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# Contingent trade policy and economic efficiency

**Phillip McCalman**[1] · **Frank Stähler**[2,3,4] · **Gerald Willmann**[5,6]

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## Abstract

This paper models the competition for a domestic market between one domestic and one foreign firm as a pricing game under incomplete cost information. As the foreign firm incurs a trade cost to serve the domestic market, it prices more aggressively, giving rise to the possibility of an inefficient allocation. In spite of asymmetric information, we can devise a contingent trade policy to correct this potential market failure. National governments, however, make excessive use of such a policy due to rent shifting motives, thus creating another inefficiency. The expected inefficiency of national policy is found to be comparatively larger (lower) at low (high) trade costs. Hence contingent trade policy conducted by national governments is preferred only when trade costs are high.


**Keywords** Asymmetric information · Contingent trade policy · Efficiency

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✉ Phillip McCalman
pmccalman@gmail.com

Frank Stähler
frank.staehler@uni-tuebingen.de

Gerald Willmann
gwillmann@wiwi.uni-bielefeld.de

1 Department of Economics, University of Melbourne, Victoria 3010, Australia

2 School of Business and Economics, University of Tübingen, Mohlstr. 36 (V4), 72074 Tübingen, Germany

3 University of Adelaide, Adelaide, Australia

4 CESifo, Munich, Germany

5 Department of Economics, University of Bielefeld, Universitätsstr. 25, 33615 Bielefeld, Germany

6 IfW Kiel, Kiel, Germany

## 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, despite the apparent legitimacy afforded by an inquisitional methodology, these policies tend to be criticized for the malleable nature of the criteria employed and their resulting excessive use. 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 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 become less transparent. In this setting it is possible to have a market failure that cannot be adequately addressed by government

[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 a 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.

intervention. It is this environment of asymmetric information in which we couch our analysis.[4]

To help fix ideas consider the steel industry, a frequent user of contingent protection.[5] Many dimensions on the cost side for steel producers display location specific idiosyncrasies: material prices, energy prices and other local bottle-necks or benefits. The demand side is also relatively lumpy. For example, the laying of a new gas and fuel pipeline in West Texas generates a fixed volume of demand for steel that is also period specific. The homogeneous nature of products (reinforced steel bar, pipes, etc) and lumpy demand tend to make for a relatively competitive setting. Moreover, many of the requests for contingent protection in the steel industry revisit the same product from the same source country, but at a different point in time.[6] This suggests that the relevant shocks tend to be transitory in nature.

To capture these features we develop a duopoly model of international competition where neither firm is reliably informed of the other's cost structure.[7] 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).[8] The virtue of this set-up is that under either complete information or asymmetric information with symmetric cost distributions 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.[9] 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, 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

[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] Steel cases represent over half of the demands for contingent protection in the USA.

[6] Supply-side uncertainty also seems to have played a role in the softwood lumber industry which has also given rise to a series of disputes between the US and Canada. Canadian supply is subject to the wood boring beetle and hence affected by stochastic shocks over time.

[7] For empirical evidence of firms operating in a stochastic environment, see Hillberry and McCalman (2016).

[8] See Spulber (1995).

[9] Shipping costs in the steel industry are non-trivial.

pronounced, representing up to 15% of ex ante surplus. Second, the foreign firm prices more aggressively abroad than in its local market, i.e., dumping occurs.[10]

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.[11] 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 rule for intervention still enable such an inference to be drawn?[12]

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 governments 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 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

[10] 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. In our setting here, it simply means that the foreign firm is less aggressive in its home market than in the domestic market when it competes against the domestic firm in both markets simultaneously. Due to symmetry, we may confine the analysis to one (domestic) market only.

[11] 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. See McCalman (2010) and McCalman (2018) for an analysis of trade and trade policy where firms have incomplete information about consumer valuations.

[12] 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 firm behavior.

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; Blonigen and Prusa 2003, 2016). 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.[13] 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 undermine 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 an unconditional policy, whereas the emphasis in this paper is on conditional policy. Note also that we take the option of contingent trade intervention as a fact of life; we do not scrutinize an optimal mechanism as an alternative.

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 in case of quantity competition but a uniform policy in case of price competition. Maggi (1999) demonstrates that allowing non-linear trade policy instruments when firms know more about market conditions can accentuate inefficiencies relative 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.

[13] 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 et al. (2010) and Maggi and Staiger (2009, 2011, 2014). For a model with costly state-verification, see Beshkar and Bond (2017).

