Non-Cooperative Tariffs in the Presence of Multinationals

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Abstract

Since World Ware II, under the General Agreement on Tariffs and Trade (GATT) and the World Trade Organisation (WTO), nations have agreed upon several rounds of multilateral tariff reductions. In order to study the economic nature of the bargaining process and the enforceability of tariff agreements, one has to evaluate the outside option, i.e., the non-cooperative tariff rates. This paper analyzes the effects of multinational firms on the non-cooperative tariff rates, using an analytical solvable two country general equilibrium model. Non-cooperative tariffs are lower in the presence of market seeking (horizontal) foreign direct investment (FDI), because the possibility of setting up a foreign plant abroad is a potential threat to the governments. In the case of production seeking (vertical) FDI, the results are less clear-cut and the non-cooperative tariff rate can turn out to be a subsidy.

Key words: Non-Cooperative Tariffs; Horizontal and Vertical Multinationals; Nash-Equilibria

JEL classification: F12; F23

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1 Introduction[1]

Since World Ware II, under the General Agreement on Tariffs and Trade (GATT) and the World Trade Organisation (WTO), nations have agreed upon several rounds of multilateral tariff reductions. Direct evidence on border costs shows that tariff barriers are now low in most countries, on average (trade-weighted or arithmetic) less than 5% for rich countries, and with a few exceptions are on average between 10% and 20% for developing countries (Anderson and van Wincoop, 2004). Another empirical fact is the steadily increase in world-wide real inflows of FDI, which increased by 17.7% per year between 1985 and 1999 (Navaretti et al., 2004, Markusen, 2002). However, even though tariff negotiations take place at the level of the WTO, there is no legal system to enforce agreements between countries at the level of the GATT and WTO. Hence, in order to study the economic nature of the bargaining process and the enforceability of tariff agreements, one has to evaluate the outside option, i.e., the non-cooperative tariff rates. And given the importance of FDI one may ask how the increased FDI activity influences the non-cooperative tariff rate.

In the tariff game every government is assumed to set its import tariffs in order to maximize national welfare.[2] If the countries are large (i.e. world prices are not fixed), higher import tariffs lead to a lower world price of the imported good. Hence, part of the cost of a tariff falls upon foreign exporters. This terms-of-trade effect leads the governments to set unilateral tariffs that are higher than would be efficient. In other words, the noncooperative setting of tariffs leads to a terms-of-trade-driven Prisoner's Dilemma.[3]

The non-cooperative tariff was derived in various models with two (for example Flam and Helpman, 1987, Gros, 1987 and McMillan, 1986) and three countries (for example Ludema, 2002), as well as in partial (for example Ludema, 2002) and general equilibrium (for example Egger et al., 2005; Flam and Helpman, 1987; Gros, 1987).[4] The role of multinationals (MNEs) for the non-cooperative

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[2] Here I follow the traditional approach, even though this hypothesis is seemingly unrealistic. However, as was pointed out by Bagwell and Staiger (2002), whether or not governments have political motivations, it is their ability to shift the costs of protection onto one another that creates the inefficiency when tariffs are selected unilaterally.

[3] The purpose of a trade agreement is then to eliminate the terms-of-trade driven externality that arise by the unilateral policies, and thereby provide governments a means of escape from a Prisoner's Dilemma. For an overview of when and how such agreements can be established see Bagwell and Staiger (2002).

[4] This is not a thorough literature overview here at all. I just mention demonstratively some papers guided by the model structure, namely monopolistic competition, which I will use later

tariff was mainly disputed for the case of horizontal multinationals, i.e. firms that serve the foreign market via a plant rather than to export in order to economize on trade barriers, such as transport costs and tariffs. In this case tariffs even can be the reason to go multinational, because high tariffs can be avoided by local production. This motive for FDI (foreign direct investment) is called tariff-jumping (confer Horst, 1971; Smith, 1987; Motta, 1992).

Recently, this tariff-jumping argument and a related effect due to antidumping actions (labeled antidumping jumping FDI by Haaland and Wooton, 1998) was tested empirically. For example for Japanese manufacturing investments in the late 1980s empirical studies find that a substantial part has been induced by EC antidumping and other trade restricting measures targeting Japanese firms (e.g., Azrak and Wynne, 1995; Barrell and Pain, 1999; Belderbos, 1997; Belderbos and Sleuwaegen, 1998; Blonigen and Feenstra, 1997; Girma et al., 1999). Fewer studies are available for other studies than Japan. Blonigen (2002) for example found that EU firms show a comparable FDI response if they are targeted by US antidumping actions. However, antidumping jumping FDI is very limited in scale in case firms in developing countries are targeted.

The effect of vertical multinationals, i.e. firms that disentangle their headquarter services from production in order to exploit factor cost differences, on tariffs is less clear cut. A vertical MNE produces in the foreign country and serves the *home* market by exports. Assuming that tariffs apply on the basis of origin, this leads to tariff revenues for the home country from its own vertical firms. Hence the question arises, if the non-cooperative tariff should be lower in this case, because the own firms are subject of the tariffs, or if it should be higher, because only part of the tariff revenue is financed from foreign firms?

Using an analytical solvable two country, two factors and two (one homogeneous and one differntiated) sectors model with national and vertical or horizontal firms in the differentiated sector, I calculate non-cooperative tariffs for various scenarios. First the non-cooperative tariff under the assumption that all firms are national firms is calculated as the benchmark case. The non-cooperative tariff rises with the size of the differentiated goods industry, which is characterized by economies of scale and monopolistic competition, and falls with the foreign's country differentiated goods industry size. Higher trade costs between countries leads to a higher non-cooperative tariff for both countries.

If horizontal MNEs are allowed, it can be shown that the non-cooperative tariff is lower. The reason is that the possibility of setting up a foreign plant abroad is a potential threat to the governments. If they rise tariffs, exporting firms may

on.

establish a plant abroad and sell at the local market, avoiding paying tariffs at all. This potential threat leads the government to lower tariffs in order to mitigate the tariff revenue loss. Hence, the theoretical findings suggest a negative relationship between the non-cooperative tariff rate and the amount of (horizontal) FDI. This result is interesting from a theoretical as well as an empirical point of view. Theoretically one normally argues that higher tariffs lead to more tariff-jumping horizontal FDI. However, this is not the end of the story if one considers non-cooperative tariff rates, as was argued above. Empirically, this theoretical result is interesting, because it is at odds with results so far. Most of these studies used the number of antidumping cases as the exogenous variable. This has the advantage that the number of antidumping cases seems to be exogenous with respect to FDI. However, the number of antidumping cases tells us nothing about the level of the tariff rate. Some studies treated the tariff rate itself as an exogenous variable. Noteworthy, as the analysis below reveals, by explicitly calculating non-cooperative tariff rates, the tariff rate itself becomes endogeneous and depends on the level of FDI. Hence, the tariff rate should be treated as an endogeneous variable in the empirical analysis.

In the case of the possibility of disentangling of headquarter services and production, the analysis becomes much harder. The reason is that different tariff rates between countries can change the firm regime. Assume that country i has initially higher import tariffs than country j. In this case vertical FDI from country i to country j is discouraged, whereas it is facilitated the other way round. Quite the contrary with exports of national firms: Exports from national firms based in country i are only burdened with low import tariffs from country j, whereas country j exports are subject to high tariffs. However, it can be shown that a Nash-equlibrium is likely to be characterized by high import subsidies from the country headquartering vertical MNEs (typically a developed country) and moderate to high tariff rates from the host country (typically a developing country). This fact cooperates with the findings of Blonigen (2002), that anti-dumping jumping FDI is very limited in scale in case firms in developing countries are targeted, as it suggests that the non-cooperative tariff rate set by the developing country is positive and a lot of FDI would not be induced if trade barriers rise, as skilled labor and capital in developing countries is typically scarce.

2 The Model

There are two countries, referred to as country 1 and 2, and indexed as $\{i, j\} = \{1, 2\}$. Both countries produce two goods, z and x. z is a homogeneous good produced at constant returns to scale by a competitive industry. x-goods are differentiated in the usual Dixit and Stiglitz (1977) fashion. I consider the following firm types: national enterprises (NEs) sell on the local market and export to the other country, where the number of national enterprises of country i is denoted by n_i; horizontal multinational enterprises (MNEs) are running production plants in both countries, where h_i denotes the number of horizontal MNEs headquartered in i; vertical MNEs are able to unbundle the headquarter and the production plant, where v_i is the number of vertical MNEs with headquarters in i and production plants only in j. In contrast to horizontal MNEs, vertical ones engage in goods trade. Quantities are indexed as follows: the first subscript indicates the country where the headquarter is based, the second subscript denotes the country where the variety is sold and the superscript refers to the firm type. Therefore, x^n_{ij} are the exports of country i-based NEs to country j and x^h_{ij} are sales of country i-based horizontal MNEs in country j.[5] Similar definitions apply for the other firm types. x_{ic} denotes the consumption of X in country i, being a CES aggregate of the individual varieties.

