P_w(\alpha, p_w(\alpha)) \quad \forall \alpha$$

is worldwide interim-efficient.

This proposition tells us that free trade is still the best outcome from a global welfare point of view even if one takes into account private information in country E. Distortions on free trade certainly do not help solving this domestic informational problem. Any trade barrier that could be imposed by E has thus as sole objective to shift revenues home.

Because $P_w(\alpha, p)$ is decreasing in α, the free-trade price $p_w(\alpha)$ is also decreasing in α. More political power of high-cost producers in country E reduces output and raises that price even if no trade barriers are imposed.

Of course, when $\alpha = 1$, imports disappear and the free-trade price boils down to the (complete information) autarky price p_a.

Small cost uncertainty. For further references, we observe that, up to terms of second-order magnitude in $\Delta\theta$, the following Taylor expansion holds when $\Delta\theta$ is small enough:

$$(5.4) \qquad p_w(\alpha) = p_a + \frac{k}{2(1+\rho)}(1-\alpha)\Delta\theta.$$

■

5.3. *Optimal Tariff*

We now investigate the unilateral choice of a tariff by country E taking into account that tariff revenues improve domestic welfare.

To this end, let first define the following function:

$$\varphi(\alpha, p) = P_w(\alpha, p) - \frac{Y(\alpha, P_w(\alpha, p)) - D(p)}{D'(p)} \frac{\partial P_w}{\partial p}(\alpha, p) \quad \forall (\alpha, p).$$

Observe that $\varphi(\alpha, p) \geq P_w(\alpha, p)$. For further references, we will also assume that this function $\varphi(\alpha, p)$ satisfies some monotonicity conditions:

Assumption 1

$$\frac{\partial \varphi}{\partial \alpha}(\alpha, p) < 0 \text{ and } \frac{\partial \varphi}{\partial p}(\alpha, p) < 1 \quad \forall (\alpha, p).$$

The first condition ensures that the domestic price charged in the non-cooperative solution increases with the political power of high-cost producers in country E. The second assumption ensures instead quasi-concavity of the optimization problem when looking for an optimal tariff.

An optimal domestic price maximizes domestic welfare:

$$p^{nc}(\alpha) \equiv \arg\max_p \mathcal{W}(\alpha, p). \tag{5.5}$$

This objective is quasi-concave when Assumption 1 holds. The optimal domestic price is then characterized by means of a first-order condition (5.6). Next proposition unveils some property of that non-cooperative equilibrium.

Proposition 6 *Consider an open economy with country E charging an import tariff and suppose that Assumption 1 holds.*

- *The domestic price defined as*

$$p^{nc}(\alpha) = \varphi(\alpha, p^{nc}(\alpha)) \quad \forall\alpha \tag{5.6}$$

is a decreasing function of α which remains above the free-trade price

$$p^{nc}(\alpha) \geq p_w(\alpha) \quad \forall\alpha \text{ with equality at } \alpha = 1.$$

- *The optimal tariff $t^{nc}(\alpha) = p^{nc}(\alpha) - p_w^{nc}(\alpha)$ is such that:*

$$t^{nc}(\alpha) = -\frac{Y(\alpha, p_w^{nc}(\alpha)) - D(p^{nc}(\alpha))}{D'(p^{nc}(\alpha))}\frac{\partial P_w}{\partial p}(\alpha, p^{nc}(\alpha)) > 0 \quad \forall\alpha. \tag{5.7}$$

Asymmetric information induces two distortions on domestic supply. The first one is by now familiar. Remind that with a fixed domestic price the output of inefficient domestic producers is reduced. Second, and this is an indirect effect that is specific to an open economy, such contraction fosters trade with the more efficient economy E^*. It thus becomes valuable to impose a positive tariff. This second effect raises again the domestic price in country E above the free-trade price depressing domestic demand and boosting foreign supply. At the same time, the world price falls below this free-trade level which in turn reduces domestic supply and boosts foreign demand. That both domestic demand and supply end up being reduced by the tariff highlights the trade-off faced by the domestic country in setting an optimal tariff. On the one hand, increasing the tariff raises revenues. On the other hand, it impacts negatively on domestic consumers' and producers' surpluses.

Small cost uncertainty. In the limiting case where uncertainty on cost parameters is small (i.e., $\Delta\theta$ small enough) to which we repeatedly refer below, the second condition in Assumption 1 actually holds when domestic demand is sufficiently elastic:

Assumption 2

$$\rho > \frac{1}{2}.$$

Proposition Bis 2 *Suppose that Assumption 2 holds. Up to terms of second-order magnitude in $\Delta\theta$, the optimal tariff, the domestic price in E, and the world price admit the following Taylor approximations when $\Delta\theta$ is small enough:*

$$t^{nc}(\alpha) = \frac{(2\rho+1)k}{(2\rho-1)(1+\rho)}(1-\alpha)\Delta\theta, \tag{5.8}$$

$$(5.9) \quad p^{nc}(\alpha) = p_a + \frac{2\rho k}{(2\rho - 1)(1+\rho)}(1-\alpha)\Delta\theta,$$

$$(5.10) \quad p_w^{nc}(\alpha) = p_a - \frac{k}{1+\rho}(1-\alpha)\Delta\theta.$$

From (5.5), the equilibrium tariff is decreasing in α. Intuitively, giving more weight to the inefficient producers (i.e., making α lower) further contracts domestic supply and thus calls for more imports. This makes it valuable to increase the tariff.

The tariff increases also sharply when the elasticity of imports is small enough. This is the case when ρ is close to $\frac{1}{2}$. When instead ρ is very large, imports are highly elastic the optimal tariff remains small.

Finally, the comparison between the non-cooperative solution and free trade shows that the price increase is half the tariff, the second half being captured by the world price decrease below the free-trade level:

$$(5.11) \quad p^{nc}(\alpha) - p_w(\alpha) = \frac{t^{nc}(\alpha)}{2}.$$

■

5.4. *Payoffs in the Non-Cooperative Trade Equilibrium*

In the sequel, we will repeatedly refer to the levels of welfare achieved in both countries in this non-cooperative tariff equilibrium. Making again the dependence on α explicit, this gives us a pair of payoff functions $(\mathcal{V}^{nc}(\alpha), \mathcal{V}^{*nc}(\alpha))$ that will serve as their status quo payoffs when countries negotiate any trade agreement.

Taking stock of our previous findings, welfare in country E can easily be defined as:

$$\mathcal{V}^{nc}(\alpha) = \mathcal{W}(\alpha, p^{nc}(\alpha)).$$

Using the Envelope Theorem immediately unveils that the importing country's payoff decreases with the extent of political pressure that high-cost importers impose on the internal political process.

$$(5.12) \quad \dot{\mathcal{V}}^{nc}(\alpha) = \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha)) > 0.$$

As high-cost firms exert more political pressure in the importing country (i.e., α getting lower), outputs distortions are more pronounced for domestic producers and imports increase. This raises import revenues, justifies greater tariffs which induce stronger allocative distortions, reducing thereby domestic welfare below the efficient outcome that would be achieved when $\alpha = 1$.

For further references, the exporting country E^*'s payoff is given by:

$$\mathcal{V}^{*nc}(\alpha) = \mathcal{W}^*(p^{nc}(\alpha)).$$

6. TRADE MECHANISMS

The non-cooperative equilibrium studied in Section 5 highlights two important features. First, a tariff shifts wealth from country E^* to country E. Second, using a tariff has a distortionary impact on consumption decisions at home and production decisions abroad so that transferring tariff revenues also entails a deadweight loss. In this Section, we now investigate the conditions under which countries are ready to negotiate a trade agreement that improves on this non-cooperative equilibrium. Such trade agreement must of course improve welfare worldwide (properly defined as before to account for internal redistributive problems in country E) and thus reduce such deadweight loss.

