Universität Bielefeld
Faculty of Business Administration and Economics
Working Papers in Economics and Management
No. 15-2013
July 2013

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Contingent Trade Policy and Economic Efficiency*

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July 2, 2013

Abstract

This paper develops an efficiency theory of contingent trade policies. We model the competition for a domestic market between one domestic and one foreign firm as a pricing game under incomplete information about production costs. The cost distributions are asymmetric because the foreign firm incurs a trade cost to serve the domestic market. We show that the foreign firm prices more aggressively to overcome its cost disadvantage. This creates the possibility of an inefficient allocation, justifying the use of contingent trade policy on efficiency grounds. Despite an environment of asymmetric information, contingent trade policy that seeks to maximize global welfare can be designed to avoid the potential inefficiency. National governments, on the other hand, make excessive use of contingent trade policy due to rent shifting motives. The expected inefficiency of national policy is larger (smaller) for low (high) trade costs compared to the laissez-faire case. In general, there is no clear ranking between the laissez-faire outcome and a contingent national trade policy.

Keywords: Contingent Trade Policy, Efficiency.
JEL Classifications: F12, F13.

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*Paper presented at several conferences and seminars. We thank Nic Schmitt, three anonymous referees, an editor and participants for helpful comments and suggestions.

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1 Introduction

Contingent protection occupies an interesting niche within the trade policy literature; if certain pre-specified criteria are met, as substantiated through a quasi-judicial process, then a country feels entitled to impose a trade barrier. Classifying policies from this procedural perspective implies that contingent protection covers a range of policies such as anti-dumping (AD), countervailing duties (CVD) and safeguards/escape clause actions. While the motivation and application of these policies varies, the pre-determined criteria for their use lends an air of legitimacy to their implementation.[1] However, regardless of the apparent legitimacy afforded by an inquisitional methodology, these policies tend to be criticized due to their excessive use which stems from the malleable nature of the criteria employed. In short, while there may exist some criteria which justify a policy intervention at a global level (i.e. some market failure), the inefficiencies from having policy implementation at a national level tends to offset any potential benefits.[2] However, it is not immediately obvious that tolerating a market failure is the better option. Hence the objective of this paper is to distinguish the circumstances under which policy action may potentially be effective from those when it will not.

To explore the issues associated with this question we construct a simple framework that includes the potential for market failure and therefore scope for a policy response. The setting we choose resembles a dumping style model. Our point of departure is to move the rationale for policy intervention away from the usual motivation of predation toward a broader and more relevant concept of allocative efficiency.[3] Therefore we focus on the question of who should be producing what and whether trade policy, in the form of duties, has a role to play in improving

[1]The original motivation for AD policy is based in the logic of predation, while CVD is motivated by "unfair" foreign policies. In contrast, the use of safeguards has been justified on the basis of maintaining sufficient flexibility to ensure the continued adherence to a trade agreement (see Bagwell and Staiger (1990)). Alternatively, contingent trade policy can be regarded as the remains of a gradual reduction of trade barriers; see Chisik (2003) for model of gradualism in free trade agreements.

[2]For instance AD duties are often seen as gratuitous in size — with duties of the order of 100% not unusual, see Bown (2007).

[3]Our focus on price discrimination is reminiscent of Brander and Krugman (1983). However, while dumping occurs in their framework, it is not the focus of their analysis. As discussed below, we adopt a market structure that emphasizes the resource allocation issues and provides a clear policy benchmark.

efficiency. If a policy-maker has complete information about the relevant costs, then determining the optimal allocation of resources is straightforward and the only real concern is one of policy failure. This is the element - policy failure - that the previous literature has focused on and sought to stress. If the policy-maker is incompletely informed about the cost structure, then both the mechanics of competition become more involved and the criteria for determining government intervention becomes less transparent. In this setting it is possible to have a market failure that cannot be adequately addressed by government intervention. It is this environment of asymmetric information in which we couch our analysis.[4]

More specifically, we develop a model of international competition where neither firm is reliably informed of the other's cost structure.[5] To sharpen the implications of competition, we assume that firms produce a homogeneous product and compete in prices; generating a winner-take-all scenario. Under complete information this set-up achieves allocative efficiency. Allocative efficiency is also achieved under the assumption of symmetry when firms are incompletely informed (that is, both firms are assumed to take cost draws from the same probability distribution).[6] The virtue of this set-up is that under either complete information or asymmetric information there is no market failure and therefore no need for government intervention. This provides us with a clear and unambiguous benchmark. However, as a model of international competition it is lacking a critical feature: transport costs. The introduction of transport costs implies that the firms are no longer symmetric. This small, but realistic change has potentially important implications for the allocation of resources: the higher cost firm can ultimately be the sole supplier in the market. This market failure has a clear source; since the foreign firm is at a disadvantage due to transport costs it prices more aggressively than the domestic firm. Consequently, when both firms have the same cost draws (inclusive of transport costs in case of the foreign firm), the foreign firm will quote a strictly lower price. This implies two things. First,

[4]A policy process distorted by political influence can also result in government failure. In this paper we abstract from this consideration and focus on the issue of whether or not a domestic government can intervene in an efficiency enhancing manner.

[5]For empirical evidence of firms operating in a stochastic environment, see Hillberry and McCalman (2011).

[6]See Spulber (1995).

in the neighborhood of these cost draws it is possible to identify outcomes where the higher cost foreign firm serves the domestic market; an inefficient allocation of resources. Moreover, this inefficiency can be very pronounced, representing up to 15% of ex ante surplus. Second, the foreign firm prices more aggressively abroad than in their local market, i.e. dumping occurs.[7]

Given such market failure, the question we address in this paper is whether the use of contingent trade policy can remedy the inefficiency and achieve an efficient allocation of resources.[8] One important obstacle the policymaker faces is that production costs are private information. Can a government infer which firm is the lower cost producer for any given set of cost draws from the firms' pricing behavior? And if the answer is positive, does the announcement of a framework for intervention still enable such an inference to be drawn?[9]

We consider this problem from two perspectives, starting with the case of a global institution seeking to maximize global welfare. We show that a global planner who announces a policy of contingent intervention will indeed be able to infer the costs from the optimal pricing functions in this new environment. In fact, the optimal pricing functions are symmetric over the sub-region of common costs. So despite the difficulties associated with the cost draws being private information, a global planner can design a policy of contingent intervention that will result in a first best outcome. The second scenario is the case where it is up to national governments to implement contingent trade policy. This is an important case to consider since historically national government have designed and implemented the most frequently used contingent protection schemes (e.g. AD). Once again we show that even though the pricing game is altered by the potential for policy intervention, a national government can still infer the relevant costs to satisfy its policy

[7]Dumped imports are typically defined to be foreign products exported at prices below "fair value," that is, either below the prices of comparable products for sale in the domestic market of the exporting country or below costs of production.

[8]A number of other papers have considered an environment of asymmetric information: Miyagiwa and Ohno (2007), Matschke and Schottner (2008) and Kolev and Prusa (2002). However, these papers are concerned with the implications of AD policy on firm behavior (output, prices and profits) and do not investigate whether AD duties can achieve a first best outcome. Martin and Vergote (2008) consider the role of asymmetric information over government preferences in trade agreements and find retaliation is a necessary feature of any efficient equilibrium. They suggest that AD policy could be interpreted as one potential manifestation of retaliation.

[9]Even in a complete information setting, Staiger and Wolak (1992) and Anderson (1992) make the point that the mere existence of anti-dumping policy will alter firms behavior.

objective. National policymakers, however, do not have any incentive to implement the global first best outcome. Seeking to maximize national welfare, they exploit the rent shifting aspect of protection and make excessive use of contingent trade policies. The resulting equilibrium will thus again be inefficient from a global perspective, this time because of rent shifting.

The presence of two inefficiencies — one stemming from market failure, the other from a purely national objective — obviously raises the question which of them is quantitatively more important. Our analysis shows that the allocative inefficiency dominates at high trade costs. For lower trade costs, on the other hand, it is the inefficiency caused by rent shifting motivated policy that is larger. At high trade costs, it might be preferable to allow national governments to conduct contingent trade policy, while for low trade costs the laissez-faire regime welfare-dominates nationally conducted policy.

This paper is not the first paper on contingent trade policies, there is a large and extensive theoretical and empirical literature on anti-dumping, countervailing duties and safeguards/escape clauses (for an overview, see for example Chapter 7 in Feenstra (2004) and Blonigen and Prusa (2003)). We regard our paper as complementary to a newer literature whose objective is to explain the flexibility of trade agreements and the existence of contingent trade policies as a response to potential shocks.[10] Our paper characterizes the conditions under which contingent trade policies are feasible (that is, can be "successfully "implemented), and it offers a rationale for why countries may have this discretion rather than be bound by a fixed policy. While this is a similar emphasis to the flexibility literature, the innovation of our paper is that we allow for an interplay between the policy environment and the actions of firms — that is, we allow the announcement of the policy rule to change firm behavior. So rather than having a given degree of uncertainty and choosing the optimal design of the institution under various constraints (e.g. ability of adjudicators), we examine how the institutions themselves can either enhance or under-

[10] One strand of this literature considers contingent trade policies as an insurance against shocks which keeps the trade agreement viable, see for example Fischer and Prusa (2003). Other papers have even endogenized the scope of an agreement by explaining the contract incompleteness by costly contracting, see Horn and Staiger (2010), Maggi and Staiger (2008) and Maggi and Staiger (2009). For a model with costly state-verification, see Beshkar and Bond (2010).

mine their own effectiveness. One paper that uses a similar framework to ours is the important early contribution by McAfee and McMillan (1989) who analyze preferences for domestic firms in public procurement auctions. While similar in motivation, they consider unconditional policy, whereas the emphasis in this paper is on conditional policy.

Our type of conditionality of the intervention distinguishes our paper also from the strategic trade literature under asymmetric information. This literature starts from the assumption that the government knows less about market and/or cost conditions than firms do. For example, Creane and Miyagiwa (2008) discuss the conditions under which firms have an incentive to disclose information to their local government. Qui (1994) shows that a government prefers to employ a menu of policies which leads to revelation of private cost information when firms compete by quantities but a uniform policy if they compete by prices. Maggi (1999) demonstrates that allowing non-linear trade policy instruments when firms know more about market conditions actually can make the equilibrium more inefficient compared to the case of complete information. Similar to these papers, our model shares the feature that the government commits itself (successfully) to an intervention. In strategic trade policy models, however, the treatment of each firm depends only on what this firm has done, and not on what the other firm has done. In our model, the announcement of a policy framework not only alters the behavior of both firms, but also potentially alters the ability of the policy to be implemented; after all an intervention takes place only if the government concludes that the "wrong" firm has won the market.