The symmetry of varieties within a group of x-goods allows to state the quasi-linear utility function of the representative individual in country i (U_i) as follows:

$$\begin{aligned} U_i &= \alpha \ln \left[n_i \left(x^n_{ii}\right)^{\frac{\epsilon-1}{\epsilon}} + n_j \left(\frac{x^n_{ji}}{\tau}\right)^{\frac{\epsilon-1}{\epsilon}} + h_i \left(x^h_{ii}\right)^{\frac{\epsilon-1}{\epsilon}} + h_j \left(x^h_{ji}\right)^{\frac{\epsilon-1}{\epsilon}} \right. \\ &+ \left. v_i \left(\frac{x^v_{ii}}{\tau}\right)^{\frac{\epsilon-1}{\epsilon}} + v_j \left(x^v_{ji}\right)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} + \left(z_{ii} + z_{ji}\right). \qquad (1) \end{aligned}$$

where α denotes the amount of income spend for the differentiated products, and $\epsilon > 1$ is the elasticity of substitution between varieties.

There are two sorts of impediments two trade. First, x-goods trade is due to iceberg transport costs τ, whereas I assume that the homogeneous good is costlessly tradeable. Second, both countries are able to levy tariffs on x-goods (t_{ij}, t_{ji}), where the two subscripts denote the source and destination country of exports, respectively. Hence, country j levies tariffs of $(t_{ij} - 1)\%$ on imports of x-goods from country i. Note, that the tariffs are non-resource absorbing price mark-ups generating revenue for the country that levies the tariff. In terms of quantity, one unit of consumption of an x-variety in country j requires a firm in i to send τ units. For convenience, quantities of x are defined as (both of NEs and vertical MNEs) firm-specific productions for the respective foreign market.

The consumer's maximization problem is solved in two steps. In the first step, the varieties x^l_{ij}, where l denotes one firm of any type, needs to be chosen such

[5] Whenever I use both indices i and j in one equation, this implies that $i \neq j$.

that the cost of attaining x_{ic} are minimized, whatever the consumption of x_{ic} is. In the second step, consumers allocate income between the z-good and the composite x-good. Let p^l_{ji} be the price of an x variety in country i produced by a firm l with headquarters in country j. The price for the homogeneous good, q_i, is indexed once, since all (indigenous and foreign) homogeneous goods consumed at a single location i must face the same price q_i. I take q_1 as the numéraire. Further, s_i denotes the price aggregator, defined as the minimum cost of buying one unit of x_{ic} at prices p^k_{ji} of an individual variety:

$$s_i = \min_{x^l_{ji}} \sum_{i,j,l} p^l_{ji} x^l_{ji} \quad \text{s.t.} \quad x_{ic} = 1. \tag{2}$$

The first-stage budgeting problem leads to demand for a variety of firm l:

$$x^l_{ji} = (p^l_{ji})^{-\epsilon} s_i^{\epsilon-1} \alpha q_i \quad \forall \quad i, j \in \{1, 2\}, \tag{3}$$

Identical price elasticities of demand and identical marginal costs (technologies) within a country ensure that the price of a locally produced good is equal to the mill price for exports. Moreover, all firms producing in the same country face the same marginal costs. Hence, prices of all goods produced in one country are equal in equilibrium. p_i denotes the price of all goods produced in country i. Further, under these conditions the quantity (before deduction of transport costs) from different firm types sold in one country has to be equal in equilibrium, $x^n_{ii} = x^h_{ii} = x^h_{ji} = x^v_{ji} \equiv x_{ii}$ and $x^n_{ji} = x^v_{ii} \equiv x_{ji}$. Accordingly, the price of x-goods originating from i and exported to j amounts to $\tau t_{ij} p_i$. With these assumptions, the price aggregator s_i of differentiated goods *consumed* in country i can be written as

$$s_i = \left[(n_i + h_i + h_j + v_j)\, p_i^{1-\epsilon} + (n_j + v_i)\, (\tau t_{ji} p_j)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}. \tag{4}$$

The second-stage budgeting yields the division of expenditures between the two sectors:

$$x_{ic} = \frac{\alpha q_i}{s_i}, \tag{5}$$

$$z_{ii} + z_{ji} = \frac{E_i}{q_i} - \alpha, \tag{6}$$

where E_i denotes total expenditures of consumers in country i.

2.1 Factor Markets and Production

Let w_{Li}, w_{Si} and w_{Ki} denote the factor rewards for unskilled labor, skilled labor and capital in country i, respectively. Assuming that z-production only uses unskilled labor (L), and one unit of unskilled labor is able to produce one unit of z-good, variable unit costs (i.e., marginal costs) c_{zi} satisfy

$$c_{zi} \geq w_{Li} \quad \perp \quad z_{ii} \geq 0, \tag{7}$$

where w_{Li} is the wage rate of unskilled workers in i. This implies

$$c_{zi} \geq q_j \quad \perp \quad z_{ij} \geq 0. \tag{8}$$

Due to normalization and the assumption of zero transport costs in the z-sector and the assumption that both countries produce z-goods, the price for the homogeneous good in both countries and the unskilled labor wage rate in both countries has to equal one.

I assume that the monopolistic-competitive x-sector also only uses unskilled labor in production, more specifically it is able to produce one unit of x-good with one unit of labor. The other two factors, skilled labor (S) and capital (K), are only used to set-up plants and run multinational networks. This assumption allows to determine the number of firms by the resource constraints for skilled labor and capital and makes the model analytical solvable. Specifically, to set-up an exporting firm one unit of capital and one unit of skilled labor is necessary. To run a plant in a foreign country, an additional unit of capital has to be invested. To run a vertical MNEs also one unit of capital and one unit of skilled labor has to be incurred. Furthermore and additional amount of δ units of skilled labor is needed in order to account for the increased communication induced by the disentangling of the headquarter services and production.

With this assumptions factor market clearing requires

$$\begin{aligned} K_i &\geq n_i + 2h_i + v_i \quad \perp \quad w_{Ki} \geq 0, & (9)\\ L_i &\geq (n_i + h_i + h_j + v_j)\, x_{ii} + (n_i + v_j)x_{ij} + z_{ii} + z_{ij} \quad \perp \quad w_{Li} \geq 0, & (10)\\ S_i &\geq n_i + h_i + (1+\delta)v_i \quad \perp \quad w_{Si} \geq 0, & (11) \end{aligned}$$

There is a fixed markup over variable costs, which is determined by the elasticity of substitution between varieties, so that the following condition has to hold

$$p_i = w_{Li}\frac{\epsilon}{\epsilon - 1}. \tag{12}$$

Free entry implies that firms earn zero profits, since operating profits are used to cover fixed costs. The corresponding zero-profit conditions determine the numbers of firms.

Since national firms in i have to bear fixed costs of $w_{Ki} + w_{Si}$, the following zero-profit condition can be stated

$$w_{Ki} + w_{Si} \geq \frac{p_i \left(x_{ii} + x_{ij}\right)}{\epsilon} \quad \perp \quad n_i \geq 0, \tag{13}$$

and similarly for vertical and horizontal MNEs:

$$w_{Ki} + (1+\delta) w_{Si} \;\; \geq \;\; \frac{p_j \left(x_{jj} + x_{ji}\right)}{\epsilon} \quad \perp \quad v_i \geq 0, \tag{14}$$

$$2w_{Ki} + w_{Si} \;\; \geq \;\; \frac{p_i x_{ii} + p_j x_{jj}}{\epsilon} \quad \perp \quad h_i \geq 0. \tag{15}$$

2.2 Income and Balance of Payments

I assume that all factors are owned by households, so that consumer income (i.e., GNP) in country i is given by

$$E_i \;\; = \;\; w_{Ki} K_i + w_{Li} L_i + w_{Si} S_i + (t_{ji} - 1) p_j x_{ji} (n_j + v_i). \tag{16}$$

where the last term on the right hand side is tariff income from x-sector imports. The equivalence of total factor income (E_i, E_j) and demand in each economy implicitly balance international payments.

3 Calculation of the Non-Cooperative Tariff Rate

Every country is assumed to maximize its inhabitants welfare. Therefore, maximization of the utility function of the representative consumer with respect to the import tariff rate leads to the non-cooperative tariff rate. It is further assumed that the firms take tariffs as given when making their location and production decision. I take the derivative of the indirect utility function given by:

$$V_i = \alpha \ln \left(\frac{\alpha q_i}{s_i} \right) + \frac{E_i}{q_i} - \alpha. \tag{17}$$

Assuming that both countries produce z-goods, $q_i = 1$ and the expression for the indirect utility function can be simplified to:

$$V_i = -\alpha \ln s_i + E_i + \alpha (\ln \alpha - 1). \tag{18}$$

In order to solve for the non-cooperative tariff, I take the first derivative with respect to the own tariff an set it equal to zero:

$$\frac{\partial V_i}{\partial t_{ji}} = 0. \tag{19}$$

To gain some insights which effects are determining the non-cooperative tariff rate, I assume constant prices and a constant firm regime and decompose the first derivative under these assumptions as follows:[6]

$$\begin{aligned}
\frac{\partial V_i}{\partial t_{ji}} &= -\frac{\alpha}{s_i}\frac{\partial s_i}{\partial t_{ji}} + \frac{\partial E_i}{\partial t_{ji}}, \qquad (20)\\
\frac{\partial E_i}{\partial t_{ji}} &= p_j x_{ji}(n_j + v_i) + (t_{ji} - 1)p_j(n_j + v_i)\frac{\partial x_{ji}}{\partial t_{ji}} + \frac{\partial w_{Ki}}{\partial t_{ji}}K_i + \frac{\partial w_{Li}}{\partial t_{ji}}L_i + \frac{\partial w_{Si}}{\partial t_{ji}}S_i.
\end{aligned}$$

Higher tariffs lead to higher prices of imported varieties and, hence, to a higher price index, i.e. to an overall higher price for differentiated products. This effect is unambiguously negative and captured by the first term of the first equation. As produces require a constant mark-up over marginal costs which is independent of the tariff rate, there is no terms-of-trade gain in this model. The traditional non-cooperative tariff consideration does therefore not apply here.

