DISCUSSION PAPER

Optimal Tariffs and Firm Technology Choice: An Environmental Approach

Nico Steffen

November 2016

Optimal Tariffs and Firm Technology Choice: An Environmental Approach

Nico Steffen[*]

Heinrich Heine University of Düsseldorf, Germany

Düsseldorf Institute for Competition Economics (DICE)

November 2016

Abstract

This paper analyzes environmental concerns by a government in a setting of rent-extracting strategic trade policy with endogenous firm investment into production technologies. The simple analysis highlights the importance of investment incentives caused by tariffs in general and shows that the resulting implications for the optimal tariff decision can be completely different between traditional tariff considerations and an environmentally conscious government. We show that an importing country in a dynamic setting with endogenous firm technology choices prefers to impose discriminatory tariffs both ex post and ex ante when emissions matter, while a commitment to uniform tariffs is optimally chosen when environmental concerns do not play a role.

Keywords: Climate policy; Carbon tariffs; Technology choice; Discriminatory tariffs.

JEL Classification Numbers: F13, F18, D24, Q58.

1   Introduction

For years, countries under the umbrella of the World Trade Organization (WTO) have concurred to promote a cooperative trade outcome and to punish those that unduly try to extract rents from importing firms through trade restrictions. The most favored nation (MFN) clause to prevent discrimination between trading partners is often regarded as the fundamental pillar of the WTO and the General Agreement on Tariffs and Trade (GATT) and exhibits several potentially welfare-improving features (see e.g. Choi, 1995, Saggi, 2004)[1].

A real agreement over global climate policy, however, has not been achieved as of yet. While alarms about environmental damage, climate change and the like are undoubtedly a major and rising global concern, they do not appear to be of equally high priority for all countries so far. Even within OECD countries, for instance, stark differences in terms of the extent of environmental policies are still present (Botta & Koźluk, 2014) and even more so for less integrated countries. Countries that *have* decided on a need to impose carbon reduction mechanisms are nonetheless concerned about the competitiveness of local firms and about the possibility of "carbon leakage" (cf. Babiker, 2005) when other countries do not implement similar policies. If production simply moves to jurisdictions where no environmental measures such as a carbon reduction program are in place, potential reductions in the home country can be nullified or even surpassed. To compensate for arising problems like these, despite years of politicians and scholars promoting trade liberalization, many are suggesting the increased use of differentiating measures again (e.g. Stiglitz, 2006, Ismer & Neuhoff, 2007); one of these being tariffs based on imports' carbon emissions as a relatively effective measure with the least prospect of legal and practical barriers (cf. Böhringer et al., 2014).

In the analysis presented here, we consider a model setting of rent-extracting strategic trade policy in oligopolistic competition in the spirit of Brander & Spencer (1984a, 1984b) with endogenous firm investment into production technologies. A main focus lies on the importance of providing dynamic innovation incentives to firms and considering imperfect

---

[1]Also cf. Horn & Mavroidis (2001) for a broad economic and legal survey on the MFN clause.

competition à la Cournot[2]. In a simple analysis of a government additionally considering environmental damages caused in the production process of foreign exporters, we will show that the results of traditional tariff considerations dealing with standard production costs need not necessarily apply any longer. The result of Choi (1995) that a commitment to uniform tariffs by a MFN clause provides higher incentives for foreign firms to invest into cost-saving technologies is turned around in the environmental setting presented here. We will show that discriminatory tariffs are optimal for the tariff-setting government both in the short and in the long-run view with respect to foreign firms' emission reduction incentives.

Section 2 of this paper starts by re-collecting the standard marginal cost results for comparative purposes. Then, we adjust this model to fit into the environmental context and results are derived and compared. The environmental model is then extended by adding a third firm from the home market. Concluding remarks follow.

2   Carbon Tariff Model

2.1   The Model by Choi (1995)

The setup used in the paper builds on the model introduced by Choi, which we briefly compare here in order to directly compare the results and highlight the arising differences.

We consider a three-stage game played between a government in a home country and two foreign firms located in different countries. All sales and consumption can only occur in the home country. Firms are symmetric ex ante, and we consider the case of linear demand $P = a - bQ$ where $Q = q_1 + q_2$.

In the first stage of the game, firms can choose their technology determining its respective costs c_1 and c_2. In the non-environmental setup, spending a higher sunk fixed cost achieves lower marginal production costs in this technology investment stage. This relationship is

---

[2]Following Kreps & Scheinkman (1983), we assume that the results hold under Bertrand competition as well when taking into account a preceding capacity build-up before price competition takes place. In a trade context, this sequence appears particularly plausible.

represented by the function $F = \Phi(c)$ and we only need to assume $\Phi' < 0$ to capture the mentioned trade-off. In the second stage, the home government decides on the import tariffs t it imposes on the foreign firms. In the last stage, given that technologies and tariffs are in place, the firms compete à la Cournot and the Nash equilibrium is determined.

Solving by backward induction, maximizing both firms' profits, we get intermediate equilibrium quantities of

$$q_i(\mathbf{c};\mathbf{t}) = \frac{a - 2c_i - 2t_i + c_j + t_j}{3b}, \quad i = 1, 2, \quad i \neq j \tag{1}$$

with c_i and t_i being a firm's own cost and tariff to be faced and c_j and t_j representing the competitor's cost and tariff. The government then considers the following welfare function by anticipation of firms' behavior

$$W(\mathbf{t};\mathbf{c}) = CS + t_1 q_1(\mathbf{t}, \mathbf{c}) + t_2 q_2(\mathbf{t}, \mathbf{c}). \tag{2}$$

We consider two different possible ways of setting tariffs. Under a uniform setting, the government sets the same tariff to all countries and firms, while tariffs may vary between different countries under a discriminatory (or preferential) regime. Initially, assume that the government can freely choose between the two. Optimal tariffs are then given for the preferential (t^*) and uniform tariff (t^{**}) regimes by

$$t_i^*(\mathbf{c}) = \frac{2a - 3c_i + c_j}{8}, \quad i = 1, 2, \quad i \neq j \tag{3}$$

$$t^{**}(\mathbf{c}) = \frac{2a - c_i - c_j}{8}. \tag{4}$$

We can see that a government which would observe one low-cost and one high-cost firm, would have an incentive to raise the low-cost firm's tariffs and lower the high-cost firm's tariffs compared to a uniform tariff. Given such an ex post cost structure across firms, it can be shown that it would be welfare-maximizing for a government to set discriminating

tariffs in this way and the effective cost-differential of production costs plus tariffs between a low-cost producer and a high-production-cost firm is reduced by the optimal tariffs.