Our paper draws on the methods in auction theory but also moves beyond it in an important way. While the laissez-faire case is strategically equivalent to an auction and can be solved in the usual manner by looking for an Bayesian Nash equilibrium, the case of policy intervention is more involved. In that case, we solve for a perfect Bayesian Nash equilibrium, since both firms and the regulator form mutual beliefs about their behavior, and more importantly, all act upon these beliefs, which must be confirmed in equilibrium. This analysis goes beyond the usual auction setup because actions are taken based on the outcome of the market game. We will show that a perfect Bayesian Nash equilibrium exists in which the regulator will learn the type of each firm and thus will be able to pursue the announced policy.

The remainder of the paper is organized as follows: In Section 2, we set up the model, solve for the price functions, and show that an allocative inefficiency can arise. Section 3 presents the analysis of a contingent trade policy that maximizes global welfare. In Section 4, we analyze the policy a national government seeking to maximize national welfare would enact, and compare it to the laissez-faire case. Section 5, finally, offers concluding remarks.

2 The model

We begin our analysis by considering a baseline setup without contingent trade policy. A key feature of the framework presented here, driven by informational asymmetries, will be the possibility of market failure (i.e. a misallocation of resources). Our setting features two firms — a domestic firm and a foreign firm — which both produce a homogeneous product for the domestic market. Consumers in this market have unit demands, a maximum willingness to pay of one, and without further loss of generality, we normalize the size of the domestic market to one. Firms compete against each other in prices; that is, consumers buy from firm i if $p_i < p_j$ (and randomize in case of equal prices). In choosing a model of price competition in homogeneous goods with inelastic demand, we squarely place the emphasis on the location of production as being the sole determinant of economic efficiency. Whereas our motivation for choosing this setup is analytical tractability, our choice also reflects key features of markets in which contingent protection is applied most frequently. In particular, these are markets characterized by a high elasticity of substitution, implying relatively homogeneous products. Comparing the value of the elasticity of substitution for products involved in anti-dumping cases to those that are not, we find that the former exhibit an elasticity of substitution that is on average 50% higher – consistent with our homogeneous products setting.[11]

[11]To arrive at this figure, we use Chad Bown's anti-dumping database (Bown (2007)) to identify the HS10 codes for anti-dumping cases initiated in the US. Since the Broda-Weinstein estimates (Broda and Weinstein (2006)) of the elasticity of substitution are also at the HS10 level, we can compare the mean elasticity of substitution across products involved in anti-dumping cases and those that aren't. There are approximately 800 HS10 codes that

Importantly, we assume that the firms' production costs, c_1 and c_2, are private information. That is, a firm knows its own cost but does not know the cost realization of its rival. As is standard in models such as ours, we assume that the beliefs of firm i about the production cost of its opponent, c_j, are described by a *cdf*, $F(c)$. That is, costs are drawn from the same distribution. Note that the asymmetry of information alone is not enough to generate a misallocation of resources. To obtain a potential market failure, we rely on adding the plausible feature that the foreign firm must pay a per unit trade cost of t (which is assumed to be common knowledge).

By adding the trade cost to the model, it now has a feature that potentially induces market failure. At the same time, adding this feature complicates the analysis since it is possible for the foreign firm to receive a cost draw that — once the transport cost is added — exceeds the domestic consumer's willingness to pay. In case of such a high cost, the foreign firm will clearly not be competitive in the domestic market, and leave the market to the domestic firm. To deal (or rather to avoid dealing) with this case, we add a pre-stage to our model where the foreign firm has to decide whether to enter the domestic market. If it decides to do so, it has to pay a market-entry cost of ϵ, which can be observed by the domestic firm. The investment required to enter the market can be relatively small, for example the search cost of finding a wholesaler and/or retailer. Importantly, the entry decision of the foreign firm signals a certain productivity range, which allows the domestic firm to update its beliefs about its opponent's productivity. If the foreign firm does not enter the market, the domestic firm is a monopolist and will set p_1 equal to one. In what follows, we shall focus on cases in which entry occurs.[12] Table 1 summarizes the sequence of decisions in our model, which can be solved backwards in the usual fashion.

In order to solve for the equilibrium, we start from the premise (to be verified later) that the optimal pricing functions $p_i(c_i)$ are monotone and strictly increasing in costs. This implies that there exist inverse pricing functions that are also monotone and strictly increasing in prices.

have been involved in US anti-dumping cases with a mean elasticity of substitution 18 for these products. This is 50% higher than the mean elasticity of substitution for products not involved in anti-dumping cases (mean elasticity is 12, in these 13,000 other products).

[12]The other case is trivial and not of particular interest. We should keep in mind, though, that our analysis is conditional on entry, and that a change in t also changes the probability of entry.

Table 1: Game structure

Stage 0: In case of a contingent trade policy, the regulating authority specifies its rule of intervention.
Stage I: Both the domestic and the foreign firm draw their marginal production costs from $[0, 1]$. Productions costs are private information.
Stage II: The foreign firm decides on entry which warrants a cost of size ϵ, $\epsilon \geq 0$, observable by the domestic firm.
Stage III: If the foreign firm has entered, both firms set their prices. If the foreign firm has not entered, the domestic firm sets its price.
Stage IV: In case of a contingent trade policy, the regulating authority observes prices and intervenes according to its rule.

We denote these inverse pricing functions by $\phi_i(p_i)$, i.e. price p_i is associated with a cost $c_i = \phi_i(p_i)$. These costs are drawn from a common distribution, characterized by the cumulative distribution function $F(c)$. The trade cost and the entry decision of the foreign firm imply that the (updated) beliefs over the other firm's cost will be asymmetric across firms. Let $F_1(c_1)$ denote the distribution of the cost of the domestic firm, which is identical to the underlying distribution $F(c)$. The distribution of the cost of the foreign firm, $F_2(c_2)$, on the other hand, is based on a Bayesian update from $F(c)$ in line with the observation that the foreign firm enters the market.

Consider now the firms' pricing decisions. Suppose the domestic firm sets a price of p_1, and the foreign firm employs the inverse pricing function $\phi_2(p_2)$. The probability that the domestic firm loses the market in the Bertrand pricing game is equal to $F_2(\phi_2(p_1))$, which captures the probability that the foreign firm has a cost below the threshold value that is implied by applying its inverse pricing function to the price p_1. In this case, the domestic firm's profit is zero as it is undercut by the foreign firm. The domestic firm wins only if $p_1 < p_2$, that is, its chances of winning are equal to $1 - F_2(\phi_2(p_1))$. A similar argument applies to the foreign firm. Hence we can write the expected profits of both firms as follows:

$$\pi_1(p_1; c_1) = (1 - F_2(\phi_2(p_1)))(p_1 - c_1), \tag{1}$$

$$\pi_2(p_2; c_2) = (1 - F_1(\phi_1(p_2)))(p_2 - c_2 - t), \tag{2}$$

where the first term in each expression on the RHS is the probability of winning the market, and the second factor is the profit margin. Note that the foreign firm has an extra cost of t to deduct from its margin.

Each firm chooses its price in order to maximize expected profit. The resulting first-order conditions for interior solutions are given by:

$$(1 - F_2(\phi_2(p_1))) - f_2(\phi_2(p_1))\phi_2'(p_1)(p_1 - c_1) = 0, \tag{3}$$

$$(1 - F_1(\phi_1(p_2))) - f_1(\phi_1(p_2))\phi_1'(p_2)(p_2 - c_2 - t) = 0, \tag{4}$$

where $f_i(c_i) = F_i'(c_i)$ denotes the density function corresponding to $F_i(c_i)$.

In order to make the model tractable, we make the following two assumptions:

ASSUMPTION 1. *Costs are distributed uniformly over the unit interval, i.e.* $F(c) = c$.

Assumption 1 will allow us to find closed form solutions for the optimal pricing functions. Furthermore, the update of beliefs is straightforward: Let γ denote the critical foreign type which is indifferent between entry and no entry into the domestic market. If the domestic firm believes that only the (productive) types will enter for which $c_2 \leq \gamma$, it follows that $F_2(c_2) = c_2/\gamma$. Since the most intense price competition will occur if the foreign can enter easily, we also assume the following:

ASSUMPTION 2. *The investment cost the foreign firm has to pay for entering the market is very small, i.e.* $\epsilon \simeq 0$.

Both assumptions enable us to determine the optimal pricing behavior for the laissez-faire case without policy intervention:

LEMMA 1. *Under Assumptions 1 and 2 and without policy intervention,* $F_2(c_2)$ *equals* $c_2/(1-t)$ *and firm 2 enters if* $c_2 \leq 1-t$*. Furthermore, in case of entry, the equilibrium pricing functions are given by:*

$$p_1(c_1) = 1 - \frac{\sqrt{1+(1-c_1)^2 K_1} - 1}{(1-c_1)K_1} \tag{5}$$

$$p_2(c_2) = 1 - \frac{\sqrt{1+(1-[c_2+t])^2 K_2} - 1}{(1-[c_2+t])K_2}, \tag{6}$$

where

$$K_1 = \frac{t(2-t)}{(1-t)^2} \geq 0 \text{ and } K_2 = -K_1 \leq 0.$$

Proof: See Appendix A.1.

Note that the solution includes the special case of symmetry when $t = 0$. In this case, both pricing functions simplify and take the form:

$$p_i(c_i) = \frac{1}{2} + \frac{c_i}{2}.$$

Returning to the case of a strictly positive trade cost, Figure 1 depicts an example of the pricing functions derived above (where we have chosen t to equal 0.2). Note that the pricing strategy of the foreign firm is depicted as a function of total cost, $c_2 + t$, and is represented by the lower of the two curves, the one that starts at $t = 0.2$. Now consider the following notion of aggressiveness: A firm's pricing strategy is more aggressive than that of its rival if it has the larger overall cost (which includes t for the foreign firm) when charging the same price. Comparing the two firms' strategies, there is a clear result:

LEMMA 2. *The foreign firm prices more aggressively than the domestic firm.*

Proof: See Appendix A.1.