The effect on income is more complex. First, there is a direct positive effect on income because of increased tariff revenues, captured by the first term on the right hand side of Equation (20). In the present model, higher tariffs imply substitution of imports by local production, which is captured by the second term. This effects is non-positive, as the elasticity of the price index with respect to the tariff rate, $\eta_{s_i,t_{ji}}$, is less or equal to one. The second term is likely to be smaller in magnitude than the first one for low values of t_{ji}, as the tariff revenue gain is large for high import volumes and the substitution effect moderate for low values of t_{ji}. The substitution possibility between domestic and foreign varieties leads to a positive non-cooperative tariff rate: Higher tariff revenues enforce to set a positive non-cooperative tariff rate, and these effect is not totally offset by the fact that producer prices do not change. The lake of price responsiveness is compensated by substituting expensive foreign goods by local goods. Note, however, that I have assumed a constant firm regime, implying, by construction, that the number of firms does not change. Hence, there is not only no terms-of-trade gain, but also no direct gain from an increase in varieties.

The last three terms capture the indirect effects of tariff changes on the factor prices. These effects are second order effects and can therefore be assumed to be small compared to the first order tariff revenue effect. Hence, the effect of tariff changes on income is likely to be positive, even though these can not be taken

[6] Confer Appendix A.1

for granted.

For reasons of comparison I also calculate the optimal tariff in the case of joint welfare maximization, defined as the sum of the utilities of both countries (i.e., assuming an utilitarian welfare function), $V_{SO} = V_1 + V_2$, and referred to as the social optimal tariff rate, t_{ji}^{SO}. The social optimal tariff rate has to satisfy the following condition:

$$\frac{\partial V_{SO}}{\partial t_{ji}} = 0. \tag{21}$$

Under the assumption of transferable utility, tariff bargaining can realize V_{SO} (see for example Myerson (1991), Chapter 8). However, if international transfers are not possible, the bargaining solution can be found by the generalized Nash-product (NP):

$$NP = \left(V_i^B - t_{ji}^N\right)^{\beta} \left(V_j^B - t_{ij}^N\right)^{\gamma}, \tag{22}$$

where t_{ji}^N and t_{ij}^N denote the non-cooperative Nash-tariffs, β (γ) capture the bargaining power of country i (j), with $\beta > 0, \gamma > 0$, and V_i^B denotes the utility level for a possible bargaining solution.

4 Non-Cooperative Tariffs in the Presence of NEs Only

Let us first investigate the non-cooperative tariff level if only national firms are present. This may be because FDI is extremely unlikely due to political risk or because the country adopts a policy that prohibits FDI.

In this case the capital and unskilled labor constraints (equations (9) and (11)) both hold only by coincidence. Figure 1 gives the skilled labor to capital endowment box. Here we see where in the endowment box which factor market constraint is binding. In the north-west of the endowment box country 1 is skilled labor rich. Therefore w_{S1} is zero, and the capital constraint determines the number of firms in country 1. Country 2 on the contrary is capital abundant, leading to a capital rent of zero. The number of firms in country 2 is therefore determined by the skilled labor constraint. In the middle of the endowment box in both countries the skilled labor constraints are binding. The south-east of the endowment box is the reversed case of the north-east.

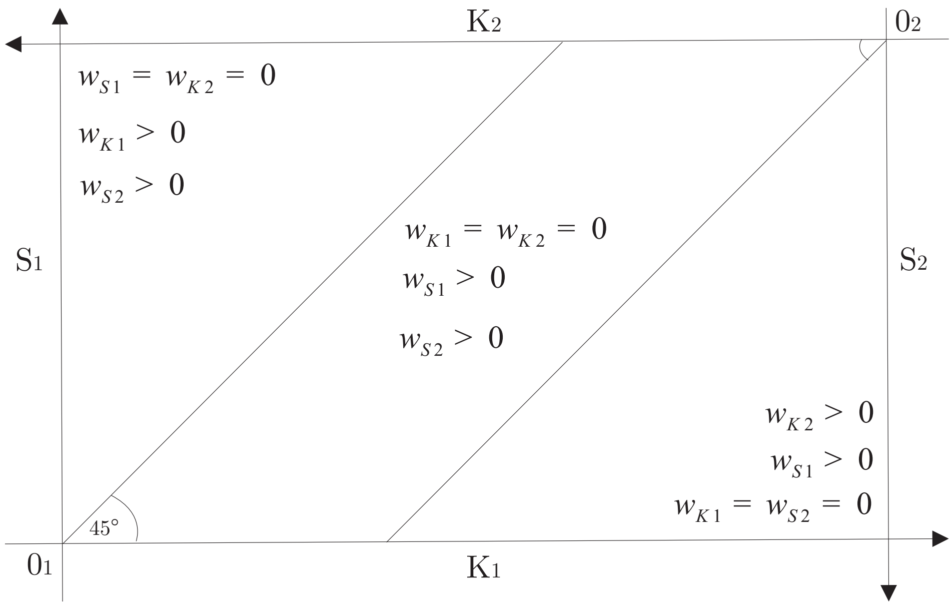

Figure 1: Skilled-labor to capital endowment box. National firms allowed only.

4.1 Full Specialization

Assume, that there is full specialization of one country in homogeneous goods production. Therefore, it runs no own national firms in the differentiated goods industry. Differentiated goods consumption relies solely on imports from abroad. The non-cooperative tariff rate is zero in this case. Helpman and Krugman (1989) calculated the optimal tariff rate in partial equilibrium to be $(t-1) = 1/\zeta$, where ζ is the elasticity of foreign supply. The elasticity of foreign supply is infinity in my model set-up as the terms-of-trades are fixed, and producers in the foreign country pass over the whole import tariff to the consumers. Hence the optimal tariff rate, as calculated by Helpman and Krugman (1989), should be zero. And this is what happens in the present model too. A country can not gain by imposing an import tariff, as no part of the costs of the tariff can be passed over to customers in the case of the given specialization pattern. Consumers are better of if they can directly consume cheaper varieties, as if the goods trade is impeded by tariffs, even though tariffs are then lump-sum transferred to customers.

The social optimal tariff rate is given by:

$$t_{ji}^{SO} = \frac{\epsilon - 1}{\epsilon}. \tag{23}$$

Hence, the joint welfare maximizing policy is to subsidize imports from the exporting country. The level of the subsidy is determined by the mark-up. The higher the mark-up the higher the subsidy. The social welfare-maximizer drives down the market price for imported varieties to their marginal costs of production.

This leads to an equalization of prices and marginal costs in the differentiated goods sector in the country specialized in homogeneous goods production. Hence, the effect of the market power from the differentiated goods exporting companies is countervailed by the import subsidy.

Result 1: *If there is full specialization of a country in homogeneous goods production and only national firms are allowed to come into existence in the other country, the non-cooperative tariff rate is zero. The social optimal tariff rate is to subsidize imports of differentiated goods.*

4.2 Partial Specialization

Assume now that both countries produce both goods, i.e. there is only partial specialization. In this case, there will be intra-industry trade in the differentiated product and inter-industry trade in the homogeneous product, where the unskilled labor abundant country will specialize in.

Focussing on the case in the middle of the box, the number of firms is given by the skilled labor endowment constraints, $n_i = S_i$. Further, $q_i = 1$, as the homogeneous good is costlessly tradeable and full agglomeration does not occur. This implies that unskilled labor wages are equalized and equal to one, $w_{Li} = 1$. The price for x-good varieties is thus determined by the elasticity of substitution, $p_i = p_j = \frac{\epsilon}{\epsilon - 1}$. Now the quantities of x-variety production can be determined. The skilled labor wage rate is given by the zero-profit constraint. Therefore income can be calculated in both countries.

An explicit solution for t_{ji} can only be found in the case of $\epsilon = 2$:[7]

$$t_{ji} = \frac{-1 + 2\tau\tilde{K}_i + \sqrt{1 + 2\tau\tilde{K}_i + 4\tau^2\tilde{K}_i^2}}{3\tau\tilde{K}_i}, \tag{24}$$

where $\tilde{K}_i = \frac{K_i}{S_j}$.

The non-cooperative tariff for country i is independent of the tariff levied form country j. Therefore the "tariff game" has a dominant strategy for each player and the setting of these non-cooperative tariff rates of both countries is a Nash-equilibrium.