To see the basic intuition behind this result, we can draw an analogy of the home government as an intermediate supplier to the foreign firms, with the intermediary good being "the right to sell in the home country". A firm with low production costs wants to sell more, therefore has a higher demand c.p. for this right to sell and will exhibit a lower elasticity of demand because of it. This low elasticity can be exploited by the government by charging a discriminating high price, that is, by setting higher tariffs.

We then consider the first-order conditions from the technology choice stage and compare them for the discriminatory (c^*) and the uniform (c^{**}) regime:

$$\Phi'(c^*) = -\frac{3(a - c^*)}{16b} \tag{5}$$

$$\Phi'(c^{**}) = -\frac{5(a - c^{**})}{16b} \tag{6}$$

It follows that $c^{**} < c^*$ in equilibrium. To see this, note that the marginal profit (RHS) of further lowering cost is always higher under the uniform regime at any *given* level of c. This means that firms have stronger incentives to decrease their cost and in the end choose a lower-cost technology when they face uniform tariffs.

This creates a dilemma for the government. It wants to charge discriminating high tariffs to low-cost firms, but in equilibrium both firms choose the same cost level after all, because any firm incentive to unilaterally decrease costs is negated by the expected discriminatory tariff. Therefore, no additional tariff income can be gained compared to uniform tariffs in the static sense. Additionally, because of the investment dynamics, there is a further welfare loss due to firms investing too little in cost reductions when they have to anticipate the possibility of discriminatory tariffs, which results in higher prices for the home consumers. Because tariffs will be de facto uniform in any equilibrium and the mere possibility for the government to opt for preferential tariffs leads to less investment and higher production costs

for firms, the government is better off by restricting itself ex ante from using them.

Here, voluntarily subscribing to a MFN clause and thereby credibly restricting oneself to uniform tariffs, is working as a commitment device to overcome the time-inconsistency problem of ex ante vs. ex post government tariff incentives.

2.2 Environment

We now consider the situation of a government that also pays attention to the environmental damage caused in production. Demand is still given by $P = a - bQ$. As a first step of changing the initial model, we introduce an environmental emission cost e in addition to classic marginal unit costs. There is again a technology, i.e. cost decision, stage with the same assumptions as before, only now firms can decrease their emission level e instead of their raw cost level c by investing. That is, we hold the raw production cost constant at $c = \bar{c}$. For this, consider a situation in which production is already operating at the border of technology in the sense that no further cost improvements in terms of real production costs can be made. However, assume that this current means of production still exhibits an emission cost which can be reduced by investing into, for example, filter vents or recycling techniques of varying qualities. For simplicity, we also normalize to $\bar{c} = 0$ w.l.o.g.

Again, we solve the model by backward induction. In the third stage, firms maximize their profits *given* technologies and tariffs. The home country can demand import tariffs from the foreign firms and tariffs are collected in the form of $T = \sum t_i q_i$. Profits of the foreign firms are then given by

$$\pi_i = (a - b(q_1 + q_2) - t_i)q_i, \quad i = 1, 2 \tag{7}$$

It is important to note that marginal environmental costs e_i do not enter the profit function directly at this point. This nicely represents the externality character of the issue, as firms do not have an inherent incentive to reduce these costs in the absence of external

intervention. We will see that the analyzed tariffs set by the importing country's government will force firms to consider the environmental emission costs they are producing. Here, tariffs are working in an indirect way, providing a potential instrument e.g. when direct governmental regulation is not possible.

Resulting from optimization of Eq. (7), we get the outputs resulting from the third-stage Cournot-Nash game with $\mathbf{t} = (t_1, t_2)$ as

$$q_i(\mathbf{t}) = \frac{a - 2t_i + t_j}{3b}, \quad i = 1, 2, \quad i \neq j. \tag{8}$$

In the second stage, the home government sets tariffs to maximize

$$W(\mathbf{t}) = (1 - u)[CS + t_1 q_1(\mathbf{t}) + t_2 q_2(\mathbf{t})] - u[e_1 q_1(\mathbf{t}) + e_2 q_2(\mathbf{t})], \quad u \in [0, 1). \tag{9}$$

On one hand, it considers the consumer surplus CS in the home country and the tariff revenues it collects from the foreign firms. These "classic" considerations are weighted here by (1-u). The interesting addition here is the latter term that depicts environmental costs like carbon emissions and enters the welfare function negatively. The parameter u therefore measures how much weight the government wants to put on the environmental considerations compared to the classic objectives.

Again, we analyze the potential tariff choices of the home government. Now, under a discriminatory tariff system, welfare maximization and the ensuing first-order conditions yield the following *optimal discriminatory tariffs* denoted by t^*, taking as given the firms' technologies $\mathbf{e} = e_1, e_2$

$$t_i^*(\mathbf{e}) = \frac{2a(1 - u) + 5e_i u + e_j u}{8(1 - u)}, \quad i = 1, 2, \quad i \neq j. \tag{10}$$

Comparing to Eq. (3) from the non-environmental setting nicely shows an important difference: the sign for the own costs e_i is now positive.