The intuition for this result is that the foreign firm wants to make up for its inherent cost disadvantage (caused by the trade cost t) in order to increase its probability of winning. Given the

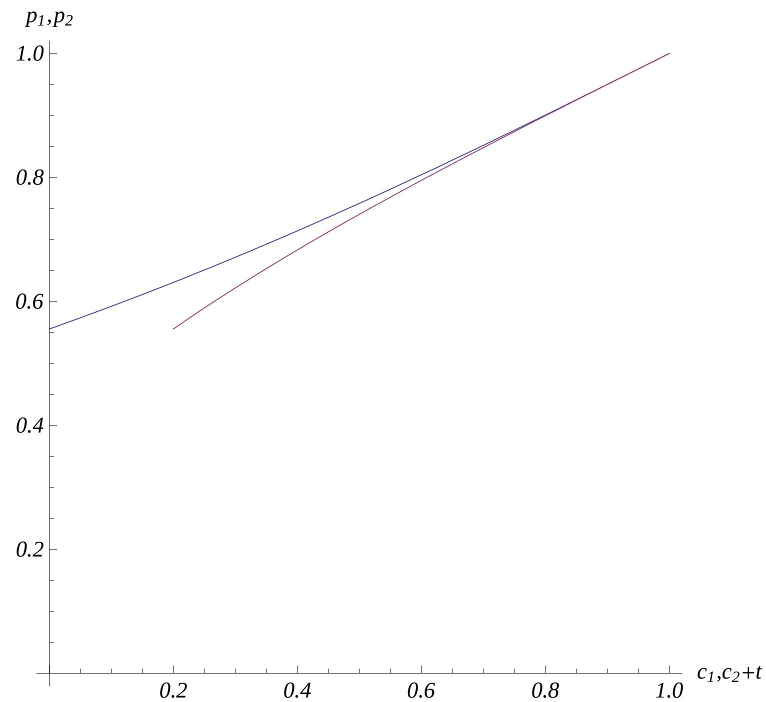

Figure 1: Equilibrium price functions for $t = 0.2$.

assumptions of unit demand and uniform cost distributions, which are made to obtain a tractable solution, a question naturally arises about the robustness of this result. Krishna (2002) relaxes the uniform distributional assumption and shows (Proposition 4.4, page 48) that the 'weak' bidder whose value distribution is stochastically dominated (reverse hazard rate dominance) by the distribution of the 'strong' bidder bids more aggressively. Appendix A.1 provides a proof along similar lines for our setup, where we additionally allow for elastic demand. That is, the result that the weaker firm prices more aggressively persists even if the uniform distributional assumption is relaxed and demand is price elastic.

One important consequence of the foreign firm's aggressive pricing behavior is the possibility that it offers the lower price even though it has the higher over-all cost. Hence this framework has the potential to generate an inefficient allocation of resources. Note that it is not always the case that the allocation is inefficient when the foreign firm offers the lower price. The inefficiency only arises when the foreign firm offers the lower price *and* has the higher cost. Formally, the outcome is inefficient whenever $p_2 < p_1$ and $c_2 + t > c_1$.

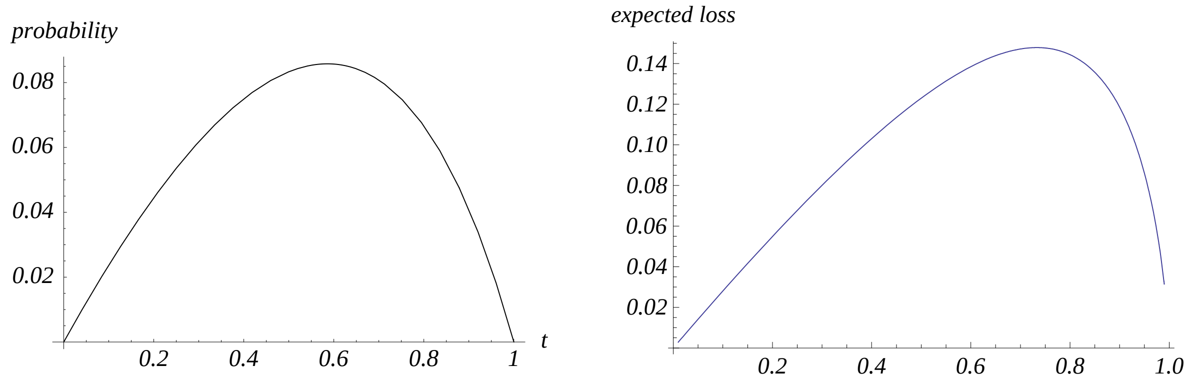

Figure 2: Probability and Conditional Expected Loss under Laissez-faire

While the model admits the possibility of an inefficient outcome it is natural to consider the likelihood of this result. Appendix A.1 shows that the probability of an inefficient trade is given by:

$$prob = \frac{1}{2} + \frac{1}{(2-t)(1-t)} - \frac{1}{1-t}. \tag{7}$$

Not surprisingly the likelihood of an inefficient outcome is a function of the size of the trade cost. To examine this relationship more closely, differentiate with respect to the trade cost:

$$\frac{\partial prob}{\partial t} = \frac{t^2 - 4t + 2}{2(t^2 - 4t + 4)} \tag{8}$$

This derivative is positive for low trade costs but becomes negative for higher t. The resulting non-monotonicity of the probability of inefficiency is displayed in Figure 2, which also shows the expected loss, conditional upon inefficient entry, which can rise up to a significant 15% of the ex ante surplus.

Note that this also has the interesting interpretation that the phenomena of inefficiency in our model is non-monotonic. That is, if trade costs are low, then a misallocation of resources is unlikely to occur because the inefficiency disappears as t goes to zero. Similarly, if trade costs are very high, then inefficiency is also unlikely to occur because the foreign firm is most likely not competitive. However, as trade costs start to fall, the likelihood of an inefficient outcome increases. Regardless of the source of the trade costs (i.e. transport costs or artificial trade barriers), the model poses a challenge for the policy maker: since the allocation of resources can be inefficient, is it possible to use government policy to improve on the market outcome? Since the market outcome is not always inefficient, the policy will necessarily be contingent.

An alternative and apparently simple solution to our problem seems to be that the regulator could give the two firms the chance to revise their prices. If firms had revealed their costs in a first round, second round Bertrand competition would lead to an efficient outcome. The problem is, however, that the two firms have no incentive to do so. If, for example, the two firms can freely revise their prices, their first-round price announcement would have no binding effect whatsoever, and would thus also not be able to signal costs. This is also true if firms can revise their announced prices only downwards as they do not lose anything by announcing a unity price in the first place. Unless their price announcements are a costly commitment, they cannot serve as signals. Matters get more complicated when the two firms compete repeatedly. Suppose that the two firms compete over two periods and that their first period price signals would indicate their costs, leading to Bertrand competition in the second period. If both firms had truthfully signalled their costs, one firm would win the market by marginally underbidding the other firm's cost. But then each firm has an incentive to appear stronger in the first period than it actually is, with the consequence that no separating equilibrium exists.[13] Thus, revision options or repetition does not solve the efficiency problem.

3 Globally Optimal Policy

Start by considering a globally efficient policy. Such a policy has the objective of avoiding the inefficiency and ensuring that the lower cost firm serves the market. The global planner, however, cannot directly observe the costs of the firms which are private information, she can only observe

[13] The non-existence of a separating equilibrium is due to the ratchet effect in sequential games of asymmetric information. For the seminal paper in the dynamic context of procurement contracts with adverse selection and moral hazard, see Laffont and Tirole (1988).

the prices that they charge.

A characteristic of the pricing functions that we derived in the previous section is that they are strictly monotone and therefore invertible. Consequently, a global planner can deduce from the announced prices what each firm's costs are, at least in a scenario without intervention. Clearly, allowing the government to intervene changes the nature of the interaction, and may lead to pricing functions that are no longer monotone. This section therefore has two goals: to determine how the equilibrium pricing functions are altered if the global planner announces the objective of allocating production to the lowest cost firm. And second, to check whether the new pricing functions are indeed monotone, so that the policy-maker can deduce the information that is required to implement the policy.

We start from the premise (to be verified later) that an equilibrium with strictly monotone pricing functions exists if the global planner announces her intention to intervene in order to allocate production to the lower cost firm. Note that the inefficiency in the (baseline) model always involved the foreign firm because the domestic firm never offered the lower price when it has the higher cost. This is not necessarily true anymore with policy intervention. Note further that we do not need monotonicity across the entire range. In particular, for $c_1 \in [0, t]$, a single domestic price is sufficient as the domestic firm has always lower cost in this range.

We now specify the candidate equilibrium in this setup. If one firm has the higher cost (inclusive of trade costs in case of the foreign firm) but the lower price, suppose that the policymaker can commit to intervene and allow the firm's competitor to serve the market at price

$$\tilde{p}_i = \alpha c_i + (1 - \alpha) p_i, \tag{9}$$

where $0 \leq \alpha \leq 1$. We choose this linear combination in order to allow for a wide range of possibilities: at one extreme, if α is chosen to be one, the government forces the firm that is awarded the market to sell at cost, while for $\alpha = 0$ the government allows the firm to charge its original higher bid price. Clearly, the choice of α will influence the respective pricing behavior. Eq. (9) is a shortcut for the negotiations between the government and the efficient firm that leads to agreement by which the government imposes the price. In our model, α determines the split of aggregate welfare gains between consumers and the efficient firm.

Operating in an environment where trade policy is made contingent on the ranking of both prices and costs complicates the form of the expected profit functions. Now, not only are profits a function of prices (as was the case in eqn (1)), but also of contingent policy. To derive the profit of each firm under this regime requires working through the implications of choosing a price, conditional on the firm's own costs, the belief on the other firms pricing function and also the potential for policy intervention.

Let us start from the fact that each firm knows its own cost c_i and treats the other firm's cost c_j as a random variable with cumulative distribution function F_j. In this case, there are two important reference points on the support of F_j. First, is the own cost c_i, as this is the threshold that prompts the global policymaker to act (i.e. if $c_i \leq c_j$ the policy maker will award the market to firm i if it does not have the lower price). Second, just as before, the cost that its own price implies on part of the other firm using the competitor's inverse bid function, i.e. $\phi_j(p_i)$, as this is the threshold for winning the market outright without intervention.