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 Sect. 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 Sect. 4, we analyze the policy a national government seeking to maximize national welfare would enact, and Sect. 5 compares it to the laissez-faire case. Section 6, 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.[14]

[14] To arrive at this figure, we use Bown's (2007) anti-dumping database to identify the HS10 codes for anti-dumping cases initiated in the US. Since the Broda and Weinstein (2006) estimates 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 are not.

There are approximately 800 HS10 codes that have been involved in US anti-dumping cases with a mean

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. However, each firm $i$ knows that its rival firm $j$ has drawn its production cost $c_j$ from the 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). This is a real resource cost due to necessary transboundary transport (and not a tariff). There is substantial evidence that this trade cost is not of the iceberg type but a per unit cost (see Hummels and Skiba 2004; Irarrazabal et al. 2015), and this is the reason why we consider a specific trade cost $t$. 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 $\epsilon$, 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 a 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. This is a market-specific entry cost to the domestic market after the firm has learned its production cost.[15] 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.[16] 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 strictly increasing in costs. This implies that there exist inverse pricing functions that are in turn strictly increasing in prices. 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

Footnote 14 (continued)

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).

[15] We could also accommodate a firm-specific entry cost prior to the cost realization.

[16] 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 expectation on costs as induced from announced prices and 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 $\epsilon$, 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 |

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:

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

where the first term in each expression on the RHS is the probability of winning the market, and the second term 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:

$$\begin{aligned} (1 - F_2(\phi_2(p_1))) - f_2(\phi_2(p_1))\phi_2'(p_1)(p_1 - c_1) &= 0, \\ (1 - F_1(\phi_1(p_2))) - f_1(\phi_1(p_2))\phi_1'(p_2)(p_2 - c_2 - t) &= 0, \end{aligned} \tag{2}$$

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 $\gamma$ 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 firm 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., $\epsilon \to 0$.

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:*

$$
\begin{aligned}
p_1(c_1) &= 1 - \frac{\sqrt{1+(1-c_1)^2 K_1} - 1}{(1-c_1)K_1}, \\
p_2(c_2) &= 1 - \frac{\sqrt{1+(1-[c_2+t])^2 K_2} - 1}{(1-[c_2+t])K_2},
\end{aligned}
\tag{3}
$$

*where*

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

***Proof*** See “Appendix 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:[17]

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

Returning to the case of a strictly positive trade cost, Fig. 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

[17] To see this, note that $K_i$ goes to zero as $t$ goes to zero and apply l’Hôpital’s rule.

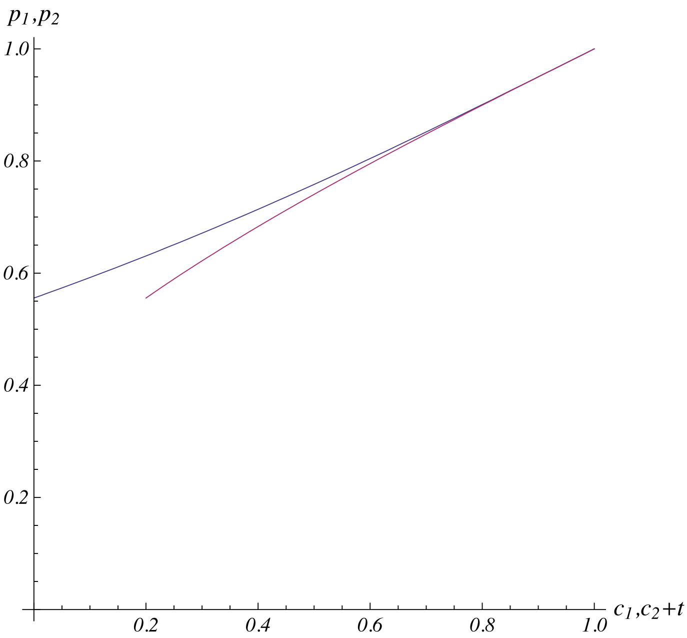


**Fig. 1** Equilibrium price functions for $t = 0.2$

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 2". □

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.[18] 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

[18] Given the 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 3" 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.

is inefficient whenever $p_2 < p_1$ and $c_2 + t > c_1$. Notice that the opposite case could hypothetically arise as well, i.e., the home firm serves the market despite having higher cost. While we do not exclude this possibility, it cannot arise in equilibrium here since we found the foreign (domestic) firm to price more (less) aggressively.

Given that the model admits the possibility of an inefficient outcome it is natural to consider the likelihood of this result. “Appendix 4” shows that the probability of an inefficient trade is given by:

$$\text{Prob}\,(p_2 < p_1 \wedge c_2 + t > c_1) = \frac{t}{2}\left(\frac{1-t}{2-t}\right). \tag{4}$$

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:

$$\frac{\partial\, \text{Prob}\,(p_2 < p_1 \wedge c_2 + t > c_1)}{\partial t} = \frac{t^2 - 4t + 2}{2(t^2 - 4t + 4)}. \tag{5}$$

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 Fig. 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.