To be more precise, a number of specific requirements must be satisfied by such trade agreement. First, participation constraints matter. By entering the negotiation, countries must get more than their non-cooperative payoffs. The agreement must thus stipulate a compensation that at the same time is large enough to convince the importing country not to use a tariff but also small enough to persuade the exporting country to also join in. Second, incentive compatibility matters. Indeed, the importing country might have certainly private information on the extent of internal political influence exerted by high-cost producers. When joining the bargaining table, that country might want to exaggerate those pressures and thus request greater compensation to join in. The agreement must thus satisfy incentive compatibility conditions that apply now to the privately informed country E itself.

This last feature is an important aspect of modeling double-edge incentives in our context. Incentives constraint *within* the importing country makes allocation dependent on the social weight given to high-cost producers there. This in turns creates an incentive problem at the international level when countries bargain one with the other.

6.1. *Incentive-Feasible Trade Mechanisms*

This section develops the precise analysis of the different constraints that characterize on feasible bargaining procedures. We closely follow Feenstra and Lewis (1994) and Amador and Bagwell (2011) in assuming that country E has private information on the extent of internal political pressures α. Instead, country E^* only knows the (atomless) distribution $G(\cdot)$ of that parameter on the support $[0, 1]$. We denote $g(\alpha) = G'(\alpha)$ the positive density function.

Incentive Compatibility. We proceed in a similar vein to what we did when describing "behind-the-border" mechanisms within country E. We take here again a normative perspective in describing all possible trade mechanisms that are incentive feasible between the two countries. A trade agreement offers to the importing country E a whole menu of options stipulating both a (domestic) price at which good 2 should be traded and a compensation that eventually covers the revenues loss from no longer relying on tariff barriers. Country E selects its most preferred option within this menu.

Following the Revelation Principle (Myerson, 1982), there is no loss of generality in viewing such trade mechanism as a pair $\{T(\hat{\alpha}), p(\hat{\alpha})\}_{\hat{\alpha}\in[0,1]}$ where $\hat{\alpha}$ is a claim of the importing country E on the extent of the political pressures that apply internally, $T(\hat{\alpha})$ a monetary compensation and $p(\hat{\alpha})$ a domestic price for good 1. The monetary compensation should be interpreted broadly. For instance, those gains could come from forcing country E^* to open other (unmodeled) markets to country E. It can also be viewed as a reduced form for the more complete scenario where E^* itself has responded to E's tariff with imposing a tariff on E^* own exports and now concedes at the negotiation stage by suppressing such retaliatory tariff war.

Denoting by $\mathcal{V}(\alpha)$ country E's equilibrium payoff when playing truthfully such mechanism, incentive compatibility now implies:

$$\mathcal{V}(\alpha) = \max_{\hat{\alpha}} \mathcal{W}(\alpha, p(\hat{\alpha})) + T(\hat{\alpha}). \tag{6.1}$$

We can replace compensation payments by their expression in terms of country E's payoff and view a trade mechanism as an incentive compatible allocation $(\mathcal{V}(\alpha), p(\alpha))$. Next Lemma provides a useful characterization of such allocations.

LEMMA 2 *An allocation $(\mathcal{V}(\alpha), p(\alpha))$ is incentive compatible if and only if:*

1. *$\mathcal{V}(\alpha)$ is absolutely continuous in α with at each point of differentiability (i.e., almost everywhere)*

$$\dot{\mathcal{V}}(\alpha) = \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p(\alpha)), \tag{6.2}$$

2. *$p(\alpha)$ is non-increasing in α.*

From (6.2), it follows immediately that an importing country E gets a greater payoff when high-cost producers have less influence on internal politics. To understand why, we must uncover the two sources of rents that this country enjoys when pretending being subject to more internal influence of those domestic producers than what it really is (i.e., when pretending to have a type $\alpha - d\alpha$ when the true political preferences are α).

From the Envelope Theorem, we first get:

$$\begin{aligned}\dot{\mathcal{V}}(\alpha) &= \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p(\alpha)) \\ &= \underbrace{\nu \Delta\theta C(y(\tilde{\theta}(\alpha, \bar{\theta}), P_w(\alpha, p(\alpha))))}_{\text{Domestic politics effect}} + \underbrace{\frac{\partial P_w}{\partial \alpha}(\alpha, p(\alpha))(Y(\alpha, P_w(\alpha, p(\alpha))) - D(p(\alpha)))}_{\text{Trade openness effect}}.\end{aligned}$$

Observe that $\dot{\mathcal{V}}(\alpha)$ is thus the sum of two terms. The first source of rent is purely due to domestic considerations: a *domestic politics effect*. The second source of rent follows from trade openness: a *trade openness effect*.

Let us consider first the *domestic politics effect*. By mimicking a type $\alpha - d\alpha$ in a trade negotiation, a country E with type α actually pretends that leaving information rent to low-cost producers in the internal political process is more costly than what it really is. To support a trade agreement, country E must thus be compensated for the amount of domestic rent left to low-cost producers that is indeed saved, which is approximatively worth:

$$\nu \Delta\theta C(y(\tilde{\theta}(\alpha, \bar{\theta}), P_w(\alpha, p(\alpha))))d\alpha.$$

Because $P_w(\alpha, p)$ is non-increasing in p and $y(\tilde{\theta}(\alpha, \bar{\theta}), p)$ is non-decreasing in p, reducing that first source of rent calls for choosing trade mechanisms that implement high values of p so that domestic supply decreases. In other words, manipulating trade negotiations is an indirect way to limit information rents for low-cost producers at home.[30]

[30] Milner and Rosendorff (1996) study the interaction between international negotiations and a domestic political situation. They examine in particular the case where domestic political constraints may create a bargaining advantage for an international negotiator: *"For instance, having farmers who riot in the streets against reduced agricultural barriers that the domestic government is considering in international negotiations may convince the other countries that pushing for such trade barriers reductions is a losing cause."* They mention a relatively large literature giving evidence of this phenomenon.

Turning now to *trade openness effect*, observe that by pretending that high-cost producers have a greater political weight $\alpha - d\alpha$, country E also convinces his negotiating partner that the domestic price is higher than what it should be and, as a result, that the world price should be lower and that revenues from an import tariff are larger than what they really are. Such manipulation can only be prevented by increasing country E's compensation by an amount approximatively worth this increase in revenues:

$$\frac{\partial P_w}{\partial \alpha}(\alpha, p(\alpha))(Y(\alpha, P_w(\alpha, p(\alpha))) - D(p(\alpha))d\alpha.$$

Because $P_w(\alpha, p)$ is non-increasing in α and $Y(\alpha, P_w(\alpha, p(\alpha))) - D(p(\alpha))$ is negative when E imports good 2, this term is thus positive as well. Reducing that second source of rent calls for bringing domestic supply and demand closer. The mechanism should stipulate prices closer to their autarky level.

From Lemma 2, it immediately follows that an incentive compatible mechanism must give greater payoffs to the importing country precisely when those imports disappear, i.e., when $\alpha = 1$. Presumably, country E then enjoys the greatest benefits from refusing to join the agreement and opting for the status quo.