To be more precise, assume first that one firm, say the domestic firm, follows an aggressive pricing policy and sets a low price such that $\phi_2(p_1) + t < c_1$ (i.e. if the foreign firm were to set a price of p_1 it would be associated with a cost draw of $c_2 = \phi_2(p_1)$, which implies a total cost less than that of the domestic firm). In other words, if both firms charged the same price, it would turn out that the foreign firm has the lower overall cost, and this would prompt a policy intervention. Hence, in the case of an aggressive pricing strategy, the domestic firm can win only if it has the lower cost, and this happens with probability $1 - F_2(c_1 - t)$.[14]

Now suppose that the domestic firm prices less aggressively such that $\phi_2(p_1) + t > c_1$. In that case, it will win outright if it charges the lower price which happens with probability $[1 - F_2(\phi_2(p_1)]$. In addition, if $(c_2 + t) \in [c_1, \phi_2(p_1)]$, the competitor wins, but is overruled by the global policy maker who will give the market to the domestic firm at price $\tilde{p}_1$. This will happen

[14] Similarly, if the foreign firm charges a low price such that $\phi_1(p_2) < c_2 + t$, it will win only if it has the lower overall cost, that is, if $c_2 + t < c_1$ which happens with probability $1 - F_1(c_2 + t)$.

with probability $[F_2(\phi_2(p_1)) - F_2(c_1 - t)]$.[15]

Given own costs, beliefs on the rival's pricing strategy and the form of contingent protection, we can now determine the profit functions of both firms. The domestic firm's expected profits are equal to

$$\pi_1 = \begin{cases} [1 - F_2(c_1 - t)](p_1 - c_1) & \text{if } \phi_2(p_1) + t < c_1, \quad (10a) \\ \\ [1 - F_2(\phi_2(p_1))](p_1 - c_1) \; + \\ \quad [F_2(\phi_2(p_1)) - F_2(c_1 - t)](\tilde{p}_1 - c_1) & \text{if } \phi_2(p_1) + t \geq c_1 \quad (10b) \end{cases}$$

and the foreign firm's expected profits are equal to

$$\pi_2 = \begin{cases} [1 - F_1(c_2 - t)](p_2 - c_2 - t) & \text{if } \phi_1(p_2) < c_2 + t, \quad (11a) \\ \\ [1 - F_1(\phi_1(p_2))](p_2 - c_2 - t) \\ +[F_1(\phi_1(p_2)) - F_1(c_2 + t)](\tilde{p}_2 - c_2 - t) & \text{if } \phi_1(p_2) \geq c_2 + t, \quad (11b) \end{cases}$$

where $\tilde{p}_1, \tilde{p}_2$ are determined according to (9).

Intuitively, if a firm prices aggressively it will win outright whenever it has the lower cost. On the other hand, for p_i above a threshold, the probability of winning outright decreases in its own price, whereas the probability of winning due to policy intervention depends positively on the price, but the margin might be lower in that case, depending on the policy rule $\tilde{p}$. The objective function is shown in Figure 3. Given the expected profit it is now possible to determine the optimal pricing strategies. Differentiating equations (10a) and (10b) with respect to p_1 yields

[15]Similarly, if the foreign firm prices less aggressively such that $\phi_1(p_2) > c_2 + t$, it wins straightaway with probability $[1 - F_1(\phi_1(p_2)]$ and will win the market for the price $\tilde{p}_2$ due to policy intervention with probability $[F_1(\phi_1(p_2)) - F_1(c_2 + t)]$.

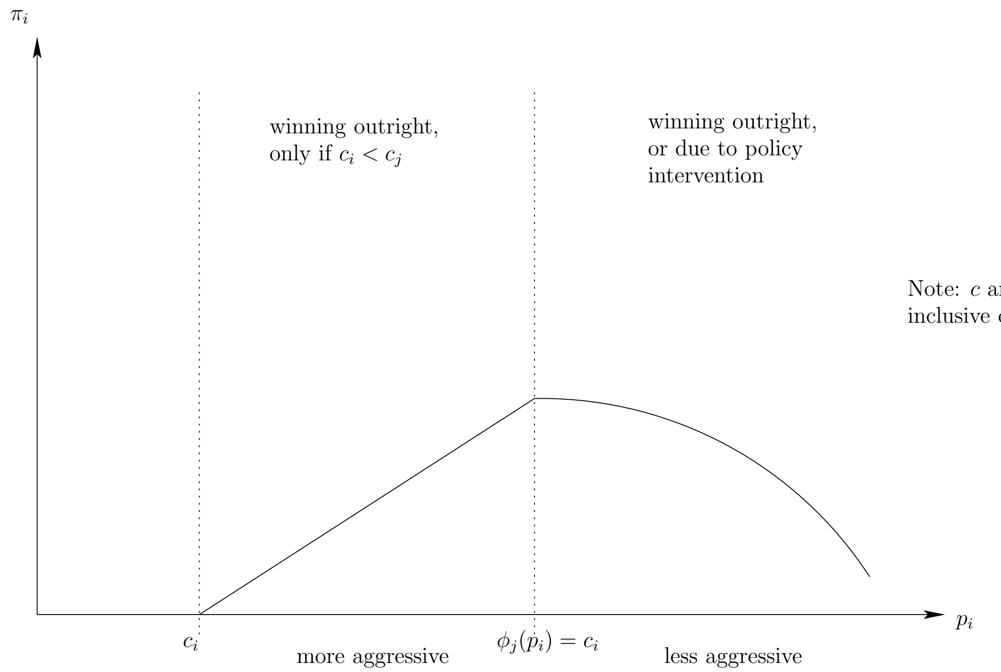

Figure 3: Profit function under contingent protection

(similar expressions hold for the foreign firm):

$$\frac{\partial \pi_1}{\partial p_1} = \begin{cases} [1 - F_2(c_1 - t)] & \text{if } \phi_2(p_1) + t < c_1, \quad (12a) \\ \\ [1 - F_2(\phi_2(p_1))] - f_2\phi_2'(p_1 - \tilde{p}_1) & \\ +(1-\alpha)(F_2(\phi_2(p_1)) - F_2(c_1 - t)). & \text{if } \phi_2(p_1) + t \geq c_1 \quad (12b) \end{cases}$$

Expression (12a) shows that the marginal profit is constant for $\phi_2(p_1) + t < c_1$, and hence expected profits increase until $\phi_2(p_1) + t = c_1$. At $\phi_2(p_1) + t = c_1$, the profit curve has a downward kink, but it is not clear *a priori* whether (12b) is positive or negative at this point. If it is positive, profits increase further, and we find the optimal price by setting (12b) equal to zero. If not, $\phi_2(p_1) + t = c_1$ gives the maximum as profits decline beyond that point.

To gain insight into the role of contingent protection in determining the optimal pricing strategy, consider the extreme where $\alpha = 0$. In this case, the regulating authority allows the efficient firm to charge the price it had posted, i.e. $\tilde{p}_1 = p_1$. The first-order condition then becomes linear everywhere:

$$\frac{\partial \pi_1}{\partial p_1} = 1 - F_2(c_1 - t) \quad \forall p_1. \tag{13}$$

This induces each firm to charge the maximum price of one because it knows that the chance of winning only depends on the cost realization. In this case, the price solely determines the profit margin if the firm happens to have the lower cost. However, all types choose this pricing policy, and hence the regulating authority cannot learn anything about the firm's type. Except for $\alpha = 0$, we have the following clear result:

PROPOSITION 1. *If Assumptions 1 and 2 hold and the government intervenes according to (9) with $\alpha \in (0, 1]$ in case of inefficiency, a perfect Bayesian Nash equilibrium exists in which $F_2(c_2) = c_2/(1-t)$, that is, firm 2 enters if $c_2 \leq 1 - t$. In case of entry, the equilibrium pricing functions are given by*

$$p_1(c_1) = \begin{cases} \dfrac{1+\alpha t}{1+\alpha} & \text{if } c_1 \in [0, t], \\[2ex] \dfrac{1+\alpha c_1}{1+\alpha} & \text{if } c_1 \in [t, 1], \end{cases}$$

$$p_2(c_2) = \frac{1+\alpha(c_2+t)}{1+\alpha} \qquad \text{if } c_2 \in [0, 1-t]$$

Proof: See Appendix A.2.

Proposition 1 shows that both firms use symmetric pricing functions across the common range of overall costs.[16] While it may be tempting to think that an equilibrium with symmetric pricing functions involves both firms charging lower prices, this is incorrect in general. For example, the pricing functions are equal to $p_1 = (1 + c_1)/2$ and $p_2 = (1 + c_2 + t)/2$ for the common support of

[16] As in the case of no intervention, these results do not rely on the assumption of a uniform distribution. The appendix shows that similar conclusion can be reached under the assumption that costs are distributed exponentially. However, the pricing functions in this case cannot be represented by a closed form solution.

overall costs if $\alpha = 1$. Furthermore, both $(1+\alpha c_1)/(1+\alpha)$ and $(1+\alpha(c_2+t))/(1+\alpha)$ increase with α. The reason for this is that a high α gives more weight on the marginal cost and less weight on the posted price for the case of intervention (see (9)). It therefore becomes less attractive to win because of intervention and the posted prices go up so as to compensate for the decrease in expected profit after potential intervention.

These pricing functions allow us to answer the two questions posed at the beginning of the section. Given that the two firms follow the same pricing policy over the set of common costs, inefficiency is no longer an equilibrium outcome. Consequently, the policy is effective in achieving its objective of a first best outcome. As for the question whether the policymaker can still infer the costs, note that the above pricing functions are strictly increasing where the supports overlap, and the domestic one is constant at the lower end. That is, the policymaker can infer which firm has the lower cost and hence the policy is feasible.