Consequently, 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

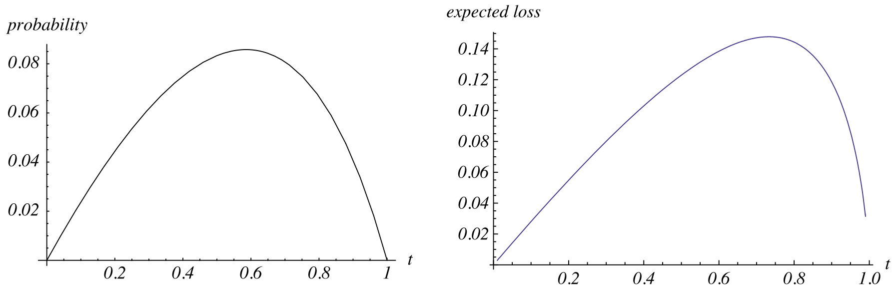


**Fig. 2** Probability and conditional expected loss under Laissez-faire

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.[19]

## 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 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 on the range of costs where both firms are active 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.

[19] 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).

How can the global planner achieve a globally optimal policy? First,the global policymaker announces monotonically increasing pricing functions $p_1^*(\gamma_1)$ and $p_2^*(\gamma_2)$ which specify her beliefs about both firms' costs. They imply that if firm 1 charges price $q_1$, the policymaker will infer that firm 1 has a cost of $\gamma_1 = p_1^{*-1}(q_1)$. Similarly, if firm 2 charges price $q_2$, the policymaker will infer that firm 1 has a cost of $\gamma_2 = p_2^{*-1}(q_2)$ such that the government believes that the foreign firm's overall cost is $\gamma_2 + t$. The policymaker will now act on the basis of these observed prices and the consequent beliefs about costs which she infers. In view of global efficiency, the policymaker wants the lower-cost firm to win the market. Consequently, she will intervene in two cases:

(i) if $p_1^* < p_2^*$ and $\gamma_1 > \gamma_2 + t$, she will tax the domestic firm prohibitively such that the foreign firm is awarded the market and can realize its price $p_2^*$;
(ii) if $p_2^* < p_1^*$ and $\gamma_1 < \gamma_2 + t$, she will impose a prohibitively high tax on the foreign firm 2 such that the domestic firm 1 wins the market and can realize its price $p_1^*$.

Note that it is in this last case that we usually see the use of a contingent trade policy which corrects the potential inefficiency that may arise under laissez-faire. The first case, by contrast, did not arise under laissez-faire, as the foreign firm was always the more aggressive bidder. However, we need to take this possibility into account as well—just as we did allow for it in the previous section—because the global policymaker would certainly want to correct any inefficiency no matter which way it goes.

We now proceed to demonstrate that these monotone price functions do in fact exist, and that it is in the best interest of each firm to reveal its cost truthfully to the global policymaker.

Consider the foreign firm whose true cost is $c_2$. It faces a policymaker who will infer the firm's cost according to the announced belief that $p_2^*(\gamma_2)$. By choosing a price, the firm thus induces a belief on part of the policymaker that it is of type $\gamma_2$. We can thus think of the foreign firm as choosing a type $\gamma_2$, and write the foreign firm's expected profit (conditional on entry) as a function of the choice variable $\gamma_2$ (its announced type) and its true cost realization $c_2$:

$$\pi_2(\gamma_2;c_2) = \text{ Prob } (t < c_1) \times (1 - F_1(\gamma_2 + t)) \times (p_2^*(\gamma_2) - (c_2 + t)).$$

The first factor is the (constant) probability that the trade cost is less than the domestic firm's cost realization which presupposes that the domestic firm will truthfully reveal its cost to the policymaker via the domestic price. The second factor is the probability of the foreign firm winning the market which depends on its cost signal, and the last factor is the profit of winning the market which depends on the true cost. The foreign firm chooses the announced cost type $\gamma_2$ in order to maximize its expected profit. The resulting first-order condition is thus:

$$\left(\frac{1}{\text{Prob } (t < c_1)}\right)\frac{\partial \pi_2(\gamma_2;c_2)}{\partial \gamma_2} = (1 - (\gamma_2 + t))p_2'(\gamma_2) - (p_2(\gamma_2) - (c_2 + t)) = 0. \tag{6}$$