In the setting without the environment, the optimal discriminatory tariffs set by the government would decrease the effective cost differential between a high- and a low-cost producer by imposing higher tariffs on the low-cost producer. Thereby, the incentive to invest into cost-reducing research is lowered for all producers[3]. However, when we now look at the tariffs in a situation of a government that cares for environmental costs caused by emission, we can see that firms will be rewarded for lower emissions through lower import tariffs, reinstating the incentive to invest into R&D. Note that the competing importing firm j will also slightly benefit from a reduction of the own costs of i, which can be seen from the positive sign on competitor's costs e_j. This can decrease the incentive to invest to some extent by also allowing a partial free-riding effect. Nevertheless, the positive sign on the competitor's technology is a result that carries over from the non-environmental analysis, but here, the positive effect on being able to reduce the own tariff to be faced clearly outweighs this factor.

Solving for the optimal non-discriminatory tariff t^{**} is straightforward, again from the maximization of welfare with the additional restriction that $t_1 = t_2$ has to hold:

$$t^{**}(\mathbf{e}) = \frac{2a(1-u) + 3e_1 u + 3e_2 u}{8(1-u)}. \tag{11}$$

Looking at the signs for emission costs $\mathbf{e}$ in comparison to the respective cost counterpart $\mathbf{c}$ in Equ. (4) of the initial setting, we see that they are also flipped. This means that lowering one's emissions now has a benefit for a firm in the sense of lowering the tariff to be faced. However, due to the uniform tariff, the effect of lowering the emission cost also benefits the competing importer in the same magnitude. In the non-environmental results, while the effects go in the opposite direction, they are the same for the own firm and the import competitor as well. Considering only the point of view of competition with the other foreign firm, tariffs under a MFN regime play no further role for the firms' considerations on costs,

---

[3]DeGraba (1990) already highlighted this insight analogously for the setting of an input supplier who price discriminates between downstream producers based on their production costs.

neither in the environmental case nor with traditional production costs.

Still, in both cases, firms will have an incentive to lower their own costs, stemming from different channels in the different cases. In the model with classic marginal costs, firms have a general incentive to lower their costs for standard competitive reasons in strategic interaction. Introducing an MFN tariff reduces this incentive by demanding higher tariffs on imports with lower costs, but then equally so for both firms. Under the discriminatory regime, in response to a fall in the cost c_i, tariff t_i is raised even more drastically while t_j on the other firm is actually *decreased*, which dampens investment incentives further as explained in the previous section.

In the environmental case, firms have no inherent incentive to lower their emission costs at all. Introducing tariffs on these emissions can now work to establish this incentive in such a setting. In this case, a MFN tariff will be set in such a way that it already gives some incentive to the importers to lower their costs. While the other importer can actually free-ride and partake in an equal amount on the cost-savings and benefits of the cost-reducing firm, both benefit from lower tariffs.

Here, the optimal tariffs set by a discriminatory regime can lead to even better results in terms of investment incentives by letting the cost-saving firm enjoy a higher benefit in the form of a lower tariff than the competitor. As stated before w.r.t. Eq. (10), the other firm is also allowed a somewhat lower tariff, but the now increasing effective cost differential, which is given here by the tariff differential only, would still allow a single cost-saving firm to expand its output relatively more while forcing the importing competitor to lower its output, as can be seen in the following equation[4] .

$$q_i^*(\mathbf{e}) = \frac{2a(1-u) - 3e_i u + e_j u}{8(1-u)b}, \quad i = 1, 2, \quad i \neq j.$$ (12)

This already hints towards the result that innovation incentives will be higher in the prefer-

---

[4]The arising technical analytical limitations are briefly discussed in the appendix. However, these do not affect the analysis of results for plausible parameter values.

ential setting here.

Finally, we look at the first stage of the game, where technology choices are made. We compare the first-order conditions to now show analytically that in the environmental setup introduced in this paper, indeed lower costs will be chosen under the discriminatory regime, as it has been already claimed intuitively from the comparison of the two setups.

Proposition 1 *Let e^* and e^{**} be the symmetric Nash equilibrium technology choices under the discriminatory tariffs and an MFN clause on carbon tariffs, respectively. Then, under linear demand and a reasonably low environmental weight $u \leq \frac{a}{a+e}$ [5], we get $e^* < e^{**}$. That is, a less carbon emitting and therefore environmentally beneficial technology is chosen by firms in the discriminatory regime.*

Proof. At the technology decision stage, the firms maximize

$$\Pi_i[\mathbf{e}; \mathbf{t}(\mathbf{e})] = \pi_i[\mathbf{e}; \mathbf{t}(\mathbf{e})] - \Phi(e_i) \tag{13}$$

which yields from $\frac{\partial \Pi_i}{\partial e_i} = 0$ and $\Phi'(e_i) = \frac{\partial}{\partial e_i}\pi_i[\mathbf{e}; \mathbf{t}(\mathbf{e})]$ the conditions under the discriminatory tariff regime (e^*) and the MFN regime (e^{**}) respectively:

$$\Phi'(e^*) = -\frac{3}{16}\frac{u}{(u-1)^2}\frac{a(1-u) - e^*u}{b} \tag{14}$$

$$\Phi'(e^{**}) = -\frac{2}{16}\frac{u}{(u-1)^2}\frac{a(1-u) - e^{**}u}{b}. \tag{15}$$

On one hand, it must hold that $\Phi'(e) < 0$ which also implies here that operating profits π_i naturally rise with falling costs. If u is sufficiently low, i.e. in the generally feasible range, the term $a(1-u) - e^*u$ becomes positive and $\Phi'(c) < 0$ is fulfilled. From $\Phi'(c^{e*}) < \Phi'(e^{**})$ for any given e it can be deduced that $e^* < e^{**}$. For a given level of e, marginal additional

---

[5]The low weight u is only needed to generally stay in the range of analytically feasible solutions, see the appendix for the derivation of the condition.

profits from lowering costs are always higher in the discriminatory case. Therefore, marginal profits will surpass the marginal cost from investing in cost reduction for a lower range of e and a lower cost level, here in terms of emission costs, is chosen in the discriminatory equilibrium. ∎

This is in contrast to the case without emissions, where the result was $c^{**} < c^{*}$.