Importantly, country E's marginal benefits of increasing domestic price decreases with α as shown from the following single-crossing property:

$$\frac{\partial^2 \mathcal{W}}{\partial \alpha \partial p}(\alpha, p) = -\frac{\partial \varphi}{\partial \alpha}(\alpha, p) D'(p) < 0 \tag{6.3}$$

In other words, a country with strong political pressures by high-cost producers (i.e., α lower) is more eager to increase the domestic price by imposing an import tariff. This property will be used later on to facilitate self-selection of different types of the importing countries along the different options left on the bargaining table.

Equipped with this remark, it becomes useful to rewrite (6.1) under an integral form as:

$$\mathcal{V}(\alpha) = \mathcal{V}(0) + \int_0^\alpha \frac{\partial \mathcal{W}}{\partial \alpha}(x, p(x))dx. \tag{6.4}$$

This expression taken in tandem with the single-crossing property (6.3) already shows that the the importing country's payoff diminishes when the trade mechanism stipulates greater levels of the domestic price. Indeed, such prices reduce the importing country's incentives to pretend being more influenced by high-cost producers in domestic policy than what it really is. As a consequence, country E's payoff is less steep with a trade agreement implementing a price schedule $p(\alpha) \geq p^{nc}(\alpha)$ than in the non-cooperative equilibrium:

$$\dot{\mathcal{V}}^{nc}(\alpha) > \dot{\mathcal{V}}(\alpha) \quad \forall \alpha. \tag{6.5}$$

Participation to the agreement. A trade agreement must also be accepted by both countries. Given that the status quo is to return to a non-cooperative equilibrium, the participation constraints for the importing country E can be written as:

$$\mathcal{V}(\alpha) \geq \mathcal{V}^{nc}(\alpha) \quad \forall \alpha \in [0, 1]. \tag{6.6}$$

Under asymmetric information, the exporting country E^*'s expected payoff is:

$$\int_0^1 \mathcal{V}^*(\alpha)dG(\alpha) = \int_0^1 (\mathcal{W}^*(p(\alpha)) - T(\alpha))dG(\alpha). \tag{6.7}$$

Taking into account that the exporting country E^* has no information on α, its participation constraint must hold in expectation over the possible levels of political influence α within country E:

$$\int_0^1 \mathcal{V}^*(\alpha)dG(\alpha) \geq \int_0^1 \mathcal{V}^{*nc}(\alpha)dG(\alpha). \tag{6.8}$$

6.2. *Optimal Trade Mechanism*

Following an approach which is by now well known from the bargaining literature (see for instance Myerson and Sattherwaite, 1983), we envision a trade agreement as a mechanism design problem under the aegis of a neutral uninformed third-party, a mediator in the parlance of the mechanism design literature.[31] Of course, this mediator should take into account political preferences within country E when evaluating worldwide welfare. Using (6.1) and (6.7), the mediator's objective function can thus be written as:

$$\int_0^1 (\mathcal{V}(\alpha) + \mathcal{V}^*(\alpha))dG(\alpha) \equiv \int_0^1 \mathcal{W}_w(\alpha, p(\alpha))dG(\alpha). \tag{6.9}$$

Had political preferences within country E been common knowledge, worldwide efficiency would thus amount to choose the free-trade price equilibrium $p_w(\alpha)$ that is a pointwise maximizer of the above objective.

Neglecting for a while the monotonicity condition from Lemma 2 that is checked ex post on the solution, an optimal mechanism must solve the following problem:

$$(\mathcal{T}): \quad \max_{(\mathcal{V}(\cdot),p(\cdot))} \int_0^1 \mathcal{W}_w(\alpha, p(\alpha))dG(\alpha) \text{ subject to (6.4), (6.6) and (6.8).}$$

6.3. *The Possibility of Efficient Agreements*

Next proposition investigates whether implementing the free-trade price is still possible even under asymmetric information on political preferences within the importing country.

Proposition 7 *Free-trade is implementable even under asymmetric information on political preferences in country E if and only if:*

$$\int_0^1 (\mathcal{W}_w(\alpha, p_w(\alpha)) - \mathcal{W}_w(\alpha, p^{nc}(\alpha))dG(\alpha) \geq \int_0^1 (1-G(\alpha)) \left(\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p_w(\alpha)) - \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha)) \right) d\alpha. \tag{6.10}$$

[31] In abstract mechanism design, this mediator just viewed as a machine transforming reports into allocations. Here, we should viewed such mediator as a metaphor for the communication process taking place between participating countries.

Under condition (6.10), free-trade, which is the worldwide efficient outcome, is implementable. The left-hand side of (6.10) represents the gains from eliminating the deadweight-loss associated with a tariff and moving from the non-cooperative price $p^{nc}(\alpha)$ to the free-trade price $p_w(\alpha)$. Of course, country E must be compensated for giving up tariff protection on its producers. As we have already discussed above, reducing the domestic price from $p^{nc}(\alpha)$ to $p_w(\alpha)$ also increases the payoff that country E can get from manipulating its domestic preferences. The right-hand side of (6.10) then captures how much extra information rent must be left to E beyond the non-cooperative solution to implement the free-trade solution. To implement an efficient trade agreement, the overall surplus must exceed those information gains that accrue to country E.[32]

Of course, such implementation requires that the importing country fully internalizes the impact of its choice of a domestic price on welfare abroad. In the spirit of D'Aspremont and Gerard-Varet (1979), this objective could be achieved with a simple *"pay-the externality"* incentive mechanism of the form $\{T(\hat{\alpha}), p_w(\hat{\alpha})\}_{\hat{\alpha}\in[0,1]}$ where the payment

$$T(\hat{\alpha}) \equiv \mathcal{W}^*(p_w(\hat{\alpha})) - \mathcal{V}^* \quad \forall \hat{\alpha}$$

reflects the impact that the importing country's choice of a domestic price has worldwide. Observe that the constant $\mathcal{V}^*$ is precisely the payoff that can be secured by the exporting country for any possible report $\hat{\alpha}$ made by E. The feasibility condition (6.10) also ensures that the *"pay-the externality"* scheme yields more payoff to the importing country than the noncooperative trade equilibrium. From (6.5), this participation constraint is harder to satisfy for country E when the political pressure of high-cost producers is stronger (i.e., α close to zero). Condition (6.10) then ensures that the trade agreement is acceptable even when those high-cost producers have the greater political weight in country E.

Small cost uncertainty. To better understand (6.10), it is now useful to think of the limiting case where informational problems in country E are not too large, i.e., when $\Delta\theta$ is small enough. Presumably, the non-cooperative $p^{nc}(\alpha)$ and the free-trade $p_w(\alpha)$ solutions are also nearby in that neighborhood and the efficiency loss on the left-hand side of (6.10) is thus of second-order magnitude. Turning now to the right-hand side, both the decrease in price $p^{nc}(\alpha) - p_w(\alpha)$ and how worldwide welfare varies with α are first-order. Overall, (6.10) boils down to a non-trivial comparison of two second-order terms. Next Proposition unveils the terms of this trade-off.