In equilibrium, the foreign firm should find it optimal to price in line with the policymaker's belief. That is, it has to be optimal for any foreign cost type to reveal its type truthfully to the domestic government. Incentive compatibility therefore implies:

$$\frac{\partial \pi_2(\gamma_2 = c_2; c_2)}{\partial \gamma_2} = (1-(c_2+t))p_2'(c_2) - (p_2(c_2)-(c_2+t)) = 0, \quad \forall c_2 \in [0, 1-t]. \tag{7}$$

Solving this differential equation (7) yields:

$$p_2(c_2) = \frac{K_2 - tc_2 - c_2^2/2}{1-(c_2+t)},$$

where $K_2$ denotes the constant of integration. Furthermore, notice that the above condition (7), for $\gamma_2 = c_2 = 1-t$, implies that $p_2(1-t) = 1$. Solving for $K_2$ and using this boundary condition, we obtain $K_2 = (1-t^2)/2$. The resulting pricing function is then:

$$p_2^*(c_2) = \frac{1+c_2+t}{2}. \tag{8}$$

Note that $p_2(c_2) - (c_2+t) \geq 0, \forall c_2 \in [0, 1-t]$, so the participation constraint is satisfied for all cost types. As for the domestic firm, we can apply the same line of reasoning for the case of $c_1 \in [t, 1]$. If $c_1 \in [0, t]$, the foreign firm cannot undercut the domestic firm, and therefore the domestic firm will charge the same limit price if it has such a low cost draw:

$$p_1^*(c_1) = \begin{cases} \dfrac{1+t}{2} & \text{if } c_1 \in [0,t], \\ \dfrac{1+c_1}{2} & \text{if } c_1 \in [t,1]. \end{cases} \tag{9}$$

Note that the government will not learn the type of the domestic firm in the range $c_1 \in [0, t]$ (as the function is not strictly increasing in this range), but only that it is in this range. However, this is not a problem as the government can be sure that the domestic firm is the lower-cost firm in this case. We summarize our results as follows:

**Proposition 1** *If Assumptions 1 and 2 hold and the government announces an intervention based on price functions $p_1^*(\gamma_1)$ and $p_2^*(\gamma_2)$ as of (8) and (9), a perfect Bayesian Nash equilibrium exists in which firm 2 enters if $c_2 \leq 1-t$ and, in case of entry, the equilibrium pricing functions are given by* (8) and (9).

Proposition 1 shows that both firms use symmetric pricing functions across the common range of (overall) costs. We thus know that intervention will never occur under this policy regime. 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, the inefficiency can no longer arise in equilibrium. The policy is therefore 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 over the common range of (overall) costs. The policymaker can thus infer which firm has the lower cost and hence the policy is feasible.

The reader might wonder why the foreign firm, pricing higher under this regime than it would without policy, does not want to deviate to a lower price if it could do so without detection. The reason is that the pricing functions under laissez-faire are the result of the maximization of expected profits with respect to own price. This optimization for all possible cost types yields the equilibrium pricing functions which represent optimal decisions dependent on the type. In the case of a globally optimal policy, pricing functions play a slightly different role: they are put forward by the policymaker to be used to infer the costs from announced prices. Each firm now maximizes by choosing its cost signal given price functions announced by the government. So the price functions under laissez-faire originate from the profit maximization over prices by the two firms. Under the global policy regime, they originate from the policymaker aiming to learn the true costs.[20]

## 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 solely if its price (not only its cost) lies 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 gets to serve the market at its proposed price. 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

[20] The policymaker's main interest is that the induced price signal should be truthful. The price itself is of lesser importance, given that the price effects on consumer surplus and on profit exactly offset each other under inelastic demand.

domestic policy mitigates or exaggerates the inefficiencies associated with market failure.

As before, we start from the premise (to be verified later) that the pricing functions are strictly increasing so that observing the bids allows the policymaker to infer the respective costs. In fact, under the nationally optimal policy regime, the domestic policymaker announces a strictly increasing pricing function $\tilde{p}_1(\gamma_1)$ only for the domestic firm. The policymaker does not need a pricing function to infer the cost of the foreign firm, as she will allow the foreign firm to win the market only if the foreign firm charges a *price* which is less than the domestic cost realization. Giving the market to the foreign firm increases national welfare only if the foreign price is lower than domestic cost because only then does the increase in consumer surplus dominate the loss of domestic profit. Suppose that the foreign firm assumes that the domestic firm reveals its true cost type to the domestic policymaker (to be confirmed in equilibrium), then the foreign firm's expected profit (conditional on entry) amounts to:

$$\pi_2(p_2) = \text{ Prob } (p_2 < c_1) \times (p_2 - (c_2 + t)) = (1 - p_2) \times (p_2 - (c_2 + t)),$$

and maximization leads to the following first-order condition, and the resulting pricing function of the foreign firm:

$$\frac{\partial \pi_2(p_2, c_2)}{\partial p_2} = 1 - 2p_2 + (c_2 + t) = 0 \Rightarrow \tilde{p}_2(c_2) = \frac{1 + (c_2 + t)}{2}. \tag{10}$$