2.3 Home Firm

As a robustness check, we now additionally consider a third firm that is located in the home market. This fits the notion of a country that is interested in reducing emissions and can do so on one hand by introducing a mechanism to guide the emissions by its local firm, but on the other hand has no political reach over the foreign firms except for the border tariffs that it can set on imports. Naturally, the welfare function will consider an additional term stemming from the producer rents of the home firm.

Again, we solve by backward induction and start by looking at the third stage first. There, firms maximize their profits given technologies and set tariffs. Demand is still given by $P = a - bQ$, where now $Q = q_h + q_1 + q_2$.

Profits of the home firm h take the form of

$$\pi_h = (a - b(q_1 + q_2 + q_h) - \bar{e})q_h \tag{16}$$

where $\bar{e}$ represents an at this point exogenously given rate to be paid for emissions by the home firm. One interpretation here is that this rate is assumed to be what emerges from an efficient and well-functioning emission market that is in place in the *home* region, but cannot be employed for *foreign* firms, e.g. due to a lack of political agreements with foreign countries. For simplicity, we also normalize this rate to $\bar{e} = 0$.

As in the previous section, the home country can demand (potentially discriminatory)

import tariffs from the foreign firms. Profits of the foreign firms are then given by

$$\pi_i = (a - b(q_1 + q_2 + q_h) - t_i)q_i, \quad i = 1, 2 \tag{17}$$

In the second stage, the home government sets tariffs to now maximize

$$W(\mathbf{t}) = (1 - u)[CS + \pi_h(\mathbf{t}) + t_1 q_1(\mathbf{t}) + t_2 q_2(\mathbf{t})] - u[e_1 q_1(\mathbf{t}) + e_2 q_2(\mathbf{t})], \quad u \in [0, 1). \tag{18}$$

The first-order conditions solve for the following optimal discriminatory tariffs denoted by t^* and uniform tariffs t^{**} respectively, again taking as given the firms' emission technologies $\mathbf{e} = e_1, e_2$

$$t_i^*(\mathbf{e}) = \frac{6a(1 - u) + 13e_i u + 3e_j u}{20(1 - u)}, \quad i = 1, 2, \quad i \neq j. \tag{19}$$

$$t^{**}(\mathbf{e}) = \frac{6a(1 - u) + 8e_1 u + 8e_2 u}{20(1 - u)}. \tag{20}$$

Tariffs overall are set more aggressively in this setting, which is to be expected. Raising the foreign competitors' costs by the tariffs now has the added advantage of increasing the home firm's profits. In addition, the creation of consumer rent is not solely dependent on foreign firms anymore. Both of these channels tend to increase the foreign tariffs set by the home government.

We can check that the greater investment incentive and therefore lower emissions chosen by the firms are still given by discriminatory tariffs in this extended setting. The first-order conditions at the technology stage are given for the discriminatory tariff regime (e^*) and the MFN regime (e^{**}) respectively by

$$\Phi'(e^*) = -\frac{9}{100} \frac{u}{(u - 1)^2} \frac{a(1 - u) - 4e^* u}{b} \tag{21}$$

$$\Phi'(e^{**}) = -\frac{4}{100} \frac{u}{(u - 1)^2} \frac{a(1 - u) - 4e^{**} u}{b} \tag{22}$$

The relative dominance of investment incentives under the preferential regime is even amplified now that the home firm is taken into account.

3 Concluding Remarks

The simple analysis of a government considering environmental damages caused in the production process of foreign exporters has shown that traditional tariff considerations facing standard production costs need not apply in this case. The result of Choi that an MFN clause provides higher incentives for foreign firms to invest into cost-saving technologies is turned around in the model presented here. Now, discriminatory tariffs are optimal for the tariff-setting government both in the short- and in the long-run view by incentivizing firms' investments into green technologies.

In the setting of investments into a reduction in standard production costs, tariffs overall actually dampened the incentive to engage in R&D that has both a global social benefit as well as a private benefit to the foreign exporters. The mere prospect of the home government potentially charging differentiating tariffs creates a commitment problem in addition, without any ex post benefit. The environmental setting represents a different issue with the foreign firms having no inherent incentive to achieve a reduction in emission costs and creating a negative externality on the home region. Here, tariffs work as an instrument to create an investment incentive for foreign firms in the first place and discriminatory tariffs provide the stronger incentive to reduce emissions even further.

The model implies the suggestion for environmentally conscious governments to drop MFN clauses altogether as an extreme case. There is an ongoing discussion if and in how far discrimination based on environmental aspects indeed might or should be reconciled with WTO guidelines (e.g. Ismer & Neuhoff, 2007, Balistreri et al., 2016). Even potentially risking WTO violation punishments and trade retaliation in the absence of a common agreement and to weigh a potential backlash against possible benefits of decreasing emissions does not

seem to be completely out of the question either (cf. Fouré et al., 2016).

In any case, the effects that can be caused by the investment incentive channel highlighted in the model presented here need to be taken into account when countries decide on both tariff and environmental policy measures.

References

Babiker, M. H. (2005), "Climate change policy, market structure, and carbon leakage", *Journal of International Economics* 65(2), 421-445.

Balistreri, E.J., D.T. Kaffine & H.Yonezawa (2016), "Optimal environmental border adjustments under the General Agreement on Tariffs and Trade", *CER-ETH-Center of Economic Research at ETH Zurich, Economics Working Paper Series* 16/235.

Böhringer, C., Fischer, C., & Rosendahl, K. E. (2014), "Cost-effective unilateral climate policy design: Size matters", *Journal of Environmental Economics and Management* 67(3), 318-339.

Botta, E. & T. Koźluk (2014),"Measuring Environmental Policy Stringency in OECD Countries: A Composite Index Approach", *OECD Economics Department Working Papers* 1177, OECD Publishing, Paris.

Brander, J., & Spencer, B. (1984a), "Tariff protection and imperfect competition", in: H. Kierzkowski, ed., Monopolistic competition and international trade, Oxford University Press.