The non-cooperative tariff depends on endowments with skilled labor and/or capital and transport costs between countries, as well as on the elasticity of demand, which is held constant in the derivation. The derivative of t_{ji} with

[7] I only report one expression for the non-cooperative tariff rate her. The modifications for different areas in the endowment box are discussed in the Appendix A.2.1.

respect to the own size of the industrialized industry is positive, whereas it is negative with respect to foreigns' size of the differentiated goods industry. This implies that the country with the larger x-goods industry will levy a higher tariff than the one with the relative smaller one. More precisely, the non-cooperative tariff will rise with the importance of the industry considered and decrease with the size of the foreigns' x-goods sector. Furthermore the derivative of t_{ji} with respect to trade costs τ is positive. This implies that higher trade costs lead to higher tariffs. This effect is typically present in models where a tariff has the effect of expanding domestic production to the benefit of domestic consumers, also referred to as the home-market effect (see for example Helpman and Krugman, 1989).

Note that the non-cooperative tariff rate will be non-negative. This reflects the prisoners dilemma situation: On the one hand you gain tariff income by rising the tariff rate, on the other hand varieties from abroad become more expensive and operating profits are transferred abroad. This last effect is important in explaining why the non-cooperative tariff rate is positive in the case of only partial specialization. In the case of full specialization, there is no relocation effect from foreign varieties to domestic varieties. Hence, as we have seen before, without this relocation, the non-cooperative tariff rate would be zero.

Result 2: *With only national firms and partial specialization, the non-cooperative tariff is non-negative and rises with the size of the differentiated goods industry and falls with the foreign's country differentiated goods industry size. Higher trade costs between countries lead to a higher non-cooperative tariff for both countries.*

For the full specialization case, the social optimal tariff rate is to subsidies imports at a rate equal to the mark-up of the exporting industry. Considering the case of partial specialization, the optimal planner has to consider the relocation effect of the import tariff rate. A higher tariff rate makes imports more expensive and shifts production towards domestic varieties. However, this relocation is incomplete and therefore the overall price for the differentiated goods, represented by the price index, will rise and consequently reduce welfare. Hence, we would expect the non-cooperative tariff rate to be smaller in the partial specialization case than in the full one. As the full specialization case revealed that the social optimal tariff rate is a subsidy, this implies that the non-cooperative tariff rate should also be an import subsidy, but the subsidy should be lower, because the relocation now goes the other way round, i.e., the exporting country can even attract more production and the domestic differentiated goods industry will be hurt. Again, an explicit solution can only be found for $\epsilon = 2$:

$$t_{ji}^{SO} = \frac{-1 + \tau\tilde{K}_i + \sqrt{1 + \tau\tilde{K}_i + \tau^2\tilde{K}_i^2}}{3\tau\tilde{K}_i}. \tag{25}$$

As shown in the Appendix A.2.1, the non-cooperative policy is indeed an import subsidy and lower as in the case of full specialization.

Result 3: *For partially specialized countries with only national firms, the social welfare-maximizing policy is to subsidies imports, even though at a lower rate as in the case of full specialization.*

5 Non-Cooperative Tariffs in the Presence of NEs and Horizontal MNEs

Now I allow both national firms and horizontal MNEs. In this case the number of firms can be determined by the factor market constraints for capital and skilled labor (equations (9) and (11)). A country which is very capital abundant will therefore only run horizontal MNEs, whereas a very skilled labor abundant country will be dominated from exporting firms. The possible firm structures are depicted in the skilled labor to capital endowment box in Figure 2 and Table 1.

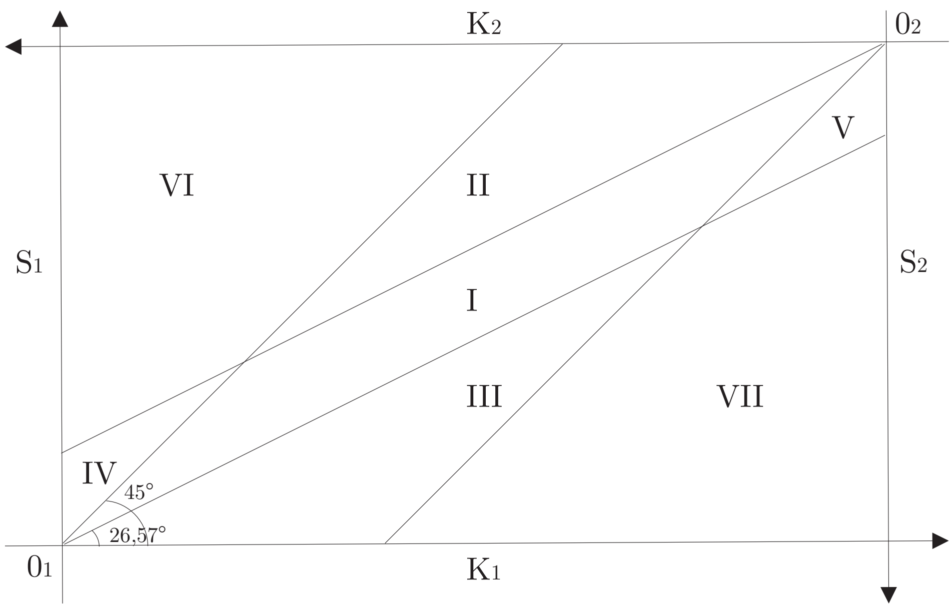

Figure 2: Skilled-labor to capital endowment box. National firms and horizontal MNEs allowed.

Area	n_1	n_2	h_1	h_2	w_{S1}	w_{S2}	w_{K1}	w_{K2}
I	✓	✓	✓	✓	+	+	+	+
II	✓	−	✓	✓	+	+	+	0
III	−	✓	✓	✓	+	+	0	+
IV	✓	✓	−	✓	+	+	0	+
V	✓	✓	✓	−	+	+	+	0
VI	✓	−	−	✓	+	0	0	+
VII	−	✓	✓	−	0	+	+	0

Legend: −...firm type not present, ✓...firm type present
+...factor price positive, 0...factor price zero

Table 1: Firm structure in the case of national firms and horizontal MNEs

5.1 Full Specialization

Assuming that the country is fully specialized in homogeneous goods production and production of differentiated goods only occurs by branch plants (i.e., the country itself does not undertake headquarter services at all), leads to nearly the same results whether or not horizontal MNEs are present. More precisely, $t_{ji} = 1$ holds whereas the social optimal tariff is now given by:

$$\begin{aligned} t_{ji}^{SO} &= \frac{K_j(1+\tau) - S_j(2+\tau)}{3(K_j - S_j)\tau} \\ &+ \frac{\sqrt{(K_j - 2S_j)^2 - (K_j^2 - 3S_jK_j + 2S_j^2)\tau + (S_j - K_j)^2\tau^2}}{3(K_j - S_j)\tau}. \end{aligned} \tag{26}$$

5.2 Partial Specialization

For the case of partial specialization only, the non-cooperative tariff again can be found analytically only for $\epsilon = 2$:[8]

$$\begin{aligned} t_{ji} &= \frac{K_j + 2S_i\tau + 2K_j\tau - 2S_j(1+\tau)}{(3S_i - 4S_j + 4K_j)\tau} \\ &+ \frac{\sqrt{(-2S_j + K_j)^2 + 2(2S_j - K_j)(S_i - 2S_j + 2K_j)\tau + 4(S_i - S_j + K_j)^2\tau^2}}{(3S_i - 4S_j + 4K_j)\tau}. \end{aligned} \tag{27}$$

It depends overall positively on own country size and negatively on foreign country size. Furthermore higher trade costs lead, as in the case with only national firms, to higher non-cooperative tariffs.

Result 4: *In the case of national firms and horizontal MNEs, the non-cooperative tariff is non-negative and rises with the size of the differentiated goods industry*

[8] For a derivation refer to Appendix A.3

and falls with the foreign's country differentiated goods industry size. Higher trade costs between countries lead to a higher non-cooperative tariff for both countries.

The interesting question is whether the presence of horizontal MNEs lowers or rises the non-cooperative tariff rate. Taking the difference of the two non-cooperative tariffs it can be shown that the non-cooperative tariff is lower if horizontal MNEs are allowed. The reason is that the possibility of setting up a foreign plant abroad is a potential threat to the governments. If they rise tariffs, exporting firms may establish a plant abroad and sell at the local market, avoiding paying tariffs at all. This potential threat leads the government to lower tariffs in order to mitigate the tariff revenue loss. This is the well-known tariff-jumping argument.

Result 5: *When horizontal MNEs are allowed, the non-cooperative tariff is lower as compared to the case with only national firms.*

The social optimal tariff rate is given by:

$$\begin{aligned} t_{ji}^{SO} &= \frac{K_j + S_i\tau + K_j\tau - S_j(2+\tau)}{3(S_i - S_j + K_j)\tau} \\ &+ \frac{\sqrt{3(2S_j - K_j)(S_i - S_j + K_j)\tau + (K_j + (S_i + K_j)\tau - S_j(2+\tau))^2}}{3(S_i - S_j + K_j)\tau}. \end{aligned} \tag{28}$$

As in the case with national firms only, the optimal policy is an import subsidy. However, as demonstrated in Table 5, the subsidy is lower with partial specialization and horizontal firms as compared to the case of full specialization or only national firms. The reason is that varieties from abroad now can not only be provided by imports but also through MNEs by local production. This mitigates the (average) price difference between goods from local and foreign owned firms. Additionally, the range of own firms varieties is larger in the case of partial specialization as compared to the case of full specialization, which leads to lower welfare gains from additional units, and, hence, to a lower subsidy.