The domestic firm correctly anticipates this foreign pricing behavior and knows that it will win the market only if its cost *signal* $\gamma_1$ is less than the foreign price. Consequently, the domestic expected profit is equal to:

$$\pi_1(\gamma_1;c_1) = \text{ Prob } (\gamma_1 < p_2) \times (\tilde{p}_1(\gamma_1) - c_1).$$

Given the foreign pricing behavior (10), we can compute

$$\begin{aligned} \text{Prob } (\gamma_1 < p_2) = \text{Prob } \left(\gamma_1 < \frac{1 + (c_2 + t)}{2}\right) \\ \text{Prob } \big(c_2 > 2\gamma_1 - (1 + t)\big) = \min \big\{1 - F_2(2\gamma_1 - (1 + t)), 1\big\} \\ \min \left\{1 - \frac{2\gamma_1 - (1 + t))}{1 - t}, 1\right\} = \min \left\{\frac{2(1 - \gamma_1)}{1 - t}, 1\right\}. \end{aligned}$$

We thus have two cases:

1. If the domestic firm's cost signal $\gamma_1$ is such that

   $$\gamma_1 > \frac{1 + t}{2},$$

   the domestic firm signals a cost which could be larger than the foreign price. In this case, the domestic firm's expected profit is equal to:

$$\pi_1(\gamma_1;c_1) = \frac{2(1-\gamma_1)}{1-t}(\tilde{p}_1(\gamma_1) - c_1),$$

and this yields the following first-order condition:

$$\left(\frac{1-t}{2}\right)\frac{\partial \pi_1(\gamma_1;c_1)}{\partial \gamma_1} = (1-\gamma_1)\tilde{p}_1'(\gamma_1) - (\tilde{p}_1(\gamma_1) - c_1) = 0.$$

In equilibrium, it needs to be true that it is optimal for any domestic cost type to reveal its type truthfully to the policymaker. So incentive compatibility requires:

$$\left(\frac{1-t}{2}\right)\frac{\partial \pi_1(\gamma_1 = c_1;c_1)}{\partial \gamma_1} = (1-c_1)\tilde{p}_1'(c_1) - (\tilde{p}_1(c_1) - c_1) = 0, \quad \forall c_1 \in \left[\frac{1+t}{2}, 1\right]. \tag{11}$$

Solving this differential equation (11) yields:

$$\tilde{p}_1(c_1) = \frac{2K_1 - c_1^2}{2(1-c_1)},$$

where $K_1$ denotes the constant of integration. We note that for $\gamma_1 = c_1 = 1$ the first-order condition implies that $\tilde{p}_1(c_1 = 1) = 1$. Using this boundary condition to solve for $K_1$, we obtain $K_1 = 1/2$, and the pricing function of the domestic firm then takes the form:

$$\tilde{p}_1(c_1) = \frac{1+c_1}{2} \quad \text{if } c_1 > \frac{1+t}{2}. \tag{12}$$

Note that $\tilde{p}_1(c_1) - c_1 \geq 0, \forall c_1 \in [(1+t)/2, 1]$, so the participation constraint is satisfied for all cost draws in this range. Furthermore, since the pricing functions of both firms are symmetric in this range, intervention will not occur. However, this case is less likely to occur than the second case to which we now turn.

2. If the the cost signal is such that

$$\gamma_1 \leq \frac{1+t}{2},$$

the domestic firm always wins the market. In this case, the expected profit of the domestic firm is equal to:

$$\pi_1(\gamma_1;c_1) = \tilde{p}_1(\gamma_1) - c_1,$$

and the resulting first-order condition,

$$\frac{\partial \pi_1(\gamma_1;c_1)}{\partial \gamma_1} = \tilde{p}_1'(\gamma_1) > 0,$$

indicates that the domestic firm will want to charge the highest possible price. For any cost draw in this range, it thus charges the same (maximum) price that keeps the foreign firm's win probability at zero. This is guaranteed by the following limit price:

$$\tilde{p}_1\left(c_1 = \frac{1+t}{2}\right) = \frac{1 + \frac{1+t}{2}}{2} = \frac{3+t}{4} \quad \text{if } c_1 \leq \frac{1+t}{2}. \tag{13}$$

Note that the government will not learn the type of the domestic firm in this range, but only that it falls into this range. However, it does not need to as it knows that the domestic firm will have a cost lower than the foreign price. We summarize our findings as follows:

**Lemma 3** *If the foreign firm of type $c_2 \in [0, 1-t]$ enters, and the national policymaker announces a policy intervention based on price functions $\tilde{p}_1(\gamma_1)$ as of* (12) *and* (13), *a perfect Bayesian Nash equilibrium exists and consists of the pricing functions given by* (10), (12) *and* (13).