Brander, J., & Spencer, B. (1984b), "Trade warfare: tariffs and cartels", *Journal of International Economics* 16(3), 227-242.

Choi, J.P. (1995), "Optimal Tariffs and the Choice of Technology: Discriminatory Tariffs vs. the 'Most Favored Nation' Clause", *Journal of International Economics* 38, 143-160.

DeGraba, P. (1990), "Input Market Price Discrimination and the Choice of Technology", *American Economic Review* 80, 1246-1253.

Fouré, J., H. Guimbard & S. Monjon (2016), "Border carbon adjustment and trade retaliation: What would be the cost for the European Union?", *Energy Economics* 54, 349-362.

Horn, H., & Mavroidis, P. C. (2001), "Economic and legal aspects of the Most-Favored-Nation clause", *European Journal of Political Economy* 17(2), 233-279.

Ismer, R., & Neuhoff, K. (2007), "Border tax adjustment: a feasible way to support stringent emission trading", *European Journal of Law and Economics* 24(2), 137-164.

Kreps, D. M., & Scheinkman, J. A. (1983), "Quantity precommitment and Bertrand competition yield Cournot outcomes", *The Bell Journal of Economics*, 326-337.

Saggi, K. (2004), "Tariffs and the most favored nation clause", *Journal of International Economics* 63(2), 341-368.

Stiglitz, J. (2006), "A New Agenda for Global Warming", *The Economists Voice* 3(7), Berkeley Electronic Press.

Appendix

Analytical Restrictions

Let us consider again the equilibrium firm quantities, given the respective optimal tariffs

$$q_i^*(\mathbf{e}) = \frac{2a(1-u) - 3e_i u + e_j u}{8(1-u)b}, \quad i = 1, 2, \quad i \neq j. \tag{23}$$

$$q_i^{**}(\mathbf{e}) = \frac{2a(1-u) - e_i u - e_j u}{8(1-u)b}, \quad i = 1, 2, \quad i \neq j. \tag{24}$$

For values of u approaching 1, the numerators would take on negative values, which is not feasible. The intuition is the following: the more and more a government cares for the environment, the more it will aim to restrict the emission causing production by the importers completely. Therefore, as can be also seen in Equs. (10) and (11), optimal tariffs for u moving towards 1 would approach ∞. In reality, it would suffice for a government to set prohibitively high *finite* tariffs in order to foreclose production and thereby avoid any emissions. More generally, to stay in the relevant range, it needs to hold that

$$q(\mathbf{e}) \geq 0, \tag{25}$$

as negative quantities are not feasible. Here, we impose symmetry of costs w.l.o.g. Due to the ex ante symmetry of importing firms, they will also symmetrically choose their optimal level of costs. This leads to the following condition:

$$2a(1-u) - 2eu \geq 0$$

$$\Leftrightarrow \quad \frac{a}{a+e} \geq u \tag{26}$$

No definite prediction can be made here, but given that a is likely to be quite larger than e, this condition is likely to hold[6]. Any values of $0.5 < u < 1$ would actually mean that a government puts *more* weight on the environmental considerations than on its traditional objectives, i.e. consumer and producer surplus and tax income, which is needed to fulfill its governmental tasks. This is, at least for the moment, very unlikely, so the analysis is very likely to hold under realistic values of a relatively small u.

---

[6]See Choi (1995,p.154) where the assumption $(a - c) = 100$ is made.

PREVIOUS DISCUSSION PAPERS

238   Steffen, Nico, Optimal Tariffs and Firm Technology Choice: An Environmental Approach, November 2016.

237   Behrens, Kristian, Mion, Giordano, Murata, Yasusada and Suedekum, Jens, Distorted Monopolistic Competition, November 2016.

236   Beckmann, Klaus, Dewenter, Ralf and Thomas, Tobias, Can News Draw Blood? The Impact of Media Coverage on the Number and Severity of Terror Attacks, November 2016.
Forthcoming in: Peace Economics, Peace Science and Public Policy.

235   Dewenter, Ralf, Dulleck, Uwe and Thomas, Tobias, Does the 4th Estate Deliver? Towars a More Direct Measure of Political Media Bias, November 2016.

234   Egger, Hartmut, Kreickemeier, Udo, Moser, Christoph and Wrona, Jens, Offshoring and Job Polarisation Between Firms, November 2016.

233   Moellers, Claudia, Stühmeier, Torben and Wenzel, Tobias, Search Costs in Concentrated Markets – An Experimental Analysis, October 2016.

232   Moellers, Claudia, Reputation and Foreclosure with Vertical Integration – Experimental Evidence, October 2016.

231   Alipranti, Maria, Mitrokostas, Evangelos and Petrakis, Emmanuel, Non-comparative and Comparative Advertising in Oligopolistic Markets, October 2016.
Forthcoming in: The Manchester School.

230   Jeitschko, Thomas D., Liu, Ting and Wang, Tao, Information Acquisition, Signaling and Learning in Duopoly, October 2016.

229   Stiebale, Joel and Vencappa, Dev, Acquisitions, Markups, Efficiency, and Product Quality: Evidende from India, October 2016.

228   Dewenter, Ralf and Heimeshoff, Ulrich, Predicting Advertising Volumes: A Structural Time Series Approach, October 2016.

227   Wagner, Valentin, Seeking Risk or Answering Smart? Framing in Elementary Schools, October 2016.

226   Moellers, Claudia, Normann, Hans-Theo and Snyder, Christopher M., Communication in Vertical Markets: Experimental Evidence, July 2016.
Forthcoming in: International Journal of Industrial Organization.

225   Argentesi, Elena, Buccirossi, Paolo, Cervone, Roberto, Duso, Tomaso and Marrazzo, Alessia, The Effect of Retail Mergers on Prices and Variety: An Ex-post Evaluation, June 2016.

224   Aghadadashli, Hamid, Dertwinkel-Kalt, Markus and Wey, Christian, The Nash Bargaining Solution in Vertical Relations With Linear Input Prices, June 2016.
Published in: Economics Letters, 145 (2016), pp. 291-294.