Result 6: *For partial specialized countries with national firms and horizontal MNEs, the social welfare-maximizing policy is to subsidies imports. However, the import subsidy is lower as compared to the case of full specialization or only national firms.*

6 Non-Cooperative Tariffs in the Presence of NEs and Vertical MNEs

Splitting up the production chain leads basically to more intra-firm trade. Assuming that tariffs apply on the basis of origin, this leads to tariff revenues for the home country from its own vertical firms. Hence, as stated in the introduction, the question arises, if the non-cooperative tariff should be lower in this case, because the own firms are subject of the tariffs, or if it should be higher, because only part of the tariff revenue is financed from foreign firms?

Analyzing this situation, there is one big difference between the cases investigated so far and the present one: Now the non-cooperative tariff rate form one country does depend on the tariff rate set by the other country. Hence, there is strategic interaction in the choice of the non-cooperative tariff rate.[9]

This interaction mainly is driven by the fact that the choice of the tariff rate has a great influence on the decision whether to run a local firm and export or to set-up the headquarters at home and run a foreign plant. Given a tariff rate for imports from country i to country j, t_{ij}, country i can encourage outward vertical FDI to country j by lowering his own import tariff, t_{ji}, whereas a higher import tariff would discourage own outward FDI.

This renders the determination of the firm-regime a hard task. Figure 3 and Table 2 show the firm structure when national firms and vertical MNEs are allowed and $t_{ji} = t_{ij}$. In order to determine the firm structure, again the factor market clearing conditions for capital and skilled labor are used, i.e. equations (9) and (11) respectively. If $K_i > S_i$, then country i will only run national firms. If skilled labor is the abundant factor, $S_i > K_i$, national as well as vertical firms (may) coexist. In this situation two cases have to be distinguished: (i) the number of firms can directly determined by the factor market equations (Areas II and IV in Figure 3), (ii) skilled labor is very abundant, so that only unskilled labor and capital remain as scarce resources (Areas III and V in Figure 3).

6.1 Full Specialization

In the presence of vertical MNEs full specialization means that there is full specialization of one country in differentiated goods production. Hence, I assume that country i is too small in order to host plants. However, country i may or may not conduct (vertical) outward FDI. Hence, I focus on a scenario where country i

[9] If the assumption of quasi-linearity of the utility function is relaxed, the reaction functions are positively sloped for the case of national firms and the case of national firms and horizontal MNEs.

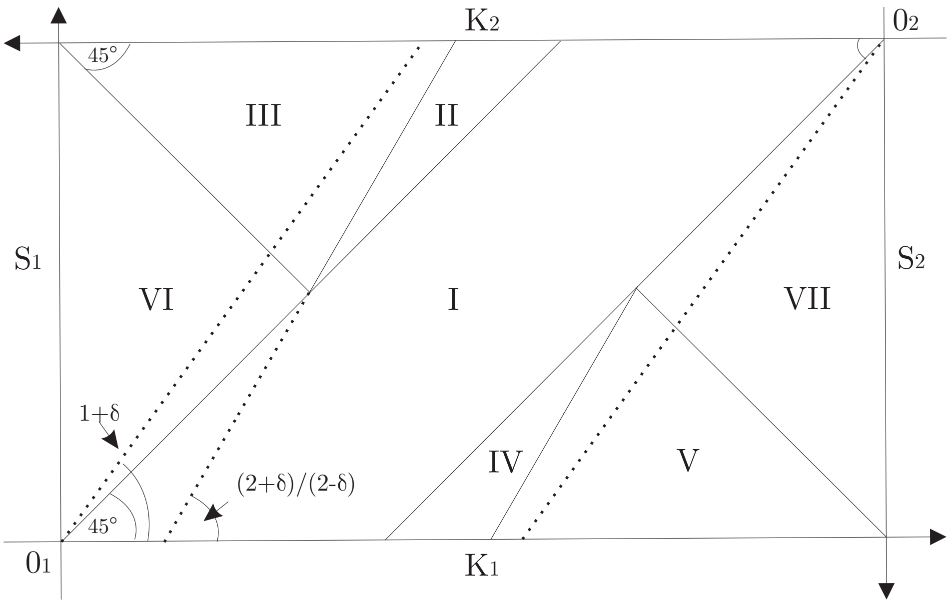

Figure 3: Skilled-labor to capital endowment box. National firms and vertical MNEs allowed.

Area	n_1	n_2	v_1	v_2	w_{S1}	w_{S2}	w_{K1}	w_{K2}
I	✓	✓	−	−	+	+	0	0
II	✓	✓	✓	−	+	+	+	0
III	✓	✓	✓	−	0	+	+	0
IV	✓	✓	−	✓	+	+	0	+
V	✓	✓	−	✓	+	0	0	+
VI	✓	✓	−	−	0	+	+	0
VII	✓	✓	−	−	+	0	0	+

Legend: −...firm type not present, ✓...firm type present
+...factor price positive, 0...factor price zero

Table 2: Firm structure in the case of national firms and vertical MNEs

conducts vertical outward FDI and does not run national firms, whereas country j only runs national firms. Further I assume no firm regime change and positive factor prices for skilled labor in country i, i.e., restricting the analysis to Area II in Figure 3. I then come up with the following expression for the non-cooperative tariff rate:

$$t_{ji} = \frac{-(S_i + S_j)\delta + \sqrt{-S_i^2\tau + 2S_i(S_i + S_j)\tau\delta + (S_i + S_j)^2\delta^2}}{S_i\tau}. \tag{29}$$

The non-cooperative tariff rate is therefore an import subsidy.

The social optimal tariff rate is given by:

$$t_{ji}^{SO} = \frac{-(S_i + S_j)\delta + \sqrt{-S_i^2\tau + S_i(2S_i + S_j)\tau\delta + (S_i + S_j)^2\delta^2}}{S_i\tau}. \tag{30}$$

By inspection it can be seen that the social optimal tariff rate is smaller than the non-cooperative tariff rate $t_{ji}^{SO} < t_{ji}$. Hence, an even higher import subsidy would maximize world welfare.

Result 7: *If the country does not host plants but my contact outward FDI, the non-cooperative tariff rate is negative, i.e., the individual welfare maximizing strategy is to subsidies imports. World welfare is maximized at an even higher import subsidy level.*

6.2 Partial Specialization

Maintaining the assumptions that the firm regime does not change, that all factor prices in country i are positive (basically restricting the analysis to Area II in Figure 3) and $\epsilon = 2$, and that the countries are not fully specialized in the sense specified above, the non-cooperative tariff formula is given by:[10]

$$\begin{aligned} t_{ji} &= \frac{1}{3\tau(S_i - K_i + S_j\delta)(S_i - K_i(1+\delta))}\Bigg(S_i^2 + S_i^2\tau + 2S_iS_j\delta + 2S_iS_j\delta\tau \\ &+ S_j^2\delta^2 + K_i^2(1+\tau+\tau\delta) + \Big[((S_i - K_i)^2(1+\tau) + (S_i - K_i)(-K_i\tau \\ &+ 2S_j(1+\tau))\delta + S_j(S_j - 2K_i\tau)\delta^2)^2 - 3\tau(S_i - K_i - S_j\delta)^2(S_i - K_i + 2S_j\delta) \\ &\times (S_i - K_i(1+\delta))\Big]^{0.5} - K_i(2S_j\delta(1+\tau+\tau\delta) + S_i(2+\tau(2+\delta)))\Bigg). \end{aligned} \tag{31}$$

The non-cooperative tariff rate depends on the share of national and vertical

[10] The derivation can be found in Appendix A.4

firms. If there are (nearly) only national firms, we are back in the case described above and the non-cooperative formula is given by Equation (24). If there are (nearly) only vertical MNEs, the non-cooperative tariff rate even gets negative, i.e., imports from abroad are subsidized.