An intriguing feature of equilibrium behavior relates to the circumstances in which the domestic government exercises its contingent trade policy. In particular, when competition between the domestic and foreign firm is relatively close in terms of announced prices, then whenever the foreign firm has the lower price, the domestic government will intervene and award the market to the domestic firm. In contrast, when the foreign firm has a clear cost advantage, so much so that its announced price is below the revealed cost of the domestic firm, a policy of no intervention is chosen by the government. This suggests that contingent protection is not a win at all cost instrument, and most likely to be applied when price differences are relatively small.

Another interesting observation is that the results are strategically equivalent to forcing the foreign firm to announce its price first, making it a von Stackelberg leader. The domestic firm as a von Stackelberg follower will underbid the foreign firm only if its cost is less than the foreign price. The equivalence demonstrates some similarity of the nationally optimal policy with strategic trade policy. While strategic trade policy makes the domestic firm behave as if it were a von Stackelberg leader, in our context, it is a von Stackelberg follower that is also the more favorable role. The nationally optimal policy ensures also that the domestic firm wins if its cost is below the foreign price.

As for the government going first when announcing the function it will use to infer cost, one example that supports our assumption is the practice of of "zeroing", whereby an AD/CVD authority lays down ex ante which prices it will (and will not) use in establishing "dumping". As is widely recognized the practice of setting to zero (or zeroing) every positive difference (when the price in the market concerned is higher than the domestic price of the foreign player) is intended to bias the process toward finding "dumping" even in cases where the foreign firm is the lowest cost location, thus favoring the local firm. Moreover, "zeroing" is particularly important in cases where the actual price difference between the local and foreign firm is relatively small.

## 5 Comparison of regimes

We may now compare the pricing functions under the nationally optimal policy with those under the other two regimes. For a comparison with the laissez-faire pricing functions (3) of Sect. 2, it proves helpful to define:

$$p(\delta, K) = 1 - \frac{\sqrt{1 + (1-\delta)^2 K} - 1}{(1-\delta)K}$$

in order to capture both $p(\delta = c_1, K = K_1) = p_1(c_1)$ and $p(\delta = c_2 + t, K = K_2) = p_2(c_2)$. We observe that

$$\lim_{K \to 0} p(\delta, K) = \frac{1+\delta}{2} \text{ and } \frac{\partial p}{\partial K} = \frac{\left(\sqrt{(1-\delta)^2 K + 1} - 1\right)^2}{2(1-\delta)K^2\sqrt{(1-\delta)^2 K + 1}} > 0.$$

We take note that both laissez-faire pricing functions coincide with symmetric pricing for $K = 0$. Since $K = 0$ when $t = 0$, and because $K_1$ increases with $t$ while $K_2$ decreases with $t$, the above derivative implies that for $t > 0$ we have:

$$p_1(c_1) > \frac{1 + c_1}{2},$$
$$p_2(c_2) < \frac{1 + c_2 + t}{2},$$

One can see that the foreign firm prices less aggressively in case of potential intervention by the domestic policymaker. The reason is that a somewhat lower price will not be sufficient to win the market, as the price would have to be less than the domestic cost. Firm 1, by contrast, follows the symmetric pricing strategy under the national policy regime only if its cost is sufficiently high, that is, if $c_1 > (1 + t)/2$. In this case, its pricing strategy is more aggressive compared to the laissez-faire outcome as the foreign firm does have a chance to win the market, and the domestic firm would like to keep the probability of losing the market small by means of aggressive pricing. Compared to the pricing functions (8) and (9) that are obtained under the globally optimal policy, the range of symmetric pricing is more limited under national policy. Symmetric pricing occurs only for $c_1 > (1 + t)/2$ while under the globally optimal policy it occurs for any $c_1 > t$.