A further observation is that while global welfare is maximized by this policy, there are potentially distributional implications. In particular, the home country will have a lower expected welfare in some cases. For example, as $\alpha \to 0$, both firms employ very flat pricing functions that approach 1. In this case, whenever the foreign firm has lower costs, the home country receives approximately zero welfare. As $t \to 0$, this occurs approximately half of the time. Under laissez-faire, the domestic country gets positive consumer surplus for almost all cost draws and half of the time also earns domestic profits. Consequently, the home country is not always better off under a global contingent trade policy. While the potentially asymmetric distribution of the costs and benefits under a global policy might suggest that the home country could be reluctant to endorse a global policy, this interpretation relies too heavily on the single sector setting. Adding a second sector, where the home country is an exporter, then creates an environment with greater symmetry that allows the potential costs and benefits to be offset. Nevertheless the distributional implication are an intriguing feature of the model.

Notice that any negative cross-country distributional issues arise partly as a function of α, which potentially makes a case to restrict the size of α. However, this isn't the only argument that can be made for restricting the value of α used in the policy rule. In particular, the global planner's indifference towards α is due to the simplifying assumption of inelastic demand. In the extreme case of $\alpha = 0$, i.e. the domestic firm gets to charge its asking price in case of policy intervention, both firms set a price of 1. At the other extreme, if $\alpha = 1$, the firms set the same (lower) price as in the symmetric laissez-faire case. The global planner is indifferent only if demand is inelastic, as she cares solely about who supplies the market, not at what price. If demand is elastic, by contrast, there is an additional consumer surplus consideration, and the global planner will prefer the lower price that results from a higher α.

4 Nationally Optimal Policy

The previous section shows that placing contingent protection under global discipline has the virtue of ensuring a first best outcome. However, historically the most prominent contingent protection instruments (AD, CVD) have been designed and implemented at the national level. This shift of fora has a number of implications including the fact that national governments have the objective of maximizing national welfare, not global welfare. In contrast to the globally optimal policy, national governments do not only seek to correct the potential inefficiency, they also pursue rent shifting motives because they value the domestic firm's profit but not the foreign competitor's. Consequently, they intervene earlier and the foreign firm will be allowed to serve the domestic market only if its price is below the domestic firm's cost, because only in that case does the gain to domestic consumers dominate the profit loss of the domestic firm. If the foreign price lies between the domestic cost and the domestic price, on the other hand, then a prohibitive import tariff is imposed, and the domestic firm is allowed to set a price equal to (9). The objective of the domestic government to maximize national welfare suggests that there is likely to be a divergence from the efficient outcomes of the globally optimal benchmark. The interesting question then is whether or not the domestic policy mitigates or exaggerates the inefficiencies associated with market failure.

To answer this question we must, once again, address the same two issues as in the previous section: How does the announcement of such a policy influence the equilibrium pricing functions? And can the policy be successfully implemented? As before, we start from the premise (to be verified later) that the pricing functions are monotonically increasing so that observing the bids allows the government to infer the respective costs.[17]

Provided that the foreign firm only gets to serve the market if its price is below the domestic firm's cost, the foreign firm's expected profit takes the following simple form:

$$\pi_2(p_2; c_2) \quad = \quad [1 - F_1(p_2)](p_2 - c_2 - t) \tag{14}$$

Note that the foreign firm's expected profit is independent of p_1, and therefore independent of the domestic firm's pricing behavior. Therefore the foreign firm's profit maximization problem can be solved independently of the domestic firm's pricing behavior.

LEMMA 3. *If a foreign firm for which $c_2 \in [0, 1-t]$ enters and a national government intervenes according to (9) as to maximize domestic welfare, the foreign firm's pricing and inverse pricing functions are respectively given by*

$$p_2(c_2) = \frac{1 + c_2 + t}{2} \qquad \text{and} \qquad \phi_2(p_2) + t = 2p_2 - 1. \tag{15}$$

Proof: For an interior solution, the first order condition is given by

$$\frac{\partial \pi_2}{\partial p_2} = [1 - F_1(p_2)] - f_1(p_2)(p_2 - \phi_2(p_2) - t) = 0 \tag{16}$$

which implies the following inverse bid function

$$\phi_2(p_2) + t = p_2 - \frac{1 - F_1(p_2)}{f_1(p_2)}. \tag{17}$$

[17] Note that in this case only the domestic pricing function needs to be monotonically increasing since the foreign price and not cost turns out to be the conditioning variable.

Assumption 1 implies (15). □

We now turn our attention to the domestic firm's behavior. Given the foreign firm's strategy, the domestic firm's profit function takes the following form:

$$\pi_1 = \begin{cases} p_1 - c_1 & \text{if } p_1 \leq (1+t)/2, \quad (18a) \\ [1 - F_2(\phi_2(p_1))](p_1 - c_1) \ + \\ [F_2(\phi_2(p_1)) - F_2(\phi_2(c_1))](\tilde{p}_1 - c_1) & \text{otherwise} \quad (18b) \end{cases}$$

where $\tilde{p}_1$ (see (9)) is the price that the government allows the domestic company to charge in case of policy intervention, as before. As long as the domestic firm charges a price below the lowest foreign price, that is $p_1 \leq p_2(c_2 = 0) = (1+t)/2$, it wins the market for sure, which leads to profits of $p_1 - c_1$. If the domestic price lies above the threshold, there is a probability that it wins the market outright, represented by the first line of (18b), or it may win due to national policy intervention, which is reflected by the second line of (18b). We now derive the domestic firm's optimal pricing strategy resulting from the above profit function.

PROPOSITION 2. *If the national government maximizes national welfare and intervenes according to (9) with*

$$\alpha \in \left(\frac{1}{2}, \frac{1}{1+t}\right]$$

a perfect Bayesian Nash equilibrium exists in which a foreign firm for which $c_2 \in [0, 1-t]$ *enters and the domestic firm's pricing function is given by*

$$p_1(c_1) = c_1 + \frac{1 - c_1}{2\alpha}. \tag{19}$$

Proof: See Appendix A.3.

Note that there is a tighter restriction on α compared to the globally optimal policy. First, given foreign pricing behavior, the domestic firm can win for sure if it charges $(1+t)/2$. This is unprofitable only if the price $\tilde{p}_1$ imposed by the authority is not too close to the cost but leaves a substantially large profit. This is the reason for the upper bound on α. Second, if α were small, the domestic firm would receive a profit close to its posted price in case of intervention. Since the domestic firm loses only if its cost is above its rival's price, it would go for the maximum price of unity for low values of α, and not only for $\alpha = 0$ as in the case of globally optimal policies. This is the reason for the lower bound on α.

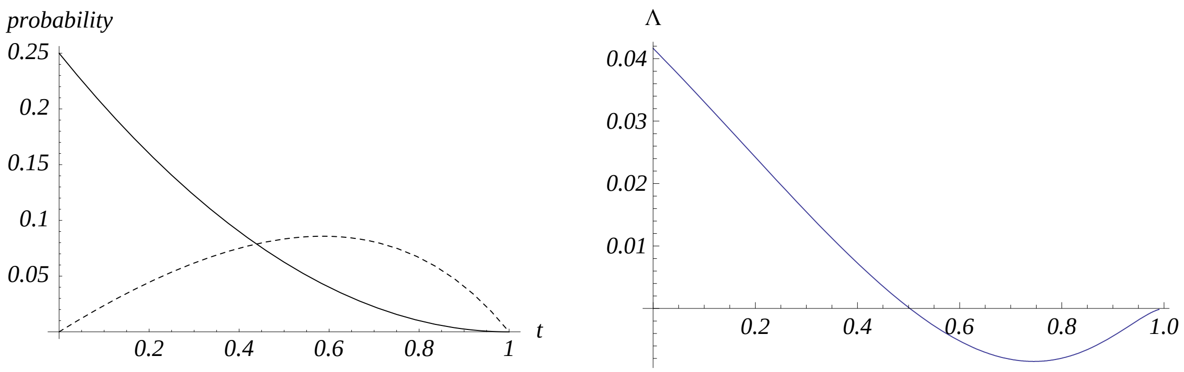

Figure 4: Comparison of Probabilities and Expected Losses

What are the consequences of a nationally conducted contingent trade policy? Given our focus on allocative efficiency, we use this as the appropriate benchmark. In the case of a nationally optimal policy, there is again the possibility of an inefficiency, that is, the higher cost firm ends up serving the market. However, it will not be a higher cost foreign firm that serves the market. Instead the national policy favors the domestic firm to the extent that it might end up serving the market despite having the higher cost. That is, the market failure that we identified in the laissez-faire scenario is replaced by a (globally) inefficient allocation brought about by the national government, only that the inefficiency now goes in the opposite direction.

To gain some insight into the likelihood of this scenario, Appendix A.3 shows that the probability of an inefficient outcome is given by $(1-t)^2/4$. This enables us to compare the probabilities of the inefficient outcomes in the laissez-faire equilibrium (see the dashed lines in Figure 4's left panel) and for the nationally optimal policies (see the solid lines in Figure 4's left panel) respectively. In the right panel, Λ is the difference in the unconditional expected loss between the nationally optimal policies and the laissez-faire equilibrium. As can be seen from the diagram, there is no unambiguous ranking of these policies.

In contrast to the laissez-faire outcome, the likelihood of the domestic policy inducing an inefficient allocation is monotonic — the inefficiency probability being much larger (lower) for low (high) levels of t. The reason is that the nationally optimal policy will call for intervention also when trade costs are low, provided the foreign price (not foreign overall cost) exceeds the domestic cost. In this case, intervention happens mostly for rent shifting motives, as the likelihood of an allocative inefficiency under laissez-faire is low. For higher trade costs, on the other hand, the foreign firm charges a higher price, and thus its probability of winning is low. The national government thus is rarely prompted to intervene. This is in contrast to the laissez-faire regime in which the foreign firm prices more aggressively. Therefore, the nationally optimal policy has a lower inefficiency probability for high trade costs.

Comparison to the laissez-faire case reveals that the nationally conducted contingent trade policy dominates for high trade costs, while laissez-faire is welfare superior (in expectation) for lower trade costs. Abstracting from other aspects, one could thus argue that nationally conducted AD policy, to take one example, might have some merit when trade costs are high. Once trade costs decrease with globalization, however, there comes a point when not allowing such nationally conducted policies would actually be preferable.