Result 8: *When vertical MNEs are important, the non-cooperative tariff is lower as compared to the case with only national firms and even can get negative, i.e., imports from abroad are subsidized.*

So far I studied the behavior of the non-cooperative tariff rate under the assumption of a constant firm regime. However, as pointed out above, this is to restrictive. Further, the question which tariff rates will be a solution to a non-cooperative tariff game can not be analyzed by sticking to a specific firm regime in the case of vertical firms because the firm regime itself depends on the tariff rates. Due to the non-linearity, analytical results can not be obtained in the case of an endogeneous firm regime. Hence, in order to examine the question of non-cooperative tariffs in this scenario, I focus on two specific examples, one from Area IV an one from Area V in Figure 3.[11]

Figures 4-6 depict the best response functions and the resulting firm structure for the example of Area IV.[12] Country 1 is the skilled labor and capital scarce country. The differentiated goods sector in country 1 is therefore small. Hence, in accordance with the existing theory and analogous to the results of the non-cooperative tax literature, country 1 will set a lower non-cooperative import tariff than country 2. Specifically, if country 2 heavily subsidizes its imports, country 1 will also subsidize imports but at a lower rate. If it would set a positive import tariff, national firms based in country 2 will vanish and, therefore, tariff revenue in country 1 will go to zero. The specific subsidy rate is a balance of the following forces: (i) By subsidizing imports form country 2 to country 1, country 1 can ensures that cheap variants from abroad are available. (ii) Trade volumes rise because country 2's exports to country 1 are encouraged. Opposite to this positive effects of the subsidization of imports is the necessary financing by the representative consumer. This two countervailing forces are balanced by the tariff rate represented by the best-response function for country 1 for high subsidy rates. If the tariff rate is as high as it was presented in the scenario with national firms only, the tariff rate will remain at this level (this is the straight line ranging from a tariff rate of -30% to 0% in Figure 4). However, if vertical MNEs would vanish because tariff rates from country 1 to country 2 become

[11] In order to derive the formula for the non-cooperative tariff rate I had to impose the assumption that the firm regime does not change. However, in considering the tariff game I have to account for changes in the firm structure. This makes it necessary to rely on simulations.

[12] Parameter values are chosen as follows: $\delta = 0.5$; $\alpha = 10$; $\tau = 1.1$; $L_1 = 50$; $L_2 = 50$; $K_1 = 3.2$; $K_2 = 4.8$; $H_1 = 0.05$; $H_2 = 4.95$

to high, country 1 tries to hold foreign vertical firms by raising import tariffs which favors country 2-based vertical MNEs over country 2-based national firms. Hence, country 1 does not want to lose foreign plants, which would lower factor prices and would reduce the varieties produced in the country.[13] This policy has the positive side effect of tariff revenue incomes. However, there is also a cost to pay: Higher import tariffs lower trade volumes and the varieties supplied from abroad. Therefore, this policy is only a preferred one, if the tariff rate country 2 imposes is not to high and therefore trade volume loses form raising import tariffs necessary to hold foreign plants are small. If this point is reached (i.e. in Figure 4, for tariff rates higher than 15%), we are again back at the non-cooperative tariff rate for the scenario with national firms only.

For low tariff rates of country 1, country 2 sets the highest possible tariff rate in order to ensure that country 1 runs national firms and not vertical MNEs. For a higher tariff rate tariff revenues would drop to zero due to the reversion of trade resulting from the firm regime change. Once the non-cooperative tariff rate for the case of national firms only is reached, the best strategy for country 2 is to set this tariff rate. If country 1 raises import tariffs even further and trade has to balance, trade volumes steadily decline. It then pays off for country 2 to subsidize imports, because: (i) By subsidizing imports from country 1 to country 2, country 2 can encourage own firms to produce abroad and reimport. This specialization in headquarter services leads to a more efficient use of the abundant factor skilled labor. (ii) It ensures that cheap variants from abroad are available. (iii) Trade volumes rise because country 2 exports headquarter services and can in exchange import differentiated goods from country 1. Opposite to this positive effects of the subsidization of imports is again the necessary financing by the representative consumer. The best answer of country 2 for any given tariff rate of country 1 is depicted by the best-response function.

Combining these two tariff rates gives us the Nash-equilibrium. In this case there is one Nash-equilibrium where only national firms exist and the non-cooperative tariff rate is given by the formula (24).

Switching now to the case of Area V[14], we see that as in the case of Area IV, country 2 sets the highest possible tariff rate in order to ensure that country 1 runs national firms and not vertical MNEs for low tariff rates of country 1. In Area V there are fare more endowment configurations where country 2 fully specializes in headquarter services and homogeneous goods production. It therefore pays

[13] In a model with unemployment, this would lead to unemployment rather than to lower factor rewards. Hence, in this case the often used argument for tariffs, industry protection, does apply here, even though foreign plants are "protected" rather than own firms.

[14] Parameter values are chosen as follows: $\delta = 0.5$; $\alpha = 10$; $\tau = 1.1$; $L_1 = 50$; $L_2 = 50$; $K_1 = 4.784$; $K_2 = 3.216$; $H_1 = 0.05$; $H_2 = 4.95$