Proposition Bis 3 *Suppose that $\Delta\theta$ is small enough. There exists $\rho^* > \frac{1}{2}$ such that free trade is implementable even under asymmetric information on domestic political preferences if and only if $\rho \leq \rho^*$.*

When ρ is close to $\frac{1}{2}$, exports are highly inelastic and the importing country can charge a very high tariff without foreign suppliers cutting their exports. The benefits of eliminating trade barriers are large and exceeds the informational cost of implementing free trade

[32] The possibility of implementing an efficient allocation is of course reminiscent of other (in-)efficiency results in a more abstract mechanism design literature like those proposed by Laffont and Maskin (1982), Myerson and Sattherwaite (1983), Cramton, Gibbons and Klemperer (1987), Mailath and Postewaite (1990) and Makowski and Mezetti (1993) among others. These papers analyze Bayesian environments (bilateral trade, public good provision, auctions and the like) and ask whether there exists a budget-balance Bayesian incentive compatible mechanism that implements an efficient allocation and that is preferred by parties to a given status quo payoff. As in our analysis, the possibility of implementing an efficient allocation follows from joint properties of those status quo payoffs and the distributions of types.

so that (6.10) indeed holds. Instead, when ρ is large, exports are quite elastic, tariffs are small and the informational cost dominates. Our model predicts thus that trade barriers are actually easier to eliminate when they are significant. ■

6.4. *Second-Best Trade Agreements*

In our search for optimal trade mechanisms, we first provide necessary and sufficient conditions satisfied by any trade mechanism that is incentive compatible and acceptable by both countries. Much in the spirit of how we proceeded to obtain (6.10), we get:

LEMMA 3 *Any incentive-feasible trade mechanism (i.e., such that (6.4), (6.6) and (6.8) hold) inducing a price profile $p(\alpha)$ satisfies:*

(6.11)
$$\int_0^1 (\mathcal{W}_w(\alpha, p(\alpha)) - \mathcal{W}_w(\alpha, p^{nc}(\alpha))dG(\alpha) \geq \int_0^1 (1-G(\alpha)) \left(\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p(\alpha)) - \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha)) \right) d\alpha.$$

Provided that $p(\alpha) \leq p^{nc}(\alpha)$ for all α and $p(\alpha)$ non-decreasing, this condition is also sufficient; i.e., there exists a contribution schedule $\{T(\hat{\alpha})\}_{\hat{\alpha}\in[0,1]}$ such that (6.4), (6.6) and (6.8) all hold.

Condition (6.11) is only necessary for implementability of a price profile. Yet, equipped with this lemma, we may optimize over an *a priori* larger set of allocations but check ex post that the optimal allocation so obtained satisfies all remaining incentive and participation constraints provided that it lies above the non-cooperative solution. Henceforth, we first solve:

$$(\mathcal{T}): \quad \max_{(\mathcal{V}(\cdot), p(\cdot))} \int_0^1 \mathcal{W}_w(\alpha, p(\alpha))dG(\alpha) \text{ subject to (6.11).}$$

The characterization of the solution to this problem is made easier when the following function

$$\psi(\alpha, p) = P_w(\alpha, p) - \frac{1 - G(\alpha)}{g(\alpha)} \frac{D'(p)}{D'(p) - Y^{*\prime}(p)} \frac{\partial \varphi}{\partial \alpha}(\alpha, p)$$

satisfies the following conditions:

ASSUMPTION 3

$$\frac{\partial \psi}{\partial \alpha}(\alpha, p) < 0, \frac{\partial \psi}{\partial p}(\alpha, p) < 1 \text{ and } \psi(\alpha, p) \leq \varphi(\alpha, p) \quad \forall (\alpha, p).$$

The first of those conditions ensures that the optimal price profile is weakly decreasing in α, an important property of incentive compatible allocations as shown in Lemma 2. The second condition guarantees quasi-concavity of the maximand in $(\mathcal{T})$. When $\Delta\theta$ is small enough, it amounts again to Assumption 2. Finally, the third condition will give a simple comparison between the second-best and the non-cooperative solution.

Proposition 8 *Suppose that Assumption 3 holds. There exists $\mu \geq 0$, the multiplier of the feasibility condition (6.11), such that the optimal second-best price $p^{sb}(\alpha)$ defined as*

$$p^{sb}(\alpha) = \frac{1}{1+\mu} P_w(\alpha, p^{sb}(\alpha)) + \frac{\mu}{1+\mu} \psi(\alpha, p^{sb}(\alpha)) \tag{6.12}$$

is such that:

- *$p^{sb}(\alpha)$ is decreasing with α.*
- *$p^{sb}(\alpha)$ lies in between the non-cooperative and free-trade solutions:*

$$p^{nc}(\alpha) \geq p^{sb}(\alpha) \geq p_w(\alpha) \quad \forall \alpha \text{ with equalities at } \alpha = 1 \text{ only.} \tag{6.13}$$

When (6.10) fails, the free-trade price $p_w(\alpha)$ can no longer be implemented under asymmetric information on country E's preferences. This is so because this country would require a large compensation for giving up tariff barriers and such large compensation cannot be supported by the exporting country E^*. To reduce this compensation and facilitate participation, the optimal policy requested by the trade mechanism must be shifted towards the non-cooperative outcome.

The multiplier of the feasibility constraint (6.11) measures how difficult it is to move prices away from the non-cooperative outcome. Indeed everything happens as if private information on domestic preferences increases country E's bargaining power vis-à-vis country E^*.

Small cost uncertainty. Turning again to the case of a small uncertainty on cost parameters highlights more interpretation of our findings. To this end, first observe that when $\Delta\theta$ is small enough, the monotonicity condition $\frac{\partial \psi}{\partial \alpha}(\alpha, p) < 0$ is implied by a standard assumption in the screening literature that we now state more formally:[33]

Assumption 4 *Monotonicity of the hazard rate:*

$$\frac{d}{d\alpha}\left(\frac{G(\alpha)-1}{g(\alpha)}\right) \geq 0 \quad \forall \alpha \in [0,1].$$

We then get:

Proposition Bis 4 *Up to terms of second-order magnitude in $\Delta\theta$, the optimal second-best price profile admits the following Taylor expansion:*

$$p^{sb}(\alpha) = p_a + \frac{k}{2(1+\rho)}(1 - \tilde{\alpha}(\alpha))\Delta\theta \tag{6.14}$$

where

$$\tilde{\alpha}(\alpha) = \alpha - \frac{\mu}{1+\mu} \frac{2\rho}{1+\rho} \frac{1-G(\alpha)}{g(\alpha)}.$$

[33] See Bagnoli and Bergstrom (2005) and Laffont and Martimort (2002, Chapter 3).

Everything happens as if the second-best price was indeed the same as in the free-trade solution provided that the political preference parameter α was replaced by a *virtual preference parameter* $\tilde{\alpha}(\alpha)$ which is lower. The intuition for this result is straightforward. Indeed, when negotiating a trade agreement, country E tends to exacerbate the political weight of high-cost importers. The extent by which it does so is captured by the difference between $\tilde{\alpha}(\alpha)$ and α. ■

7. CONCLUSION

To be written

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APPENDIX: PROOFS

Proof of Lemma 1: An incentive compatible allocation is thus a pair $(\pi(\theta, r), y(\theta))$ that satisfies the incentive constraints. (3.1) for an low-cost firm and for a high-cost one

$$\pi(\bar{\theta}, r) - \pi(\underline{\theta}, r) \geq -\Delta\theta C(y(\underline{\theta})). \tag{A1}$$

Consider now a monotonic allocation such that (3.2) holds and (3.1) is binding. Then, condition (A1) holds since:

$$\pi(\bar{\theta}, r) - \pi(\underline{\theta}, r) = -\Delta\theta C(y(\bar{\theta})) \geq -\Delta\theta C(y(\underline{\theta})).$$

Q.E.D.

Proof of Proposition 1: The incentive constraint (3.1) is necessarily binding at the optimum of $(\mathcal{P})$ when $\alpha < 1$. The intuition is straightforward. When the decision-maker in country E attributes a low weight to low-cost firms in his objective function, he has an incentive to give relatively bigger subsidies to high-cost ones. Benefiting from those large subsidies makes it valuable for low-cost firms to mimic high-cost ones. That (3.1) is binding leads us to rewrite the maximization problem only in terms of supply curves as:

$$(\mathcal{P}): \quad \max_{y(\cdot)} \mathcal{U}(D(p)) - pD(p) + E_\theta(ry(\theta) - \tilde{\theta}(\alpha,\theta)C(y(\theta))) + R(p_w, p).$$

Pointwise optimization immediately leads to (3.4). Condition (3.2) is satisfied and Lemma 1 allows us to check that the omitted constraint (A1) holds.