The most important difference to the global policy regime, however is that an intervention may actually occur under national policy. Since the intervention will occur if the domestic firm's cost lies below the foreign price, but not the foreign cost, the nationally optimal policy may give rise to a new, potential (global) inefficiency: The domestic firm may win the market even though it has the higher cost. This cannot occur in the (limited) range of symmetric pricing, but it may if $c_1 < (1 + t)/2$ (the more likely case). As under laissez-faire, we thus again have the possibility of an inefficient outcome; that is, the higher cost firm ends up serving the market. Contrary to the laissez-faire case, however, it will be the domestic firm

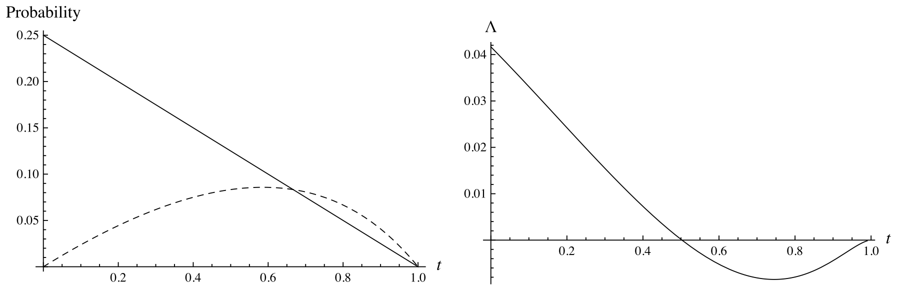


**Fig. 3** Comparison of probabilities and expected losses

that might end up serving the market despite having the higher cost. The reason for this is that national policy favors the domestic firm out of a rent shifting motive. The market failure that we identified under laissez-faire is thus replaced by a new (global) inefficiency brought about by the policy intervention of the national government. Only that this new type of inefficieny goes the other way.

To gain some insight into the likelihood of this scenario, "Appendix 5" shows that the probability of an inefficient outcome (conditional on entry by the foreign firm) is given by $(1 - t)/4$. This enables us to compare the probabilities of the inefficient outcomes in the laissez-faire equilibrium (see the dashed line in Fig. 3's left panel) and for the nationally optimal policies (see the solid line in Fig. 3's left panel) respectively. In the right panel, $\Lambda$ 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. We summarize our results in

**Proposition 2** *The global allocative inefficiency implied by the nationally optimal policies is larger (smaller) than the global allocative inefficiency of the laissez-faire equilibrium if trade costs are low (large).*

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.

## 6 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.

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## Appendix 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 $\gamma$ below. Given that the domestic firm knows the size of $\epsilon$ 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 $\gamma$. 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 (2) are fulfilled for all $p_i \in [\underline{p}, \overline{p}]$. We will now establish that

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

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

$$\begin{aligned} \gamma - \phi_2(p_1) - \phi_2'(p_1)(p_1 - c_1) &= 0, \\ 1 - \phi_1(p_2) - \phi_1'(p_2)(p_2 - c_2 - t) &= 0. \end{aligned}$$

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

$$(\phi_2'(p) - 1)(p - \phi_1(p)) = \gamma - \phi_2(p) - p + \phi_1(p),$$
$$(\phi_1'(p) - 1)(p - \phi_2(p) - t) = 1 - \phi_1(p) - p + \phi_2(p) + t.$$

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:

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

Equations (A.2), (A.7) and (A.8) completely describe the equilibrium behavior of both firms in terms of their inverse price functions.[21] 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 $\gamma$ which will be indifferent between entry and no entry. This type's expected profit must be equal to the investment $\epsilon$ 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 $\epsilon$ 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 (A.11) and solving for $p$ yields (3).

[21] 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.

## Appendix 2: Proof of Lemma 2

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 (3) equal to each other gives

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

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

$$\begin{aligned} &(1-c_1)\left(1 - \frac{1-c_1}{\sqrt{\frac{1-(2-t)\,t\,\left(2-c_1\right)c_1}{(1-t)^2}}}\right) \geq 0 \\ \Leftrightarrow &\sqrt{\frac{1-(2-t)\,t\,\left(2-c_1\right)c_1}{(1-t)^2}} \geq 1 \\ \Leftrightarrow &\, 1-(2-t)t(2-c_1)c_1 \geq (1-t)^2. \end{aligned} \tag{A.13}$$

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.