5 Concluding remarks

This paper has developed an efficiency theory of contingent trade policy. We show that there is a case for policy intervention if firms compete in prices under incomplete information. The reason is that, in the absence of intervention, the foreign firm prices more aggressively, and therefore might end up serving the market in spite of having the higher overall cost. In case of a globally optimal policy, inefficiency does not occur as both firms employ the same pricing strategy across the common range of overall costs. Hence the policymaker does not actually have to intervene, the threat of intervention alone leads to allocative efficiency. In case of a nationally optimal policy, driven by rent shifting motives, it is the domestic firm that can be the source of inefficiency, and inefficiency is likely to occur for low trade costs in contrast to the laissez-faire outcome. This observation strengthens the need for global policy coordination of contingent trade policies as markets become ever more integrated.

Global policy coordination of contingent trade policy, however, is not yet part of multilateral trade agreements. Until now, such policies are mostly a national matter, except perhaps for countries within the European Union. The need for global policy coordination in view of deeper integration raises the question whether the existing trade agreements should continue to allow such contingent trade policies in the first place. Should future trade agreements not rather give the option of intervention to supranational authorities, instead of individual countries? Or at a minimum provide greater discipline on them.

Failing an ability to include contingent protection within multilateral agreements, these policies are under national control. This leaves us with the question of whether policy options such as anti-dumping, safeguards, and countervailing duties may become increasingly susceptible to national interests. Our paper has shown that the likelihood of inefficiency, when these policies are carried out by national governments, increases as trade costs decline. Yet this is exactly the setting where contingent protection has the weakest justification.

Appendix

A.1 Equilibrium pricing strategies without policy intervention

In case of entry, denote $\gamma, \gamma \in [0, 1-t]$ as the critical foreign type which is indifferent between entry and no entry. We will determine γ below. Given that the domestic firm knows the size of ϵ and observes this investment, it will update its beliefs if it observes entry such that the foreign types which enter will be uniformly distributed between 0 and γ. Consequently, the expected profits of both firms are equal to

$$\begin{aligned} \pi_1(p_1; c_1) &= \left(1 - \frac{\phi_2(p_1)}{\gamma}\right)(p_1 - c_1), \\ \pi_2(p_2; c_2) &= (1 - \phi_1(p_2))(p_2 - c_2 - t). \end{aligned} \tag{A.1}$$

First, let us establish that both firms will employ a price strategy such that the optimal price functions have a common upper and lower bound for those prices by which each firm is able to win demand. Let the lower (upper) bound be denoted by $\underline{p}(\overline{p})$. If $p_i = \underline{p}$, firm i will win with certainty, so there is no reason to undercut this price. This confirms the common lower price bound, and hence $\phi_1(0) = \phi_2(0) = \underline{p}$. Suppose that the first-order conditions (3) are fulfilled for all $p_i \in [\underline{p}, \overline{p}]$. We will now establish that

$$\begin{aligned} \overline{p} &= \frac{1+t+\gamma}{2}, \\ \phi_1(\overline{p}) &= \frac{1+t+\gamma}{2}, \quad \phi_2(\overline{p}) = \gamma \\ \phi_1(p_1) &= c_1, \quad \forall p_1 \in [\overline{p}, 1] \end{aligned} \tag{A.2}$$

are part of the equilibrium pricing strategies. Note that (A.2) specifies that the domestic firm charges its cost for all prices above $\overline{p}$; in these cases, the domestic firm cannot win the market and will be beaten by the foreign firm with probability one. As we have assumed that the first-order conditions hold up to $\overline{p}$, we have to prove that no firm is better off by charging a higher price. As for the domestic firm, $\pi_1(\overline{p}; \overline{p}) = 0$ because it will win with zero probability. A higher price leads also to zero profits as it does not change the zero win probability; hence, the domestic firm has no incentive to deviate from this strategy. The foreign firm is supposed to charge $\overline{p}$ for $c_2 = \gamma$. Given that the domestic firm charges its cost for all prices above $\overline{p}$, the foreign firm profit is equal to

$$\pi_2(\overline{p}; \gamma) = (1 - \overline{p})(\overline{p} - \gamma - t) = \frac{(1-t-\gamma)^2}{4} \tag{A.3}$$

if it follows the prescribed strategy and

$$\pi_2(p_2 > \overline{p}; \gamma) = (1 - p_2)(p_2 - \gamma - t)$$

if it charges a higher price. Maximizing $\pi_2(p_2 > \overline{p}; \gamma)$ over p_2 leads to an optimal $p_2 = \overline{p}$, and hence also the foreign firm has no incentive to deviate.

For all $p_1, p_2 \in [\underline{p}, \overline{p}]$, the first-order conditions for (A.1) are

$$\gamma - \phi_2(p_1) - \phi_2'(p_1)(p_1 - c_1) = 0,$$
$$1 - \phi_1(p_2) - \phi_1'(p_2)(p_2 - c_2 - t) = 0.$$

Note that each first-order condition depends on both inverse price functions. We now follow a solution concept similar to Krishna (2002) as to determine the boundary conditions and to simplify the differential equations. In equilibrium, $c_i = \phi_i(p_i)$, and using p as the argument in the inverse price functions allows us to rewrite the first-order condition as

$$\begin{aligned}(\phi_1'(p) - 1)(p - \phi_2(p) - t) &= 1 - \phi_1(p) - p + \phi_2(p) + t,\\ (\phi_2'(p) - 1)(p - \phi_2(p)) &= \gamma - \phi_2(p) - p + \phi_1(p).\end{aligned}$$

Adding up yields

$$\frac{-d}{dp}(p - \phi_1(p))(p - \phi_2(p) - t) = 1 + t + \gamma - 2p, \tag{A.4}$$

and integration implies

$$(p - \phi_1(p))(p - \phi_2(p) - t) = p^2 - (1 + t + \gamma)p + K, \tag{A.5}$$

where K denotes the integration constant. We can determine K by using the upper boundary condition. For $p = \overline{p}$, the LHS of (A.5) is zero and we find that

$$K = \frac{(1 + t + \gamma)^2}{4},$$

so that (A.5) reads

$$(p - \phi_1(p))(p - \phi_2(p) - t) = p^2 - (1 + t + \gamma)p + \frac{(1 + t + \gamma)^2}{4} \tag{A.6}$$

in equilibrium. Furthermore, $\phi_1(0) = \phi_2(0) = \underline{p}$ so that

$$\underline{p}(\underline{p} - t) = \underline{p}^2 - (1 + t + \gamma)\underline{p} + \frac{(1 + t + \gamma)^2}{4}$$

which leads to

$$\underline{p} = \frac{(1 + t + \gamma)^2}{4(1 + \gamma)}. \tag{A.7}$$

We can use (A.6) as to rewrite the first-order conditions such that each depends on a single inverse price function only:

$$\begin{aligned}\gamma - \phi_2(p) &= \phi_2'(p)\frac{p^2 - (1 + t + \gamma)p + \frac{(1+t+\gamma)^2}{4}}{p - \phi_2(p) - t} = 0, \qquad \text{(A.8)}\\ 1 - \phi_1(p) &= \phi_1'(p)\frac{p^2 - (1 + t + \gamma)p + \frac{(1+t+\gamma)^2}{4}}{p - \phi_1(p)} = 0.\end{aligned}$$

Eqs. (A.2), (A.7) and (A.8) completely describe the equilibrium behavior of both firms in terms of their inverse price functions.[18] Hence, they represent the solution to stage II of our game, given that no intervention will occur. As for stage I, eq. (A.3) allows us to determine the critical type γ which will be indifferent between entry and no entry. This type's expected profit must be equal to the investment ϵ such that

$$\gamma = 1 - t - 2\sqrt{\epsilon}.$$

An interior solution requires that $2\sqrt{\epsilon} < 1 - t$. More importantly, as we deal with markets to which entry is easy, $\gamma \simeq 1 - t$ for a ϵ sufficiently close to zero. For $\gamma \simeq 1 - t$, (A.8) simplifies to

$$\begin{aligned} 1 - t - \phi_2(p) &= \phi_2'(p)\frac{(1-p)^2}{p - \phi_2(p) - t}, \\ 1 - \phi_1(p) &= \phi_1'(p)\frac{(1-p)^2}{p - \phi_1(p)}. \end{aligned} \tag{A.9}$$

Because prices must not fall short of overall costs, $\phi_1', \phi_2' > 0$, and hence the solutions to (A.9) satisfy that the (inverse) price functions increase with the costs (prices). Solving these equations gives the inverse price functions

$$\phi_1(p) = 1 - \frac{2(1-p)}{1 - (1-p)^2 K_1} \tag{A.10}$$

$$\phi_2(p) = 1 - \frac{2(1-p)}{1 - (1-p)^2 K_2} - t, \tag{A.11}$$

where the K_i's are the constants of integration. Note that the domestic firm's price policy will no longer include a range of prices in which it will charge its cost (and win with zero probability) because

$$\overline{p} = 1 \text{ and } \underline{p} = \frac{1}{2-t}$$

for $\gamma \simeq 1 - t$. Using the last condition, that is $\phi_1(0) = \phi_2(0) = 1/(2-t)$, we find that

$$K_1 = \frac{t(2-t)}{(1-t)^2} \geq 0 \text{ and } K_2 = -K_1 \leq 0.$$

Plugging K_1 and K_2 back into (A.10) and solving for p yields (5).

To determine the probability that an inefficient outcome occurs, contingent upon entry of the foreign firm, we define the borderline $\tilde{c}_2(c_1)$ between the inefficient and the efficient set of cost draws at which the resulting prices are equal. Setting p_1 and p_2 in (5) equal to each other gives

$$\tilde{c}_2(c_1) = 1 - \frac{1 - c_1}{\sqrt{\frac{1 - (2-t)\ t\ (2-c_1)\ c_1}{(1-t)^2}}} - t. \tag{A.12}$$

[18] It is possible to derive explicit solutions for the inverse price functions. These functions, however, cannot be inverted as to solve for the price functions. The results are available upon request.

The foreign firm prices more aggressively if $\tilde{c}_2(c_1) + t \leq c_1$ which is equivalent to

$$(1-c_1)\left(1-\frac{1-c_1}{\sqrt{\frac{1-(2-t)\,t\,(2-c_1)\,c_1}{(1-t)^2}}}\right) \geq 0$$
$$\Leftrightarrow \sqrt{\frac{1-(2-t)\,t\,(2-c_1)\,c_1}{(1-t)^2}} \geq 1$$
$$\Leftrightarrow 1-(2-t)t(2-c_1)c_1 \geq (1-t)^2. \quad \text{(A.13)}$$

Note that the LHS decreases with c_1 and is thus at least equal to $1-2t+t^2 = (1-t)^2$ or larger which completes the proof for Lemma 2.