223   Fan, Ying, Kühn, Kai-Uwe and Lafontaine, Francine, Financial Constraints and Moral Hazard: The Case of Franchising, June 2016.
Forthcoming in: Journal of Political Economy.

222   Benndorf, Volker, Martinez-Martinez, Ismael and Normann, Hans-Theo, Equilibrium Selection with Coupled Populations in Hawk-Dove Games: Theory and Experiment in Continuous Time, June 2016.
Published in: Journal of Economic Theory, 165 (2016), pp. 472-486.

221   Lange, Mirjam R. J. and Saric, Amela, Substitution between Fixed, Mobile, and Voice over IP Telephony – Evidence from the European Union, May 2016.
Forthcoming in: Telecommunications Policy.

220   Dewenter, Ralf, Heimeshoff, Ulrich and Lüth, Hendrik, The Impact of the Market Transparency Unit for Fuels on Gasoline Prices in Germany, May 2016.
Forthcoming in: Applied Economics Letters.

219   Schain, Jan Philip and Stiebale, Joel, Innovation, Institutional Ownership, and Financial Constraints, April 2016.

218   Haucap, Justus and Stiebale, Joel, How Mergers Affect Innovation: Theory and Evidence from the Pharmaceutical Industry, April 2016.

217   Dertwinkel-Kalt, Markus and Wey, Christian, Evidence Production in Merger Control: The Role of Remedies, March 2016.

216   Dertwinkel-Kalt, Markus, Köhler, Katrin, Lange, Mirjam R. J. and Wenzel, Tobias, Demand Shifts Due to Salience Effects: Experimental Evidence, March 2016.
Forthcoming in: Journal of the European Economic Association.

215   Dewenter, Ralf, Heimeshoff, Ulrich and Thomas, Tobias, Media Coverage and Car Manufacturers' Sales, March 2016.
Published in: Economics Bulletin, 36 (2016), pp. 976-982.

214   Dertwinkel-Kalt, Markus and Riener, Gerhard, A First Test of Focusing Theory, February 2016.

213   Heinz, Matthias, Normann, Hans-Theo and Rau, Holger A., How Competitiveness May Cause a Gender Wage Gap: Experimental Evidence, February 2016.
Forthcoming in: European Economic Review.

212   Fudickar, Roman, Hottenrott, Hanna and Lawson, Cornelia, What's the Price of Consulting? Effects of Public and Private Sector Consulting on Academic Research, February 2016.

211   Stühmeier, Torben, Competition and Corporate Control in Partial Ownership Acquisitions, February 2016.
Published in: Journal of Industry, Competition and Trade, 16 (2016), pp. 297-308.

210   Muck, Johannes, Tariff-Mediated Network Effects with Incompletely Informed Consumers, January 2016.

209   Dertwinkel-Kalt, Markus and Wey, Christian, Structural Remedies as a Signalling Device, January 2016.
Published in: Information Economics and Policy, 35 (2016), pp. 1-6.

208   Herr, Annika and Hottenrott, Hanna, Higher Prices, Higher Quality? Evidence From German Nursing Homes, January 2016.
Published in: Health Policy, 120 (2016), pp. 179-189.

207   Gaudin, Germain and Mantzari, Despoina, Margin Squeeze: An Above-Cost Predatory Pricing Approach, January 2016.
Published in: Journal of Competition Law & Economics, 12 (2016), pp. 151-179.

206 Hottenrott, Hanna, Rexhäuser, Sascha and Veugelers, Reinhilde, Organisational Change and the Productivity Effects of Green Technology Adoption, January 2016.
Published in: Energy and Ressource Economics, 43 (2016), pp. 172–194.

205 Dauth, Wolfgang, Findeisen, Sebastian and Suedekum, Jens, Adjusting to Globalization – Evidence from Worker-Establishment Matches in Germany, January 2016.

204 Banerjee, Debosree, Ibañez, Marcela, Riener, Gerhard and Wollni, Meike, Volunteering to Take on Power: Experimental Evidence from Matrilineal and Patriarchal Societies in India, November 2015.

203 Wagner, Valentin and Riener, Gerhard, Peers or Parents? On Non-Monetary Incentives in Schools, November 2015.

202 Gaudin, Germain, Pass-Through, Vertical Contracts, and Bargains, November 2015.
Published in: Economics Letters, 139 (2016), pp. 1-4.

201 Demeulemeester, Sarah and Hottenrott, Hanna, R&D Subsidies and Firms' Cost of Debt, November 2015.

200 Kreickemeier, Udo and Wrona, Jens, Two-Way Migration Between Similar Countries, October 2015.
Forthcoming in: World Economy.

199 Haucap, Justus and Stühmeier, Torben, Competition and Antitrust in Internet Markets, October 2015.
Published in: Bauer, J. and M. Latzer (Eds.), Handbook on the Economics of the Internet, Edward Elgar: Cheltenham 2016, pp. 183-210.

198 Alipranti, Maria, Milliou, Chrysovalantou and Petrakis, Emmanuel, On Vertical Relations and the Timing of Technology, October 2015.
Published in: Journal of Economic Behavior and Organization, 120 (2015), pp. 117-129.

197 Kellner, Christian, Reinstein, David and Riener, Gerhard, Stochastic Income and Conditional Generosity, October 2015.

196 Chlaß, Nadine and Riener, Gerhard, Lying, Spying, Sabotaging: Procedures and Consequences, September 2015.

195 Gaudin, Germain, Vertical Bargaining and Retail Competition: What Drives Countervailing Power? September 2015.

194 Baumann, Florian and Friehe, Tim, Learning-by-Doing in Torts: Liability and Information About Accident Technology, September 2015.

193 Defever, Fabrice, Fischer, Christian and Suedekum, Jens, Relational Contracts and Supplier Turnover in the Global Economy, August 2015.

192 Gu, Yiquan and Wenzel, Tobias, Putting on a Tight Leash and Levelling Playing Field: An Experiment in Strategic Obfuscation and Consumer Protection, July 2015.
Published in: International Journal of Industrial Organization, 42 (2015), pp. 120-128.