Q.E.D.

PROOF OF PROPOSITION 2: *Autarky prices.* Observe that

$$D(p_a(\alpha)) = E_\theta(y(\tilde{\theta}(\alpha,\theta), p_a(\alpha))) < E_\theta(y(\theta, p_a(\alpha)))$$

implies $p_a(\alpha) > p_a$.

Small cost uncertainty. First, observe that when $\Delta\theta$ is small enough, both $p_w^{nc}(\alpha)-p_a$, $p_a(\alpha)-p_a$ and $t^{nc}(\alpha)$ are also small enough. A first-order Taylor expansion in $\Delta\theta$ then gives us:

$$Y(\alpha, p_a(\alpha)) = S\left(\frac{p_a}{\theta^*}\right) + \frac{1}{\theta^*}S'\left(\frac{p_a}{\theta^*}\right)(p_a(\alpha) - p_a) - \frac{k}{\theta^*}S'\left(\frac{p_a}{\theta^*}\right)(1-\alpha)\Delta\theta.$$

Another first-order Taylor expansion yields:

$$D(p_a(\alpha)) = D(p_a) + D'(p_a)(p_a(\alpha) - p_a).$$

Inserting those Taylor expansions into the market equilibrium condition yields:

$$\left(\frac{1}{\theta^*}S'\left(\frac{p_a}{\theta^*}\right) - D'(p_a)\right)(p_a(\alpha) - p_a) = \frac{k}{\theta^*}S'\left(\frac{p_a}{\theta^*}\right)(1-\alpha)\Delta\theta.$$

Simplifying yields (4.1).

Q.E.D.

PROOF OF PROPOSITION 3: Consider the problem of a planner with objective:

$$\mathcal{U}(D) - E_\theta(z(\theta)) + \alpha\nu\pi(\underline{\theta}) + (1-\alpha\nu)\pi(\bar{\theta})$$

where $z(\theta)$ is some transfer (measured in units of good 1) from consumers to the firms producing good 2, $\pi(\theta)$ the firm's payoff in state θ and D the total consumption of good 2. Actually, the firm's payoff in state θ writes as:

$$\pi(\theta) = z(\theta) - \theta C(y(\theta)).$$

Replacing transfers by their values in terms of firms' payoff, the planner's objective function can be written as:

$$\text{(A2)} \qquad \mathcal{U}(D) - E_\theta(\theta C(y(\theta))) - \nu(1-\alpha)(\pi(\underline{\theta}) - \pi(\bar{\theta})).$$

The feasibility condition is:

$$\text{(A3)} \qquad D = E_\theta(y(\theta)).$$

Again, a (direct) mechanism is a pair $\{z(\hat{\theta}), y(\hat{\theta})\}_{\hat{\theta}\in\Theta}$ (note that it is no longer contingent on the domestic price:. Incentive compatibility now implies that the following condition holds

$$\pi(\theta) = \max_{\hat{\theta}\in\Theta} z(\hat{\theta}) - \theta C(y(\hat{\theta})).$$

Of course, Lemma 1 still applies for those allocations and (3.1) is binding when optimizing the objective in (A2) subject to the feasibility condition (A3) and the incentive constraint (3.1).

We can thus rewrite the optimization problem in a more compact form as:

$$y^p(\alpha,\theta) = \arg\max_{y(\cdot)} \mathcal{U}(E_\theta(y(\theta)) - E_\theta(\tilde{\theta}(\alpha,\theta)C(y(\theta))).$$

Denoting by $p_a(\alpha)$ the marginal utility for good 2 at the optimum, the optimality condition in state θ can be written as:

$$\mathcal{U}'(E_\theta(y^p(\alpha,\theta))) = p_a(\alpha) = \tilde{\theta}(\alpha,\theta)C'(y^p(\alpha,\theta))$$

which indeed defines supply (and demand through the feasibility condition (A3)) at the market allocation under autarky, i.e., $y^p(\alpha,\theta) \equiv y(\tilde{\theta}(\alpha,\theta), p_a(\alpha))$ for all θ. *Q.E.D.*

PROOF OF PROPOSITION 4: It follows immediately from the fact that

$$Y(\alpha,p) = E_\theta(y(\tilde{\theta}(\alpha,\theta),p) < E_\theta(y(\theta,p) = Y^*(p) \quad \forall p.$$

Q.E.D.

PROOF OF PROPOSITION 6 : Using (5.1) and (5.2), we rewrite domestic welfare in E as:

$$\mathcal{W}(\alpha,p) \equiv \mathcal{U}(D(p)) - pD(p) + E_\theta(P_w(\alpha,p)y(\tilde{\theta}(\alpha,\theta),P_w(\alpha,p)) - \tilde{\theta}(\alpha,\theta)C(y(\tilde{\theta}(\alpha,\theta),P_w(\alpha,p)))$$
$$+(p - P_w(\alpha,p))D(p).$$

Differentiating this expression with respect to p yields

$$\frac{\partial \mathcal{W}}{\partial p}(\alpha,p) = (p - P_w(\alpha,p))D'(p) + (Y(\alpha,P_w(\alpha,p)) - D(p))\frac{\partial P_w}{\partial p}(\alpha,p).$$

Observe also that:

$$\text{(A4)} \qquad \frac{\frac{\partial \mathcal{W}}{\partial p}(\alpha,p)}{D'(p)} = p - \varphi(\alpha,p).$$

For further reference observe that Assumption 1 also implies (6.3).

From Assumption 1, the right-hand side above is increasing in p which shows that $\mathcal{W}(\alpha,p)$ is quasi-concave.

Differentiating then (5.1) with respect to p yields:

$$\text{(A5)} \qquad \frac{\partial P_w}{\partial p}(\alpha,p) = -\frac{Y^{*\prime}(p) - D'(p)}{Y_p(\alpha,P_w(\alpha,p)) - D'(P_w(\alpha,p)))} < 0.$$

In the free market equilibrium, $p = p_w(\alpha) = P_w(\alpha,p_w(\alpha))$ as defined by

$$\text{(A6)} \qquad D(p_w(\alpha)) - Y(\alpha,P_w(\alpha,p^{as}(\alpha)) = Y^*(p_w(\alpha)) - D(p_w(\alpha)).$$

Observe that $Y(\alpha,P_w(\alpha,p_w(\alpha)) < Y^*(p_w(\alpha))$ implies

$$\text{(A7)} \qquad D(p_w(\alpha)) - Y^*(p_w(\alpha)) > 0$$

and thus

$$p_w(\alpha) < p_a(\alpha).$$

Inserting the condition $P_w(\alpha, p_w(\alpha)) = p_w(\alpha)$ into (A5) also implies

$$\text{(A8)} \qquad \frac{\partial P_w}{\partial p}(\alpha, p_w(\alpha)) = -\frac{{Y^*}'(p_w(\alpha)) - D'(p_w(\alpha))}{Y_p(\alpha, p_w(\alpha)) - D'(p_w(\alpha))}.$$

We use this property below when doing Taylor expansions in the neighborhood of $\Delta\theta = 0$.