Probability of an Inefficiency

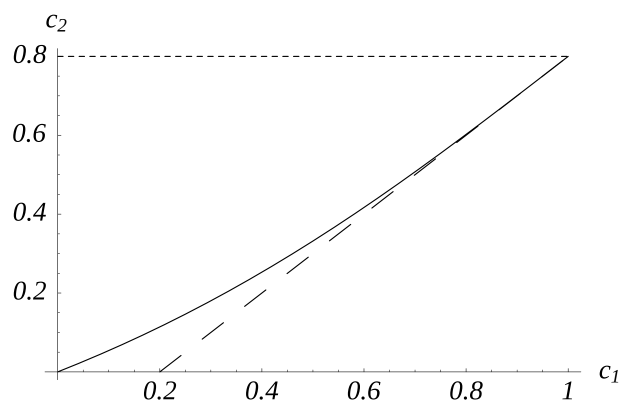

Figure 5: Inefficiency in the laissez-faire equilibrium

The probability of inefficiency can be best derived from two graphs in the $c_2 - c_1-$space. Figure 5 shows equation (A.12) for $t = 0.2$ as the solid line. The broken line is the efficiency border $c_2 = c_1 - t$ where both firms are equally efficient. For $c_1 < t$, the domestic firm is the efficient one in any case. In the laissez-faire equilibrium, the foreign firm wins (loses) if $\tilde{c}_2 < (>) c_1$, and the domestic firm should win from a global perspective if $c_2 > c_1 - t$. The area between the two lines represents the inefficiency. Note that the size of the rectangle is $1-t$ due to the upper bound for c_2. The probability of inefficiency can thus be computed as the area below the solid line minus the area below the broken line, corrected by the factor $1/(1-t)$:

$$\frac{1}{1-t}\left(\int_0^1 \tilde{c}_2(c_1)dc_1 - \int_t^1 (c_1-t)dc_1\right)$$
$$= \frac{1}{2} + \frac{1}{(2-t)(1-t)} - \frac{1}{1-t}. \quad \text{(A.14)}$$

Proof for general distribution and demand functions

We now show — adapting the proof of proposition 4.4 in Krishna (2002) — that this result is robust when relaxing the uniform distributional assumption and allowing demand to be price elastic. Let $x(p)$ be any downward sloping differentiable demand function with $x(1) = 0$. The expected profit functions of the domestic and foreign firm then take the following form:

$$\begin{aligned}\pi_1(p_1) &= (1 - F_2(\phi_2(p_1)))(p_1 - c_1)x(p_1),\\ \pi_2(p_2) &= (1 - F_1(\phi_1(p_2)))(p_2 - (c_2 + t))x(p_2);\end{aligned}$$

and the corresponding first order conditions of profit maximization are:

$$\begin{aligned}\phi_2'(p_1) &= \frac{1 - F_2(\phi_2(p_1))}{f_2(\phi_2(p_1))}\frac{x(p_1) + (p_1 - c_1)x'(p_1)}{(p_1 - c_1)x(p_1)},\\ \phi_1'(p_2) &= \frac{1 - F_1(\phi_1(p_2))}{f_1(\phi_1(p_2))}\frac{x(p_2) + (p_2 - (c_2 + t))x'(p_2)}{(p_2 - (c_2 + t))x(p_2)}.\end{aligned}$$

We want to establish that the foreign firm sets a lower price if it has the same (total) cost, i.e. $p_2(c) < p_1(c)\forall c \in [t, 1]$. The proof proceeds by contradiction. Suppose there exists a common point; that is, for some $\tilde{p} \in (\underline{p}, 1)$ $\phi_1(\tilde{p}) = \phi_2(\tilde{p}) + t = z$. Then the first order conditions above imply:

$$\begin{aligned}\phi_2'(\tilde{p}) &= \frac{1 - F_2(z - t)}{f_2(z - t)}\frac{x(\tilde{p}) + (\tilde{p} - z)x'(\tilde{p})}{(\tilde{p} - z)x(\tilde{p})}\\ \phi_1'(\tilde{p}) &= \frac{1 - F_1(z)}{f_1(z)}\frac{x(\tilde{p}) + (\tilde{p} - z)x'(\tilde{p})}{(\tilde{p} - z)x(\tilde{p})}\end{aligned}$$

where F_2^{incl} is the foreign firm's cost distribution defined in terms of total cost, i.e. $F_2^{incl}(c) \equiv F_2(c-t)$. Assume that F_2^{incl} stochastically dominates $F_1 = F$ in terms of hazard rate (not reverse hazard rate) dominance. A linearly decreasing density as implied by $F = 2c - c^2$ is one example that gives rise to such dominance. Stochastic dominance together with the above derivatives of the inverse pricing functions implies that $p_1'(z) > p_2'(c)$ at any common point. This implies that there is at most one intersection. Therefore if $p_1(c)$ were less than $p_2(c)$ for some $c \in (t, 1)$, then — no matter whether there is an intersection or not — this would imply that $p_2(c) > p_1(c)$ at $c = t + \epsilon$. However, we know that $p_1(0) = p_2(t)$ and hence $p_1(t) > p_2(t)$ which is a contradiction.

A.2 Globally optimal contingent trade policies

Following the discussion in the paper the objective functions are:

$$\pi_1 = \begin{cases} [1 - F_2(c_1 - t)](p_1 - c_1) & \text{if } \phi_2(p_1) + t < c_1,\\ \\ [1 - F_2(\phi_2(p_1))](p_1 - c_1)\ + \\ \quad [F_2(\phi_2(p_1)) - F_2(c_1 - t)](\tilde{p}_1 - c_1) & \text{if } \phi_2(p_1) + t \geq c_1 \end{cases}$$

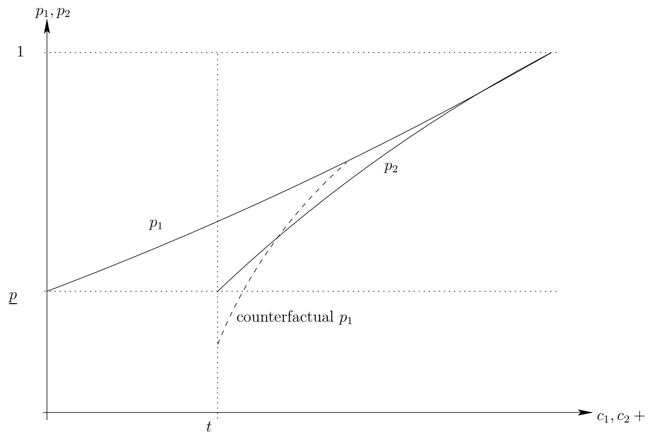

Figure 6: Pricing functions

and the foreign firm's expected profits are equal to

$$\pi_2 = \begin{cases} [1 - F_1(c_2 + t)](p_2 - c_2 - t) & \text{if } \phi_1(p_2) < c_2 + t, \\ \begin{array}{c} [1 - F_1(\phi_1(p_2))](p_2 - c_2 - t) \\ +[F_1(\phi_1(p_2)) - F_1(c_2 + t)](\tilde{p}_2 - c_2 - t) \end{array} & \text{if } \phi_1(p_2) \geq c_2 + t \end{cases}$$

where $\tilde{p}_1 = \alpha c_1 + (1 - \alpha)p_1$, $\tilde{p}_2 = \alpha(c_2 + t) + (1 - \alpha)p_2$. Using these definitions, the objective functions can be simplified to:

$$\pi_1 = \begin{cases} [1 - F_2(c_1 - t)](p_1 - c_1) & \text{if } \phi_2(p_1) + t < c_1, \\ [1 - \alpha F_2(\phi_2(p_1)) + (1 - \alpha)F_2(c_1 - t)](p_1 - c_1) & \text{if } \phi_2(p_1) + t \geq c_1 \end{cases}$$

$$\pi_2 = \begin{cases} [1 - F_1(c_2 + t)](p_2 - c_2 - t) & \text{if } \phi_1(p_2) < c_2 + t, \\ [1 - \alpha F_1(\phi_1(p_2)) + (1 - \alpha)F_1(c_2 + t)](p_2 - c_2 - t) & \text{if } \phi_1(p_2) \geq c_2 + t \end{cases}$$

Now adopt the assumption of a uniform distribution for $c \in [0, 1]$, i.e. $F(c) = c$ and $f(c) = 1$. Since the foreign firm only serves the market if it receives a sufficiently low cost draw, we can derive the updated distribution function for the foreign firm as: $F_2(c) = \frac{c}{1-t}$ for $c \in [0, 1-t]$ and $f_2(c) = \frac{1}{1-t}$.

$$\pi_1 = \begin{cases} [1 - t - (c_1 - t)]\dfrac{(p_1 - c_1)}{(1 - t)} & \text{if } \phi_2(p_1) + t < c_1, \\ [1 - t - \alpha\phi_2(p_1) + (1 - \alpha)(c_1 - t)]\dfrac{(p_1 - c_1)}{(1 - t)} & \text{if } \phi_2(p_1) + t \geq c_1 \end{cases}$$

$$\pi_2 = \begin{cases} [1 - (c_2 + t)](p_2 - c_2 - t) & \text{if } \phi_1(p_2) < c_2 + t, \\ [1 - \alpha(\phi_1(p_2)) + (1 - \alpha)(c_2 + t)](p_2 - c_2 - t) & \text{if } \phi_1(p_2) \geq c_2 + t \end{cases}$$

First order conditions give:

$$\frac{\partial \pi_1}{\partial p_1} = \begin{cases} [1-t-(c_1-t)] > 0 & \text{if } \phi_2(p_1)+t < c_1, \\ [1-t-\alpha\phi_2(p_1)+(1-\alpha)(c_1-t)] - \alpha\phi_2'(p_1)(p_1-c_1) & \text{if } \phi_2(p_1)+t \geq c_1 \end{cases}$$

$$\frac{\partial \pi_2}{\partial p_2} = \begin{cases} [1-(c_2+t)] > 0 & \text{if } \phi_1(p_2) < c_2+t, \\ [1-\alpha(\phi_1(p_2))+(1-\alpha)(c_2+t)] - \alpha\phi_1'(p_2)(p_2-(c_2+t)) & \text{if } \phi_1(p_2) \geq c_2+t \end{cases}$$