191 Ciani, Andrea and Bartoli, Francesca, Export Quality Upgrading under Credit Constraints, July 2015.

190 Hasnas, Irina and Wey, Christian, Full Versus Partial Collusion among Brands and Private Label Producers, July 2015.

189   Dertwinkel-Kalt, Markus and Köster, Mats, Violations of First-Order Stochastic Dominance as Salience Effects, June 2015.
       Published in: Journal of Behavioral and Experimental Economics, 59 (2015), pp. 42-46.

188   Kholodilin, Konstantin, Kolmer, Christian, Thomas, Tobias and Ulbricht, Dirk, Asymmetric Perceptions of the Economy: Media, Firms, Consumers, and Experts, June 2015.

187   Dertwinkel-Kalt, Markus and Wey, Christian, Merger Remedies in Oligopoly under a Consumer Welfare Standard, June 2015
       Published in: Journal of Law, Economics, & Organization, 32 (2016), pp. 150-179.

186   Dertwinkel-Kalt, Markus, Salience and Health Campaigns, May 2015
       Published in: Forum for Health Economics & Policy,19 (2016), pp. 1-22.

185   Wrona, Jens, Border Effects without Borders: What Divides Japan's Internal Trade? May 2015.

184   Amess, Kevin, Stiebale, Joel and Wright, Mike, The Impact of Private Equity on Firms' Innovation Activity, April 2015.
       Published in: European Economic Review, 86 (2016), pp. 147-160.

183   Ibañez, Marcela, Rai, Ashok and Riener, Gerhard, Sorting Through Affirmative Action: Three Field Experiments in Colombia, April 2015.

182   Baumann, Florian, Friehe, Tim and Rasch, Alexander, The Influence of Product Liability on Vertical Product Differentiation, April 2015.

181   Baumann, Florian and Friehe, Tim, Proof beyond a Reasonable Doubt: Laboratory Evidence, March 2015.

180   Rasch, Alexander and Waibel, Christian, What Drives Fraud in a Credence Goods Market? – Evidence from a Field Study, March 2015.

179   Jeitschko, Thomas D., Incongruities of Real and Intellectual Property: Economic Concerns in Patent Policy and Practice, February 2015.
       Forthcoming in: Michigan State Law Review.

178   Buchwald, Achim and Hottenrott, Hanna, Women on the Board and Executive Duration – Evidence for European Listed Firms, February 2015.

177   Heblich, Stephan, Lameli, Alfred and Riener, Gerhard, Regional Accents on Individual Economic Behavior: A Lab Experiment on Linguistic Performance, Cognitive Ratings and Economic Decisions, February 2015
       Published in: PLoS ONE, 10 (2015), e0113475.

176   Herr, Annika, Nguyen, Thu-Van and Schmitz, Hendrik, Does Quality Disclosure Improve Quality? Responses to the Introduction of Nursing Home Report Cards in Germany, February 2015.

175   Herr, Annika and Normann, Hans-Theo, Organ Donation in the Lab: Preferences and Votes on the Priority Rule, February 2015.
       Forthcoming in: Journal of Economic Behavior and Organization.

174   Buchwald, Achim, Competition, Outside Directors and Executive Turnover: Implications for Corporate Governance in the EU, February 2015.

173   Buchwald, Achim and Thorwarth, Susanne, Outside Directors on the Board, Competition and Innovation, February 2015.

172   Dewenter, Ralf and Giessing, Leonie, The Effects of Elite Sports Participation on Later Job Success, February 2015.

171   Haucap, Justus, Heimeshoff, Ulrich and Siekmann, Manuel, Price Dispersion and Station Heterogeneity on German Retail Gasoline Markets, January 2015.

170   Schweinberger, Albert G. and Suedekum, Jens, De-Industrialisation and Entrepreneurship under Monopolistic Competition, January 2015
Published in: Oxford Economic Papers, 67 (2015), pp. 1174-1185.

169   Nowak, Verena, Organizational Decisions in Multistage Production Processes, December 2014.

168   Benndorf, Volker, Kübler, Dorothea and Normann, Hans-Theo, Privacy Concerns, Voluntary Disclosure of Information, and Unraveling: An Experiment, November 2014.
Published in: European Economic Review, 75 (2015), pp. 43-59.

167   Rasch, Alexander and Wenzel, Tobias, The Impact of Piracy on Prominent and Non-prominent Software Developers, November 2014.
Published in: Telecommunications Policy, 39 (2015), pp. 735-744.

166   Jeitschko, Thomas D. and Tremblay, Mark J., Homogeneous Platform Competition with Endogenous Homing, November 2014.

165   Gu, Yiquan, Rasch, Alexander and Wenzel, Tobias, Price-sensitive Demand and Market Entry, November 2014
Forthcoming in: Papers in Regional Science.

164   Caprice, Stéphane, von Schlippenbach, Vanessa and Wey, Christian, Supplier Fixed Costs and Retail Market Monopolization, October 2014.

163   Klein, Gordon J. and Wendel, Julia, The Impact of Local Loop and Retail Unbundling Revisited, October 2014.

162   Dertwinkel-Kalt, Markus, Haucap, Justus and Wey, Christian, Raising Rivals' Costs through Buyer Power, October 2014.
Published in: Economics Letters, 126 (2015), pp.181-184.

161   Dertwinkel-Kalt, Markus and Köhler, Katrin, Exchange Asymmetries for Bads? Experimental Evidence, October 2014.
Published in: European Economic Review, 82 (2016), pp. 231-241.

160   Behrens, Kristian, Mion, Giordano, Murata, Yasusada and Suedekum, Jens, Spatial Frictions, September 2014.

159   Fonseca, Miguel A. and Normann, Hans-Theo, Endogenous Cartel Formation: Experimental Evidence, August 2014.
Published in: Economics Letters, 125 (2014), pp. 223-225.