Positive tariff. Solving $\frac{\partial \mathcal{W}_0}{\partial t}(\alpha, p^{nc}(\alpha)) = 0$ immediately yields (5.6) and (5.7). It follows immediately that: $p^{nc}(\alpha) > p_w(\alpha) > p_w^{nc}(\alpha)$.

Monotonicity. Differentiating (5.6) with respect to α yields:

$$\dot{p}^{nc}(\alpha) = \frac{\frac{\partial \varphi}{\partial \alpha}(\alpha, p^{nc}(\alpha))}{1 - \frac{\partial \varphi}{\partial p}(\alpha, p^{nc}(\alpha))} < 0$$

where the last inequality follows from Assumption 1.

Q.E.D.

Proof of Proposition Bis 2 : *Small cost uncertainty.* First, observe that when $\Delta\theta$ is small enough, both $P_w(\alpha, p) - p_a$ and $p - p_a$ are also small enough. First-order Taylor expansions in $\Delta\theta$ then give us:

$$\text{(A9)} \qquad Y(\alpha, P_w(\alpha, p)) = S\left(\frac{p_a}{\theta^*}\right) + \frac{1}{\theta^*} S'\left(\frac{p_a}{\theta^*}\right)(P_w(\alpha, p) - p_a) - \frac{k}{\theta^*} S'\left(\frac{p_a}{\theta^*}\right)(1-\alpha)\Delta\theta,$$

$$\text{(A10)} \qquad D(P_w(\alpha, p)) = D(p_a) + D'(p_a)(P_w(\alpha, p) - p_a),$$

$$\text{(A11)} \qquad Y^*(p) = S\left(\frac{p_a}{\theta^*}\right) + \frac{1}{\theta^*} S'\left(\frac{p_a}{\theta^*}\right)(p - p_a),$$

$$\text{(A12)} \qquad D(p) = D(p_a) + D'(p_a)(p - p_a).$$

Inserting those expressions into (5.1), we obtain:

$$\text{(A13)} \qquad P_w(\alpha, p) = -p + 2p_a + \frac{k}{1+\rho}(1-\alpha)\Delta\theta.$$

It follows that:

$$\text{(A14)} \qquad \frac{\partial P_w}{\partial \alpha}(\alpha, p) = -\frac{k}{1+\rho}\Delta\theta \text{ and } \frac{\partial P_w}{\partial p}(\alpha, p) = -1.$$

Using the definition of $\varphi(\cdot)$, (A9), (A12) and (A14), we then get the following Taylor approximation:

$$\text{(A15)} \qquad \varphi(\alpha, p) = p_a + \left(\frac{1}{\rho} - 1\right)(p - p_a) + \frac{2k}{1+\rho}(1-\alpha)\Delta\theta.$$

Observe that Assumption 1 implies then Assumption 2.

Inserting (A15) into (5.6) and simplifying yields (5.9): Using then (A13) and $p_w^{nc}(\alpha) = P_w(\alpha, p^{nc}(\alpha))$ gives us (5.10). From this, we finally obtain $t^{nc}(\alpha) = p^{nc}(\alpha) - p_w^{nc}(\alpha)$ as in (5.8). *Q.E.D.*

Proof of Lemma 2: Differentiating (A4) with respect to p implies the single-crossing property (6.3) where the strict inequality follows from Assumption 1.

Define now $f(T,p,\alpha) = \mathcal{W}(\alpha,p) + T$. Observe that f is differentiable and absolutely continuous in α for any (T,p,α). Moreover, $|f_\alpha(T,p,\alpha)| = |\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha,p)|$ is bounded by some bounded integrable function when p is itself bounded. From Theorem 2 and Corollary 1 in Milgrom and Segal (2002), it follows immediately that $\mathcal{V}(\alpha)$ is absolutely continuous and thus almost everywhere differentiable with (6.4) holding.

Incentive compatibility implies for any pair $(\alpha,\hat{\alpha})$:

$$\mathcal{W}(\alpha,p(\alpha)) + T(\alpha) \geq \mathcal{W}(\alpha,p(\hat{\alpha})) + T(\hat{\alpha}).$$

Reversing the role of α and $\hat{\alpha}$ and summing both sides of the inequalities so obtained, using (6.3), and simplifying yields immediately $p(\alpha) \leq p(\hat{\alpha})$ for $\alpha \geq \hat{\alpha}$. $p(\cdot)$ is non-increasing and thus a.e. differentiable.

Using the fact that $\mathcal{V}(\cdot)$ is absolutely continuous and satisfies everywhere (6.4), and the fact that $\frac{\partial^2 \mathcal{W}}{\partial \alpha \partial p}(\alpha,p) < 0$, it is routine to check that incentive compatibility immediately follows when $p(\cdot)$ is non-increasing.

Q.E.D.

Proof of Proposition 7: *Necessity.* Denote by $\mathcal{V}_w(\alpha)$ (resp. $\mathcal{V}^*_w(\alpha)$) the payoff profile for country E (resp. E^*) when the price schedule is the free-trade price $p_w(\alpha)$. These profiles are defined as:

$$\mathcal{V}_w(\alpha) = \mathcal{V}^{nc}(0) + \int_0^\alpha \frac{\partial \mathcal{W}}{\partial \alpha}(x,p_w(x))dx$$

and

$$\text{(A16)} \quad \mathcal{V}^*_w(\alpha) = \mathcal{W}_w(\alpha,p_w(\alpha)) - \mathcal{V}_w(\alpha).$$

From (6.5), we deduce that the participation constraint (6.6) necessarily holds for that profile:

$$\mathcal{V}_w(\alpha) \geq \mathcal{V}^{nc}(\alpha) \quad \forall \alpha.$$

Integrating by parts, we also obtain:

$$\text{(A17)} \quad \int_0^1 \mathcal{V}_w(\alpha)dG(\alpha) = \mathcal{V}^{nc}(0) + \int_0^1 (1-G(\alpha))\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha,p_w(\alpha))d\alpha$$

while

$$\text{(A18)} \quad \int_0^1 \mathcal{V}^{nc}(\alpha)dG(\alpha) = \mathcal{V}^{nc}(0) + \int_0^1 (1-G(\alpha))\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha,p^{nc}(\alpha))d\alpha.$$

We may rewrite the left-hand sides above to obtain:

$$\text{(A19)} \quad \int_0^1 (\mathcal{W}_w(\alpha,p_w(\alpha)) - \mathcal{V}^*_w(\alpha))dG(\alpha) = \mathcal{V}^{nc}(0) + \int_0^1 (1-G(\alpha))\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha,p_w(\alpha))d\alpha$$

and

$$\text{(A20)} \quad \int_0^1 (\mathcal{W}_w(\alpha,p^{nc}(\alpha)) - \mathcal{V}^{*nc}(\alpha))dG(\alpha) = \mathcal{V}^{nc}(0) + \int_0^1 (1-G(\alpha))\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha,p^{nc}(\alpha))d\alpha.$$

Substracting (A20) from (A19) finally gives us:

$$\int_0^1 (\mathcal{W}_w(\alpha, p_w(\alpha)) - \mathcal{W}_w(\alpha, p^{nc}(\alpha)) = \int_0^1 \mathcal{V}_w^*(\alpha)dG(\alpha) - \int_0^1 \mathcal{V}^{*nc}(\alpha)dG(\alpha)$$

$$+ \int_0^1 (1 - G(\alpha)) \left(\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p_w(\alpha)) - \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha)) \right) d\alpha.$$

Taking into account (6.8) yields the efficiency condition (6.10).