Note that in equilibrium it must be the case that $\phi_2(p_1) + t \geq c_1$ (the domestic firm prices less aggressively than foreign) and $\phi_1(p_2) \geq c_2 + t$ (the foreign firm prices less aggressively than domestic). However, the domestic firm cannot price strictly less aggressively than the foreign firm at the same time that the foreign firm is pricing strictly less aggressively than the domestic firm. That is for $c_1 \in [t, 1]$ and $c_2 \in [0, 1-t]$ the firms pursue a symmetric pricing strategy in equilibrium. This implies $\phi(p) = \phi_1(p) = \phi_2(p) + t$. These conditions imply that the relevant part of the first order condition is the same for both firms:

$$[1-\phi(p)] - \alpha\phi'(p)(p-\phi(p)) = 0 \tag{A.23}$$

Solving this differential equation and using the boundary condition that a cost of 1 implies a price of 1 gives:

$$\begin{aligned} p_1(c_1) &= \begin{cases} \dfrac{1+\alpha t}{1+\alpha} & \text{if } \ c_1 \in [0,t], \\ \dfrac{1+\alpha c_1}{1+\alpha} & \text{if } \ c_1 \in [t,1] \end{cases} \\ p_2(c_2) &= \frac{1+\alpha(c_2+t)}{1+\alpha} \quad \text{if } \ c_2 \in [0,1-t] \end{aligned} \tag{A.24}$$

To verify the symmetry of the pricing functions over the common support of total costs, consider the objective function of the domestic firm under the conjecture that $\phi_2(p) = \frac{p(1+\alpha)-1-\alpha t}{\alpha}$.

$$\pi_1 = \begin{cases} [1-t-(c_1-t)]\dfrac{(p_1-c_1)}{(1-t)} & \text{if } \phi_2(p_1)+t < c_1, \\ [2-p(1+\alpha)-c_1(1-\alpha)]\dfrac{(p_1-c_1)}{(1-t)} & \text{if } \phi_2(p_1)+t \geq c_1 \end{cases}$$

$$\frac{\partial \pi_1}{\partial p_1} = \begin{cases} [1-t-(c_1-t)] > 0 & \text{if } \phi_2(p_1)+t < c_1, \\ 2-p_1(1+\alpha)-c_1(1-\alpha)-(1+\alpha)(p_1-c_1) & \text{if } \phi_2(p_1)+t \geq c_1 \end{cases}$$

Setting this last equation to zero and solving for p_1 verifies that a symmetric pricing strategy is a best response for a common total cost. A similar exercise can be conducted for the foreign firm.

While providing a characterization for general distribution functions is complicated by the inability to find analytical solutions to the pricing functions, we can demonstrate that the symmetric pricing property evident above is not solely driven by the assumption of a uniform distribution. Instead of a uniform distribution assume that costs are drawn from an exponential distribution $F(c) = \frac{1-e^{-c}}{1-e^{-1}}$ for $c \in [0,1]$ and $f(c) = \frac{e^{-c}}{1-e^{-1}}$. Since the foreign firm also has to pay a transport cost, the updated distribution for the foreign is $F_2(c) = \frac{1-e^{-c_2}}{1-e^{-(1-t)}}$ and $f_2(c_2) = \frac{e^{-c_2}}{1-e^{-(1-t)}}$ for $c_2 \in [0, 1-t]$.

$$\pi_1 = \begin{cases} [1 - \frac{1-e^{-(c_1-t)}}{1-e^{-(1-t)}}](p_1 - c_1) & \text{if } \phi_2(p_1) + t < c_1, \\ [1 - \alpha\left(\frac{1-e^{-(\phi_2(p_1)-t)}}{1-e^{-(1-t)}}\right) + (1-\alpha)\left(\frac{1-e^{-(c_1-t)}}{1-e^{-(1-t)}}\right)](p_1 - c_1) & \text{if } \phi_2(p_1) + t \geq c_1 \end{cases}$$

$$\pi_2 = \begin{cases} [1 - \frac{e^{-(c_2+t)}}{1-e^{-1}}](p_2 - c_2 - t) & \text{if } \phi_1(p_2) < c_2 + t, \\ [1 - \alpha\left(\frac{1-e^{-(\phi_1(p_2))}}{1-e^{-1}}\right) + (1-\alpha)\left(\frac{1-e^{-(c_2+t)}}{1-e^{-1}}\right)](p_2 - c_2 - t) & \text{if } \phi_1(p_2) \geq c_2 + t \end{cases}$$

First order conditions give:

$$\begin{aligned} \frac{\partial \pi_1}{\partial p_1} &= [1 - \frac{1-e^{-(c_1-t)}}{1-e^{-(1-t)}}] > 0 && \text{if } \phi_2(p_1) + t < c_1, \\ &= [1 - \alpha\left(\frac{1-e^{-(\phi_2(p_1)-t)}}{1-e^{-(1-t)}}\right) + (1-\alpha)\left(\frac{1-e^{-(c_1-t)}}{1-e^{-(1-t)}}\right)] \\ &\quad - \alpha\left(\frac{e^{-(\phi_2(p_1)-t)}}{1-e^{-(1-t)}}\right)\phi_2'(p_1)(p_1 - c_1) && \text{if } \phi_2(p_1) + t \geq c_1 \end{aligned}$$

$$\begin{aligned} \frac{\partial \pi_2}{\partial p_2} &= [1 - \frac{e^{-(c_2+t)}}{1-e^{-1}}] > 0 && \text{if } \phi_1(p_2) < c_2 + t \\ &= [1 - \alpha\left(\frac{1-e^{-\phi_1(p_2)}}{1-e^{-1}}\right) + (1-\alpha)\left(\frac{1-e^{-(c_2+t)}}{1-e^{-1}}\right)] \\ &\quad - \alpha\left(\frac{e^{-\phi_1(p_2)}}{1-e^{-1}}\right)\phi_1'(p_2)(p_2 - (c_2 + t)) && \text{if } \phi_1(p_2) \geq c_2 + t \end{aligned}$$

Suppose both firms adopt a symmetric pricing strategy ($\phi_1(p) = \phi_2(p) + t = \phi(p)$) for common total costs ($c_1 = c_2 + t = \tilde{c}$), then the relevant part of the above first order conditions have a common form and evaluated at the optimum can be written as:

$$\left(1 - \alpha e^{-(1-\phi(p))} + (1-\alpha)e^{-(1-\tilde{c})}\right) - \alpha\phi'(p)(p - \tilde{c}) = 0 \tag{A.29}$$

While this equation doesn't have a closed form solution, it does share the property that the equilibrium pricing functions will be symmetric for common total costs.

A.3 Nationally optimal contingent trade policies

Below the lowest price of the foreign firm, the domestic firm's profit function is strictly increasing in p_1. This implies that the domestic firm will never set a price below $(1+t)/2$ but instead charge $(1+t)/2$ which leads to profits of $\hat{\pi}_1 = (1+t)/2 - c_1$.

Above the threshold, the first order condition for (18b) leads to (19). Note that this function is monotonically increasing as long as $\alpha > 1/2$. For $\alpha = 1/2$ the domestic firm charges a price of one, independent of its cost draw. For a lower α, that is, when the government allows the domestic firm to charge a relatively high price in case of intervention, the first order condition would imply a decreasing price above unity, but given our assumption that the willingness to pay is bounded at one, it charges a price of one for all $\alpha \leq 1/2$.

For $\alpha > 1/2$ we need to check that the profit resulting from the above pricing rule exceeds the profit $\hat{\pi}_1$ that the firm would obtain by charging the lowest price of the foreign competitor. Plugging (19) back into (18b) results in the following condition:

$$\pi_1^* = \frac{(1-c)^2}{2(1-t)\alpha} \geq \hat{\pi}_1 = \frac{1+t}{2} - c. \tag{A.30}$$

This condition is satisfied for all cost draws $c_1 \in [0,1]$ as long as $\alpha \leq 1/(1+t)$. As in the case of globally optimal policies, any foreign firm for which $c_2 \in [1-t, 1]$ cannot make any profit by entering as its break even price is unity. Furthermore, no firm for $c_2 \in [0, 1-t]$ cannot be better off by not entering as there is a positive probability that it will win the market. This completes the proof of Proposition 2.

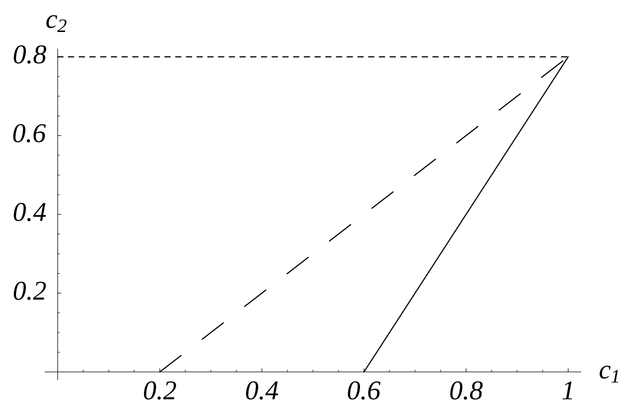

Figure 7: Inefficiency for nationally optimal policies

As for the inefficiency probability, we proceed similarly as in Appendix A.1. Figure 7 also shows the efficiency border as a broken line for $t = 0.2$. However, now the domestic firm is the source of potential inefficiency. Setting (15) and (19) equal to each other, we get a critical $\hat{c_2} = 2c_1 - (1+t)$ which is given by the solid line. This line gives the costs for which both firms charge the same prices, and hence the domestic firm wins if c_2 is larger. This function is only defined for $c_1 \in [(1+t)/2, 1]$. The probability of inefficiency is given by the area below the broken line minus the area below the solid line, corrected by $1/(1-t)$:

$$\frac{1}{1-t}\left(\frac{(1-t)^2}{2} - \frac{1}{2}\left(1 - \frac{1+t}{2}\right)(1-t)\right) = \frac{(1-t)^2}{4}. \tag{A.31}$$

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