158   Stiebale, Joel, Cross-Border M&As and Innovative Activity of Acquiring and Target Firms, August 2014.
Published in: Journal of International Economics, 99 (2016), pp. 1-15.

157   Haucap, Justus and Heimeshoff, Ulrich, The Happiness of Economists: Estimating the Causal Effect of Studying Economics on Subjective Well-Being, August 2014.
Published in: International Review of Economics Education, 17 (2014), pp. 85-97.

156   Haucap, Justus, Heimeshoff, Ulrich and Lange, Mirjam R. J., The Impact of Tariff Diversity on Broadband Diffusion – An Empirical Analysis, August 2014.
Published in: Telecommunications Policy, 40 (2016), pp. 743-754.

155   Baumann, Florian and Friehe, Tim, On Discovery, Restricting Lawyers, and the Settlement Rate, August 2014.

154   Hottenrott, Hanna and Lopes-Bento, Cindy, R&D Partnerships and Innovation Performance: Can There be too Much of a Good Thing? July 2014.
Published in: Journal of Product Innovation Management, 33 (2016), pp. 773-794.

153   Hottenrott, Hanna and Lawson, Cornelia, Flying the Nest: How the Home Department Shapes Researchers' Career Paths, July 2015 (First Version July 2014).
Forthcoming in: Studies in Higher Education.

152   Hottenrott, Hanna, Lopes-Bento, Cindy and Veugelers, Reinhilde, Direct and Cross-Scheme Effects in a Research and Development Subsidy Program, July 2014.

151   Dewenter, Ralf and Heimeshoff, Ulrich, Do Expert Reviews Really Drive Demand? Evidence from a German Car Magazine, July 2014.
Published in: Applied Economics Letters, 22 (2015), pp. 1150-1153.

150   Bataille, Marc, Steinmetz, Alexander and Thorwarth, Susanne, Screening Instruments for Monitoring Market Power in Wholesale Electricity Markets – Lessons from Applications in Germany, July 2014.

149   Kholodilin, Konstantin A., Thomas, Tobias and Ulbricht, Dirk, Do Media Data Help to Predict German Industrial Production? July 2014.
Published online first in: Journal of Forecasting, 2016.

148   Hogrefe, Jan and Wrona, Jens, Trade, Tasks, and Trading: The Effect of Offshoring on Individual Skill Upgrading, June 2014.
Published in: Canadian Journal of Economics, 48 (2015), pp. 1537-1560.

147   Gaudin, Germain and White, Alexander, On the Antitrust Economics of the Electronic Books Industry, September 2014 (Previous Version May 2014).

146   Alipranti, Maria, Milliou, Chrysovalantou and Petrakis, Emmanuel, Price vs. Quantity Competition in a Vertically Related Market, May 2014.
Published in: Economics Letters, 124 (2014), pp. 122-126.

145   Blanco, Mariana, Engelmann, Dirk, Koch, Alexander K. and Normann, Hans-Theo, Preferences and Beliefs in a Sequential Social Dilemma: A Within-Subjects Analysis, May 2014.
Published in: Games and Economic Behavior, 87 (2014), pp. 122-135.

144   Jeitschko, Thomas D., Jung, Yeonjei and Kim, Jaesoo, Bundling and Joint Marketing by Rival Firms, May 2014.

143   Benndorf, Volker and Normann, Hans-Theo, The Willingness to Sell Personal Data, April 2014.

142   Dauth, Wolfgang and Suedekum, Jens, Globalization and Local Profiles of Economic Growth and Industrial Change, April 2014.
Published in: Journal of Economic Geography, 16 (2016), pp. 1007-1034.

141   Nowak, Verena, Schwarz, Christian and Suedekum, Jens, Asymmetric Spiders: Supplier Heterogeneity and the Organization of Firms, April 2014.

140   Hasnas, Irina, A Note on Consumer Flexibility, Data Quality and Collusion, April 2014.

139   Baye, Irina and Hasnas, Irina, Consumer Flexibility, Data Quality and Location Choice, April 2014.

138   Aghadadashli, Hamid and Wey, Christian, Multi-Union Bargaining: Tariff Plurality and Tariff Competition, April 2014.
Published in: Journal of Institutional and Theoretical Economics (JITE), 171 (2015), pp. 666-695.

137   Duso, Tomaso, Herr, Annika and Suppliet, Moritz, The Welfare Impact of Parallel Imports: A Structural Approach Applied to the German Market for Oral Anti-diabetics, April 2014.
Published in: Health Economics, 23 (2014), pp. 1036-1057.

136   Haucap, Justus and Müller, Andrea, Why are Economists so Different? Nature, Nurture and Gender Effects in a Simple Trust Game, March 2014.

135   Normann, Hans-Theo and Rau, Holger A., Simultaneous and Sequential Contributions to Step-Level Public Goods: One vs. Two Provision Levels, March 2014.
Published in: Journal of Conflict Resolution, 59 (2015), pp.1273-1300.

134   Bucher, Monika, Hauck, Achim and Neyer, Ulrike, Frictions in the Interbank Market and Uncertain Liquidity Needs: Implications for Monetary Policy Implementation, July 2014 (First Version March 2014).

133   Czarnitzki, Dirk, Hall, Bronwyn, H. and Hottenrott, Hanna, Patents as Quality Signals? The Implications for Financing Constraints on R&D? February 2014.
Published in: Economics of Innovation and New Technology, 25 (2016), pp. 197-217.

132   Dewenter, Ralf and Heimeshoff, Ulrich, Media Bias and Advertising: Evidence from a German Car Magazine, February 2014.
Published in: Review of Economics, 65 (2014), pp. 77-94.

131   Baye, Irina and Sapi, Geza, Targeted Pricing, Consumer Myopia and Investment in Customer-Tracking Technology, February 2014.

130   Clemens, Georg and Rau, Holger A., Do Leniency Policies Facilitate Collusion? Experimental Evidence, January 2014.

Older discussion papers can be found online at:

http://ideas.repec.org/s/zbw/dicedp.html