Sufficiency. Suppose now that (6.10) holds. Consider the "pay-the externality" mechanism of the form $(T(\hat{\alpha}), p_w(\hat{\alpha}))_{\hat{\alpha}\in[0,1]}$ where the payment $T_w(\hat{\alpha})$ is defined as

$$T_w(\hat{\alpha}) = \mathcal{W}^*(p_w(\hat{\alpha})) - \mathcal{V}^{*nc} \quad \forall \hat{\alpha}$$

with

$$\mathcal{V}^{*nc} = \int_0^1 \mathcal{V}^{*nc}(\alpha))dG(\alpha).$$

With such scheme, country E ends up choosing "truthfully" the (interim-efficient) free-trade price since indeed:

$$\alpha = \arg\max_{\hat{\alpha}} \mathcal{W}_w(\alpha, p_w(\hat{\alpha})) - \mathcal{V}^{*nc}.$$

By construction, country E^* accepts this agreement since it gets a fixed payoff $\mathcal{V}^{*nc}$ whatever E's announcement.

Finally, country E joins the agreement for any realization of the parameter α when:

$$\text{(A21)} \quad \mathcal{W}_w(\alpha, p_w(\alpha)) - \mathcal{V}^{*nc} \geq \mathcal{W}(\alpha, p^{nc}(\alpha)) \quad \forall \alpha.$$

Denote $\Delta\mathcal{V}(\alpha) = \mathcal{W}_w(\alpha, p_w(\alpha)) - \mathcal{W}(\alpha, p^{nc}(\alpha))$. Using the Envelope Theorem yields the following expression of the derivative of this function:

$$\text{(A22)} \quad \dot{\overline{\Delta\mathcal{V}}}(\alpha) = \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p_w(\alpha)) - \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha)) \geq 0$$

where the last inequality follows from (6.3) and $p_w(\alpha) \leq p^{nc}(\alpha)$ for all α. Finally, the participation constraint (A21) holds everywhere when it holds at $\alpha = 0$. This gives us the condition:

$$\text{(A23)} \quad \Delta\mathcal{V}(0) \geq \mathcal{V}^{*nc}.$$

Integrating by parts, we get:

$$\text{(A24)} \quad \int_0^1 \Delta\mathcal{V}(\alpha)dG(\alpha) = \Delta\mathcal{V}(0) - \int_0^1 (1 - G(\alpha)) \left(\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p_w(\alpha)) - \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha)) \right) d\alpha.$$

Rearranging terms, (A24) amounts to (6.10).

Q.E.D.

Proof of Proposition Bis 3: Since $p_w(\alpha)$ maximizes $\mathcal{W}_w(\alpha, p)$, the left-hand side of (6.10) can thus be approximated with the following second-order Taylor approximation in $\Delta\theta$:

$$-\frac{1}{2}\int_0^1 \frac{\partial^2 \mathcal{W}_w}{\partial p^2}(\alpha, p_a)(p_w(\alpha) - p^{nc}(\alpha))^2 dG(\alpha) \tag{A25}$$

Taking Taylor expansions for (5.3) yields also:

$$\frac{\partial^2 \mathcal{W}_w}{\partial p^2}(\alpha, p_a) = 2(D'(p_a) - Y^{*'}(p_a)) = 2D'(p_a)\frac{1+\rho}{\rho}.$$

The left-hand side of (A25) then becomes:

$$-D'(p_a)\frac{(2\rho+1)^2 k^2 \Delta\theta^2}{4(2\rho-1)^2(1+\rho)\rho}\int_0^1 (1-\alpha)^2 dG(\alpha) \tag{A26}$$

From (A4), we have also:

$$\frac{\partial^2 \mathcal{W}_w}{\partial \alpha \partial p}(\alpha, p_a) = -\frac{\partial \varphi}{\partial \alpha}(\alpha, p_a)D'(p_a).$$

Using (A15), we finally obtain another Taylor expansion:

$$\frac{\partial^2 \mathcal{W}_w}{\partial \alpha \partial p}(\alpha, p_a) = 2D'(p_a)\frac{k\Delta\theta}{1+\rho}.$$

Inserting this result into the right-hand side of (6.10), we obtain:

$$-D'(p_a)\frac{(2\rho+1)k^2\Delta\theta^2}{(2\rho-1)(1+\rho)^2}\int_0^1 (1-\alpha)(1-G(\alpha))d\alpha.$$

Finally, the efficiency condition (6.10) becomes:

$$\frac{(1+\rho)(2\rho+1)}{4\rho(2\rho-1)} \geq \frac{\int_0^1 (1-\alpha)(1-G(\alpha))d\alpha}{\int_0^1 (1-\alpha)^2 dG(\alpha)}.$$

The left-hand side is a monotonically decreasing function of ρ from $+\infty$ to $\frac{1}{4}$ on the interval $\rho > \frac{1}{2}$. There is a unique solution ρ^* to

$$\frac{(1+\rho^*)(2\rho^*+1)}{4\rho^*(2\rho^*-1)} = \frac{\int_0^1 (1-\alpha)(1-G(\alpha))d\alpha}{\int_0^1 (1-\alpha)^2 dG(\alpha)}. \tag{A27}$$

An integration by parts then yields:

$$\int_0^1 (1-\alpha)(1-G(\alpha))d\alpha = \frac{1}{2}\int_0^1 (1-\alpha)^2 dG(\alpha) + \frac{1}{2}.$$

Hence, we get:

$$\frac{\int_0^1 (1-\alpha)(1-G(\alpha))d\alpha}{\int_0^1 (1-\alpha)^2 dG(\alpha)} \geq \frac{1}{2}.$$

This implies that there exists a unique $\rho^* > \frac{1}{2}$ such that (A27) holds. Efficiency is possible for $\rho \leq \rho^*$ only. *Q.E.D.*

PROOF OF LEMMA 3: *Necessity.* We first consider a relaxed optimization problem where (6.6) is replaced by:

$$\mathcal{V}(\alpha) \geq \mathcal{V}^{nc}(0). \tag{A28}$$

Together with (6.4) and the fact that $\mathcal{V}(\alpha)$ is increasing in α, we deduce that (A28) is harder to satisfy at $\alpha = 0$.

When $p(\alpha) \leq p^{nc}(\alpha)$ for all α, (6.3) then implies that:

$$\mathcal{V}(\alpha) = \mathcal{V}(0) + \int_0^{\alpha} \frac{\partial \mathcal{W}}{\partial \alpha}(x, p(x))dx \geq \mathcal{V}^{nc}(0) + \int_0^{\alpha} \frac{\partial \mathcal{W}}{\partial \alpha}(x, p^{nc}(x))dx = \mathcal{V}^{nc}(\alpha).$$

Hence, (6.6) holds everywhere when it holds at $\alpha = 0$. Integrating by parts, we also obtain:

$$\int_0^1 \mathcal{V}(\alpha)dG(\alpha) = \mathcal{V}(0)+\int_0^1 (1-G(\alpha))\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p(\alpha))d\alpha \geq \mathcal{V}^{nc}(0)+\int_0^1 (1-G(\alpha))\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p(\alpha))d\alpha.$$

Using (A16), we get:

$$\int_0^1 (\mathcal{W}_w(\alpha, p_w(\alpha)) - \mathcal{V}_w^*(\alpha))dG(\alpha) \geq \mathcal{V}^{nc}(0) + \int_0^1 (1 - G(\alpha))\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p(\alpha))d\alpha. \tag{A29}$$

Substracting (A18) from (A29) finally gives us:

$$\int_0^1 (\mathcal{W}_w(\alpha, p(\alpha)) - \mathcal{W}_w(\alpha, p^{nc}(\alpha)) \geq \int_0^1 \mathcal{V}^*(\alpha))dG(\alpha) - \int_0^1 \mathcal{V}^{*nc}(\alpha))dG(\alpha)$$

$$+ \int_0^1 (1 - G(\alpha)) \left(\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p_w(\alpha)) - \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha)) \right) d\alpha.$$

Taking into account (6.8) yields the feasibility condition (6.11).