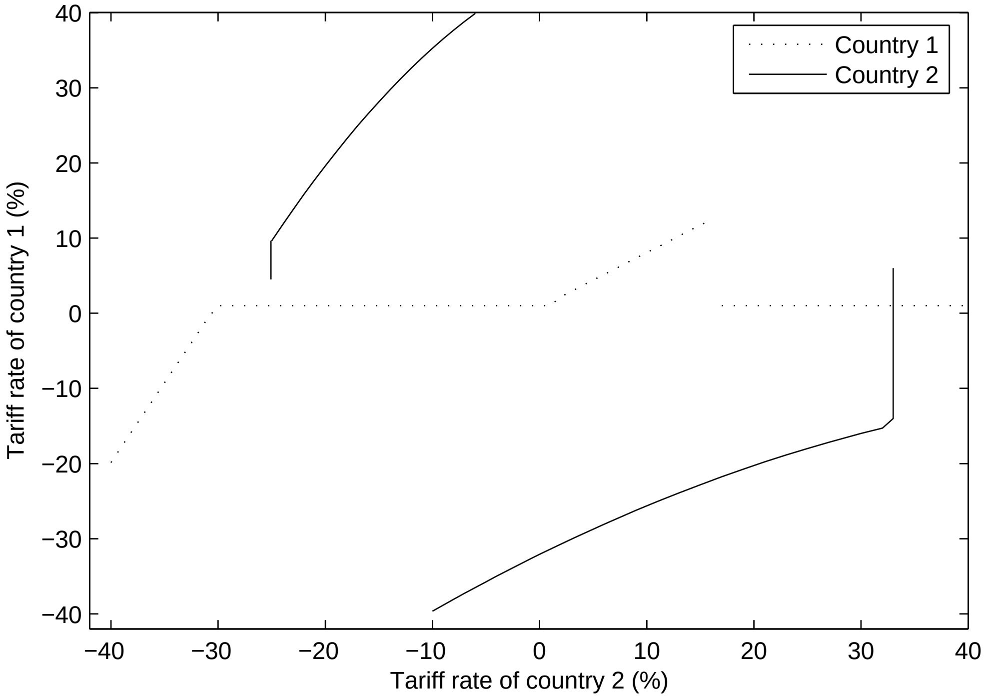

Figure 4: Best response functions. Example from Area IV

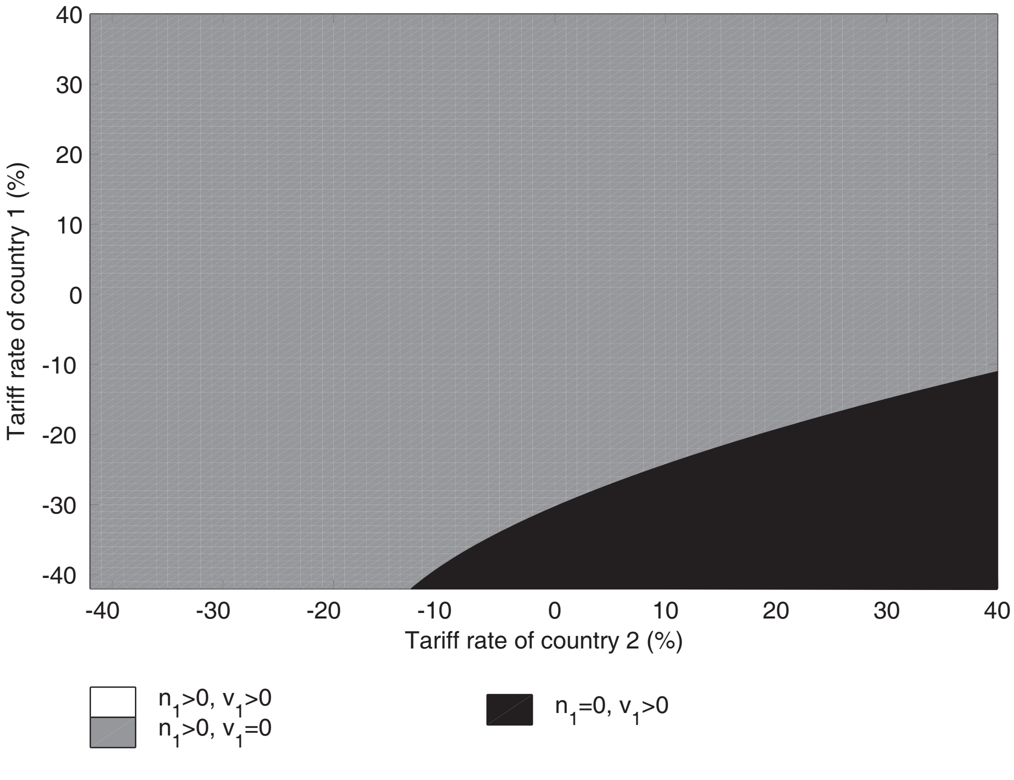

Figure 5: Firm structure. Example from Area IV

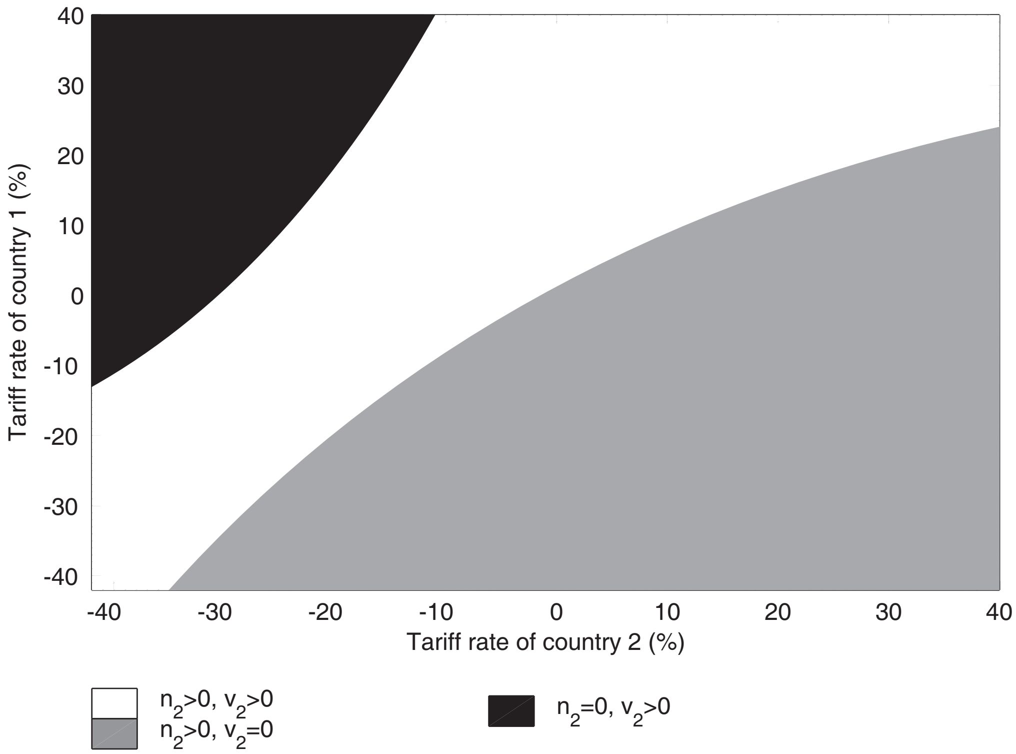

Figure 6: Firm structure. Example from Area IV

off for country 2 for even lower tariff rates of country 1 to subsidize imports. Note, that the tariff rate of country 1 is irrelevant if country 2 only runs vertical MNEs. Hence, the non-cooperative tariff rate is constant at -50% for tariff rates of country 1 higher than -18% in Figure 7.

The reaction "function" for country 1 is a bit more complicated in this scenario. Country 1 can influence directly the mode of supply for his customers by appropriate tariff policy. If the import tariffs are low enough, country 2 firms will rather export than supply the customers locally. On the other hand, high import tariffs lead to more vertical FDI and hence to more varieties that are directly supplied to the customers in country 1. As a direct supply lowers the price for customers, country 1 tries to encourage vertical FDI. If exporting firms based in country 2 vanish, tariff policy in country 1 does no longer matter. Hence, instead of a reaction function, we get an area where the lower boundary is the tariff rate just high enough to drive country 2 based national firms out of the market.

From Figure 7 it is clear that now more Nash-equilibria are possible. All points along the vertical line of the reaction function of country 2 at $t_{ij} = -50\%$ are Nash-equilibria. Further any mixed strategy of country 1 containing tariff rates ranging from -18% to 40% constitute Nash-equilibria. Hence, in this case high import subsidies from country 2 and moderate to high tariff rates from country 1 constitute Nash-equilibria. Even though there are more Nash-equilibria, the

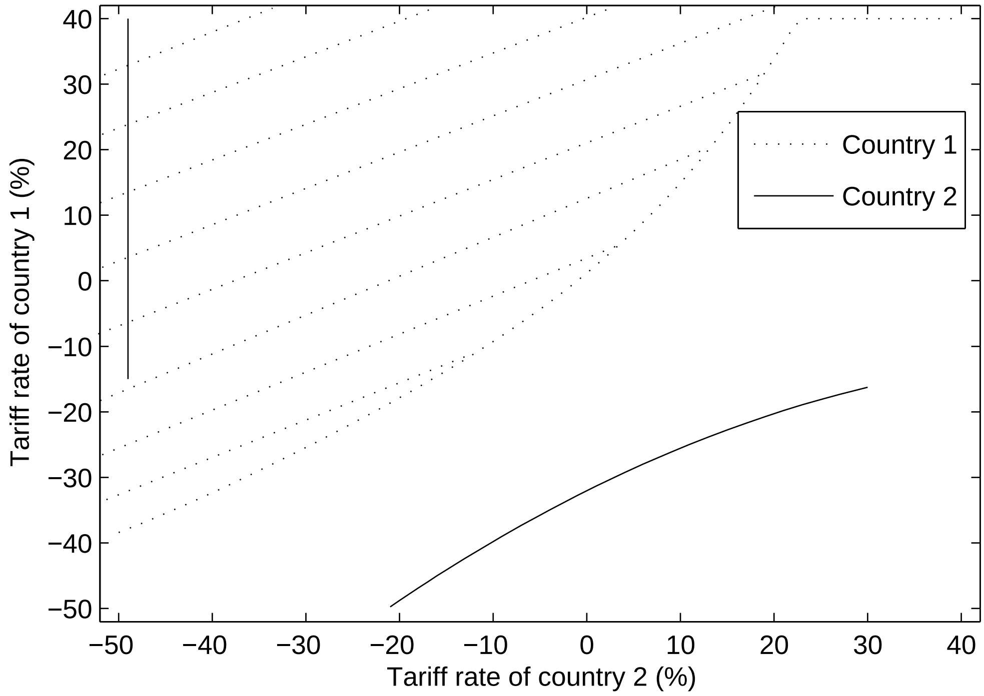

Figure 7: Best response functions. Example from Area V

"qualitative" nature of all these equilibria is the same. Country 1 (the very skilled labor scarce country) specializes in headquarter services and country 2 is specialized in production. These subsidies of country 2 are quite different form the ones often discussed in the literature. On the one hand side, they do not favor inward FDI, but rather encourage outward FDI. On the other hand, they are not intended to raise wages via new plant set-ups. Rather wages are raised by the possibility to specialize in headquarter services leading to a rise in demand for skilled labor in research and development, management, marketing, finance, and other headquarter related activities.[15]

Result 9: *(i) If the skilled labor abundant country can encourage high volumes of outward vertical FDI, a Nash-equilibrium can be found for high enough tariff rates of the skilled labor scarce country. This Nash-equlibrium is characterized by high import subsidies from the skilled labor abundant country 2 and moderate to high tariff rates from the skilled labor scarce country 1. (ii) If due to factor endowments even with high subsidization vertical MNEs are not very prominent, the Nash-equilibrium is characterized by national firms only.*

The social optimal tariff rate for the Area II and the assumptions that the firm regime does not change and that all factor prices in country i are positive can be

[15]In a model with equilibrium unemployment this policy would not raise wages, but rather create now jobs.