## Appendix 3: 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 $x(1) = 0$ (Fig. 4).

The expected profit functions of the domestic and foreign firm then take the following form:

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

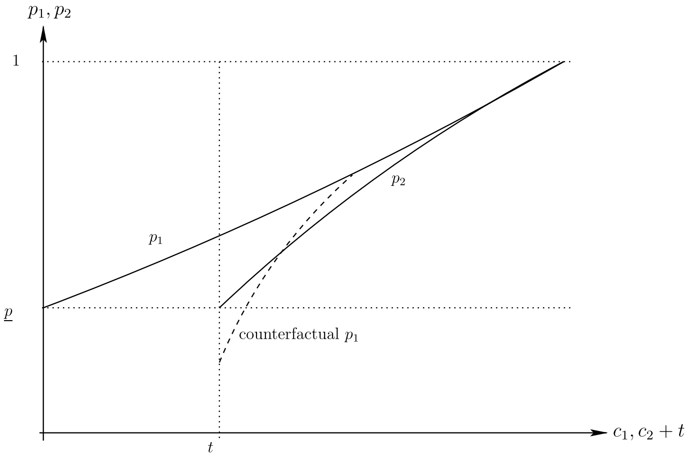


**Fig. 4** Pricing functions

and the corresponding first-order conditions of profit maximization are:

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

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:

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

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.

## Appendix 4: Probability of an inefficiency

The probability of inefficiency can be best derived from two graphs in the $c_2 - c_1-$ space. Figure 5 shows Eq. (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 $1/(1 - t)$:

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

## Appendix 5: Inefficiency under national policy

We want to calculate the probability of inefficiency in the case of national policy. National policy intervenes if $p_2 < p_1$ and $p_2 > c_1$. The intervention awards the market to the domestic firm, which is inefficient (from a global perspective) if $c_1 > c_2 + t$. The cost combinations that satisfy these three conditions are depicted by the color-shaded area in Fig. 6. Under the assumption of independent uniform

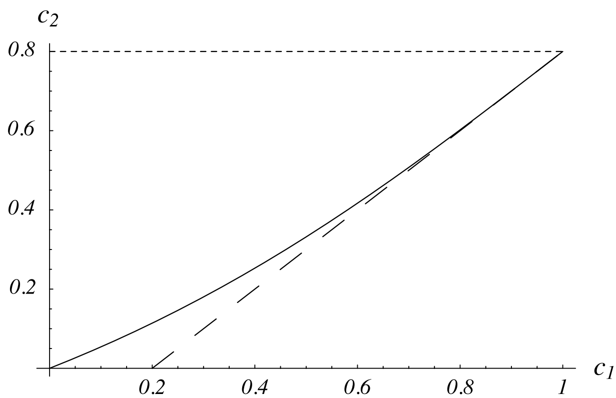


**Fig. 5** Inefficiency in the laissez-faire equilibrium

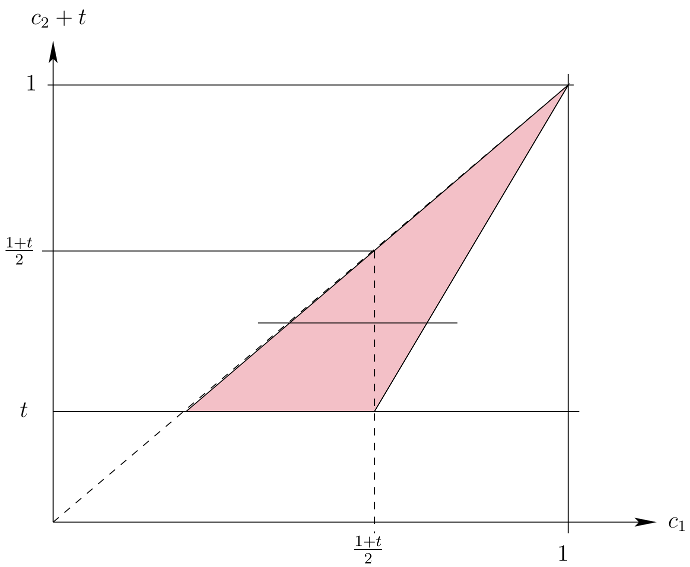


**Fig. 6** Inefficiency under national policy

distributions, the probability of inefficiency (unconditional on entry) amounts to the size of the color-shaded area, that is:

$$\frac{(1-t)^2}{2} - \frac{(1-(1+t)/2)(1-t)}{2} = \frac{(1-t)^2}{4}$$

The probability conditional on entry by the form firm is thus $(1-t)/4$.

In order to calculate the expected inefficiency (conditional on entry), we integrate the distance from the diagonal over the shaded area (where the inner integral is horizontal along the line depicted in Fig. 6) and divide by the probability of entry:

$$\frac{1}{1-t}\int_{c_2=0}^{1-t}\int_{c_1=c_2+t}^{(c_2+t)/2+1/2}(c_1-(c_2+t))dc_1dc_2 = \frac{1/24 - t/8 + t^2/8 - t^3/24}{1-t}.$$

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