Sufficiency. Suppose that (6.11) holds, we need to recover a contribution schedule $\{T(\hat{\alpha})\}_{\hat{\alpha}\in[0,1]}$ such that the mechanism $\{T(\hat{\alpha}), p(\hat{\alpha})\}_{\hat{\alpha}\in[0,1]}$ is both incentive compatible and satisfy the participation constraints (6.6) and (6.8). Define country E's utility profile as:

$$\mathcal{V}(\alpha) = \mathcal{V}^{nc}(0) + \int_0^{\alpha} \frac{\partial \mathcal{W}}{\partial \alpha}(x, p(x))dx$$

When $p(\alpha) \leq p^{nc}(\alpha)$ for all α, (6.3) implies:

$$\mathcal{V}(\alpha) \geq \mathcal{V}^{nc}(0) + \int_0^{\alpha} \frac{\partial \mathcal{W}}{\partial \alpha}(x, p^{nc}(x))dx = \mathcal{V}^{nc}(\alpha)$$

as requested by (6.6) .

Consider now the following contribution schedule:

$$T(\hat{\alpha}) = \mathcal{V}^{nc}(0) + \int_0^{\hat{\alpha}} \frac{\partial \mathcal{W}}{\partial \alpha}(x, p(x))dx - \mathcal{W}(\hat{\alpha}, p(\hat{\alpha})) \quad \forall \hat{\alpha} \in [0, 1]$$

With such scheme, country E ends up choosing "truthfully" the price $p(\alpha)$. Indeed $\mathcal{W}(\alpha, p(\hat{\alpha}))+ T(\hat{\alpha})$ is quasi-concave in $\hat{\alpha}$ when (6.3) holds and $p(\alpha)$ is non-increasing. A first-order condition for optimality then reveals that:

$$\alpha = \arg\max_{\hat{\alpha}} \mathcal{W}(\alpha, p(\hat{\alpha})) + T(\hat{\alpha}).$$

By construction, country E^* accepts this agreement when (6.8) holds. Observe that

$$\int_0^1 \left(\mathcal{W}^*(p(\alpha)) - T(\alpha)\right) dG(\alpha) = \int_0^1 \left(\mathcal{W}_w(\alpha, p(\alpha)) - \mathcal{V}(\alpha)\right) dG(\alpha).$$

$$\int_0^1 \mathcal{W}_w(\alpha, p(\alpha))dG(\alpha) - \int_0^1 \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p(\alpha))(1 - G(\alpha))d\alpha - \mathcal{V}^{nc}(0).$$

When (6.11) holds, we have:

$$\int_0^1 \mathcal{W}_w(\alpha, p(\alpha))dG(\alpha) - \int_0^1 \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha))(1 - G(\alpha))d\alpha - \mathcal{V}^{nc}(0)$$

$$\geq \int_0^1 \mathcal{W}_w(\alpha, p^{nc}(\alpha))dG(\alpha) - \int_0^1 \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha))(1 - G(\alpha))d\alpha - \mathcal{V}^{nc}(0)$$

$$\int_0^1 \left(\mathcal{W}^*(p^{nc}(\alpha)) + \mathcal{W}(\alpha, p^{nc}(\alpha))\right) dG(\alpha) - \int_0^1 \frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p^{nc}(\alpha))(1-G(\alpha))d\alpha - \mathcal{V}^{nc}(0) = \int_0^1 \mathcal{V}^{*nc}(\alpha)dG(\alpha)$$

where the last equality is obtained after integrating by parts. Putting everything together then yields

$$\int_0^1 \left(\mathcal{W}^*(p(\alpha)) - T(\alpha)\right) dG(\alpha) \geq \int_0^1 \mathcal{V}^{*nc}(\alpha)dG(\alpha)$$

as requested. *Q.E.D.*

PROOF OF PROPOSITION 8: *Second-best price schedule.* Denoting by $\mu \geq 0$ the multiplier of (6.11), we define the Lagrangean for problem $(\mathcal{T})$ as:

$$\mathcal{L}(\alpha, p, \mu) = (1 + \mu)g(\alpha)\mathcal{W}_w(\alpha, p) - \mu(1 - G(\alpha))\frac{\partial \mathcal{W}}{\partial \alpha}(\alpha, p).$$

Differentiating with respect to p yields:

$$\frac{\partial \mathcal{L}}{\partial p}(\alpha, p, \mu) = (1 + \mu)(p - P_w(\alpha, p))(D'(p) - Y^{*'}(p))g(\alpha) + \mu(1 - G(\alpha))D'(p)\frac{\partial \varphi}{\partial \alpha}(\alpha, p)$$

or

$$\frac{\frac{\partial \mathcal{L}}{\partial p}(\alpha, p, \mu)}{(1 + \mu)g(\alpha)D'(p) - Y^{*'}(p)} = p - \frac{1}{1 + \mu}P_w(\alpha, p) - \frac{\mu}{1 + \mu}\psi(\alpha, p).$$

From Assumptions 1 and 3, we deduce that the right-hand side above is increasing in p and thus $\mathcal{L}(\alpha, p, \mu)$ is quasi-concave in p. The first-order condition for optimality can then be written as (6.12).

Monotonicity. Differentiating (6.12) with respect to α yields:

$$\dot{p}^{sb}(\alpha) = \frac{\frac{1}{1+\mu}\frac{\partial P_w}{\partial \alpha}(\alpha, p^{sb}(\alpha)) + \frac{\mu}{1+\mu}\frac{\partial \psi}{\partial \alpha}(\alpha, p^{nc}(\alpha))}{1 - \frac{1}{1+\mu}\frac{\partial P_w}{\partial p}(\alpha, p^{sb}(\alpha)) - \frac{\mu}{1+\mu}\frac{\partial \varphi}{\partial p}(\alpha, p^{sb}(\alpha))} < 0$$

where the last inequality follows from Assumptions 1 and 3.

Comparative statics. The fact that $\frac{\partial \varphi}{\partial \alpha}(\alpha, p) < 0$ implies:

$$p^{sb}(\alpha) = \frac{1}{1 + \mu}P_w(\alpha, p^{sb}(\alpha)) + \frac{\mu}{1 + \mu}\psi(\alpha, p^{sb}(\alpha)) \geq P_w(\alpha, p^{sb}(\alpha))$$

From there and the quasi-concavity of $\mathcal{W}_w(\alpha, p)$, it follows that:

$$p^{sb}(\alpha) \geq p_w(\alpha).$$

The last condition in Assumption 3 together with the fact that $P_w(\alpha, p^{sb}(\alpha)) \leq \varphi(\alpha, p^{sb}(\alpha))$ also implies:

$$p^{sb}(\alpha) = \frac{1}{1+\mu} P_w(\alpha, p^{sb}(\alpha)) + \frac{\mu}{1+\mu} \psi(\alpha, p^{sb}(\alpha)) \leq \varphi(\alpha, p^{sb}(\alpha)).$$

From there and the quasi-concavity of $\mathcal{W}(\alpha, p)$, it also follows that:

$$p^{sb}(\alpha) \leq p^{nc}(\alpha).$$

Q.E.D.

PROOF OF PROPOSITION BIS 4: Using (A13) and (A15) yields (6.14). *Q.E.D.*