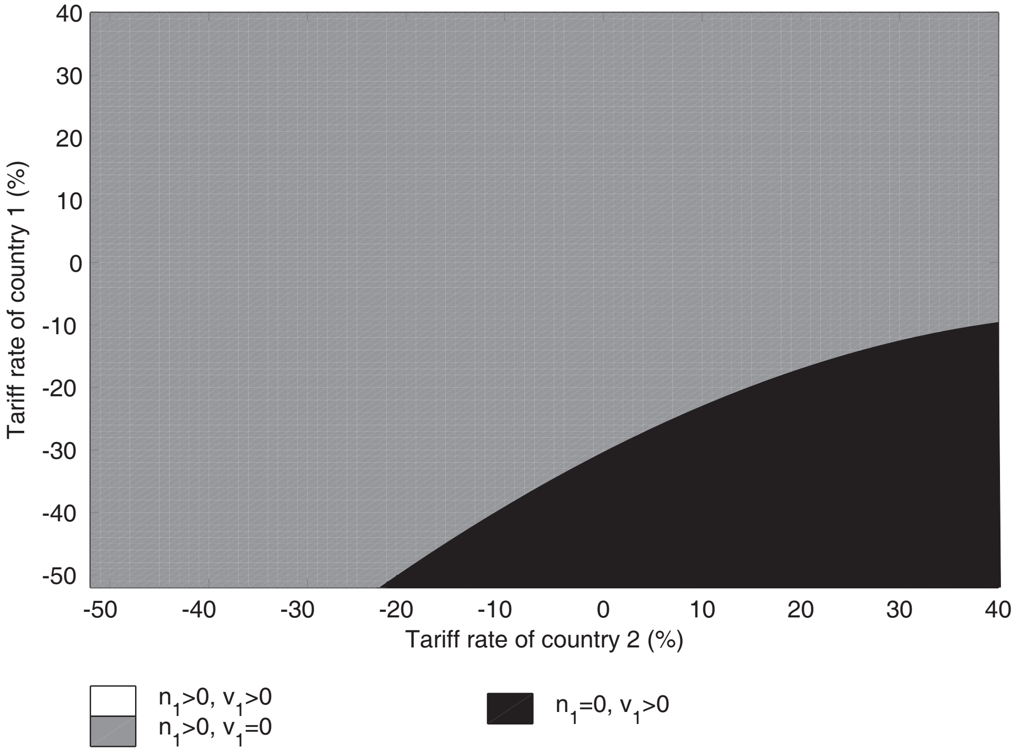

Figure 8: Firm structure. Example from Area V

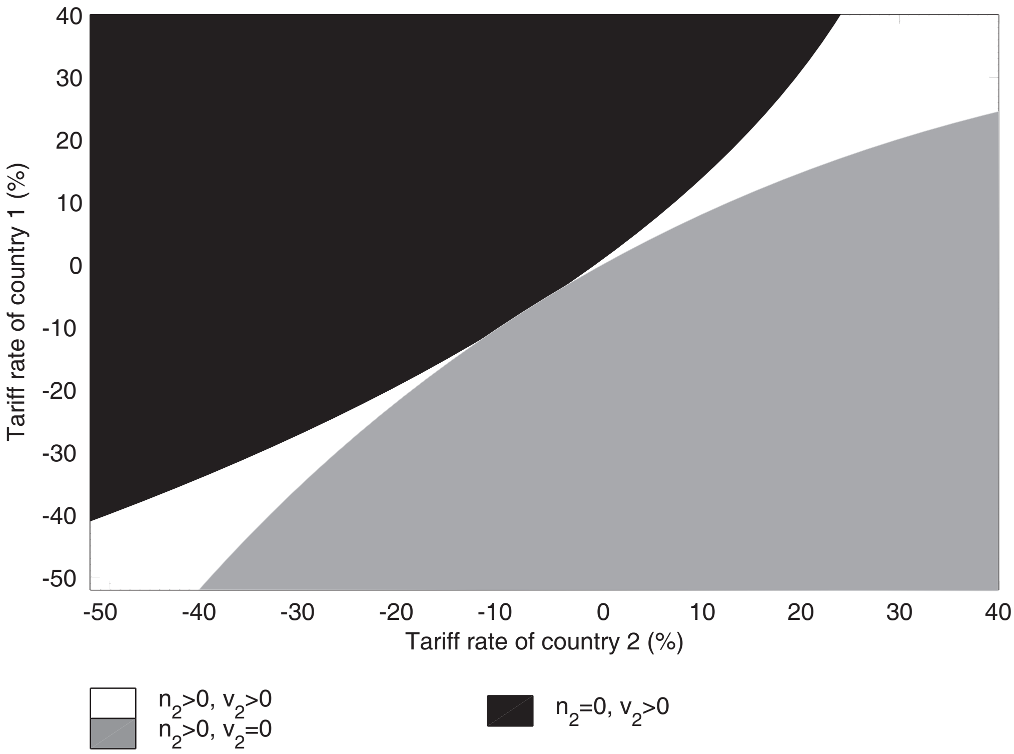

Figure 9: Firm structure. Example from Area V

written as:

$$t_{ji}^{SO} = \frac{1}{3\tau(S_i - K_i(1+\delta))}\Bigg(S_i - K_i + S_i\tau - K_i\tau + S_j\delta - K_i\tau\delta \tag{32}$$
$$\pm \sqrt{-3\tau(S_i - K_i + S_j\delta)(S_i - K_i(1+\delta)) + [S_i(1+\tau) + S_j\delta - K_i(1+\tau+\tau\delta)]^2}\Bigg).$$

This expression is likely to be smaller than one. Hence, an import subsidy is the world-welfare maximizing policy. For the investigated cases above the following optimal tariff rates can be found: (i) In Area IV, the tariff rate for country 1 is $(t_{21} - 1) = -50\%$ and for country 2 $(t_{12} - 1) = -33\,1/3\%$. (ii) In Area V, there is a range of tariff rates for country 1 leading all to the same outcome, namely $(t_{21} - 1) \in [-39\%; 40\%]$, whereas the social optimal tariff rate for country 2 is $(t_{12} - 1) = -50\%$.

7 Conclusions

Two empirical facts are well known: (i) Tariffs were steadily reduced upon several rounds of multilateral tariff reductions since World Ware II. (ii) World-wide FDI growth was much stronger than trade growth in the last two decades. Even though tariff negotiations take place at the level of the WTO, there is still no possibility to enforce tariff agreements. Hence, in order to study the economic nature of the bargaining process, one has to evaluate the outside option, i.e., the non-cooperative tariff rates. The question then remains whether and how FDI influences these non-cooperative tariff rates.

This paper shows that the non-cooperative tariff rate is in generally lower when multinational firms are allowed. So fare the theoretical literature emphasized the tariff-jumping argument, which says that FDI is encouraged if tariffs are raised. Looking at non-cooperative tariff rates reveals that exactly the opposite prediction occurs. Because higher tariffs encourage FDI, governments will find it welfare-maximizing to set lower tariffs in order to avoid tariff revenue losses.

The optimal tariff rate from a social planner point of view, which is assumed to maximize welfare according to a utilitarian social welfare function, turns out to be negative in most cases, i.e., imports should be subsidized. The social welfare-maximizer countervails the effect of the market power from the differentiated goods exporting companies. For the full specialization case with national firms only, the social optimal tariff rate is to subsidies imports at a rate equal to the mark-up of the exporting industry. Considering the case of partial specialization, the optimal planner has to consider the relocation effect of the import tariff rate from foreign to domestic varieties. This leads to a lower world welfare maximizing import subsidy.

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A Appendix

A.1 Calculation of the Non-Cooperative Tariff Rate

To gain some insights which effects are determining the non-cooperative tariff rate, I assume constant prices and a constant firm regime. The first order condition of the indirect utility function $V_i = -\alpha \ln s_i + E_i + \alpha(\ln \alpha - 1)$ with respect to t_{ji} can be than be decomposed as follows:

$$\frac{\partial V_i}{\partial t_{ji}} = -\frac{\alpha}{s_i}\frac{\partial s_i}{\partial t_{ji}} + \frac{\partial E_i}{\partial t_{ji}}, \tag{A1}$$

where

$$\frac{\partial s_i}{\partial t_{ji}} = s_i^{\epsilon}(n_j + v_i)(\tau p_j)^{1-\epsilon} t_{ji}^{-\epsilon} > 0, \tag{A2}$$

and

$$\frac{\partial E_i}{\partial t_{ji}} = p_j x_{ji}(n_j+v_i)+(t_{ji}-1)p_j(n_j+v_i)\frac{\partial x_{ji}}{\partial t_{ji}}+\frac{\partial w_{Ki}}{\partial t_{ji}}K_i+\frac{\partial w_{Li}}{\partial t_{ji}}L_i+\frac{\partial w_{Si}}{\partial t_{ji}}S_i, \tag{A3}$$

with

$$\begin{aligned}\frac{\partial x_{ji}}{\partial t_{ji}} &= \alpha p_j^{-\epsilon}(1-\epsilon)t_{ji}^{-\epsilon}s_i^{\epsilon-1} + \alpha p_j^{-\epsilon}t_{ji}^{1-\epsilon}(\epsilon-1)s_i^{\epsilon-2}\frac{\partial s_i}{\partial t_{ji}} = \\ &= \alpha p_j^{-\epsilon}t_{ji}^{-\epsilon}s_i^{\epsilon-1}(\epsilon-1)\left[\eta_{s_i,t_{ji}} - 1\right] \leq 0, \end{aligned} \tag{A4}$$

because

$$\eta_{s_i,t_{ji}} = \frac{\partial s_i}{\partial t_{ji}} \frac{t_{ji}}{s_i} = \frac{(n_j + v_i)(\tau t_{ji} p_j)^{1-\epsilon}}{(n_i + h_i + h_j + v_j) p_i^{1-\epsilon} + (n_j + v_i)(\tau t_{ji} p_j)^{1-\epsilon}} \leq 1. \quad \text{(A5)}$$

The first term on the right hand side of Equation (A1) is unambiguously negative. Higher tariffs lead to higher prices of imported varieties and, hence, to a higher price index, i.e., to an overall higher price for differentiated products. Note, that in this model there is no terms-of-trade gain by construction. Produces require a constant mark-up over marginal costs which is independent of the tariff rate.

The second term on the right hand side of Equation (A1) captures the effect of tariff rate changes on income. First, there is a direct positive effect on income because of increased tariff revenues, captured by the first term on the right hand side of Equation (A3). Second, higher tariffs imply substitution of imports by local production, which is captured by the second term. This effects is non-positive, as the elasticity of the price index with respect to the tariff rate, $\eta_{s_i,t_{ji}}$, is less or equal to one. The second term is likely to be smaller in magnitude than the first one for low values of t_{ji}, as the tariff revenue gain is large for high import volumes and the substitution effect moderate for low values of t_{ji}. The last three terms capture the indirect effects of tariff changes on the factor prices. These effects are second order effects and can therefore be assumed to be small compared to the first order tariff revenue effect. Hence, the effect of tariff changes on income is likely to be positive, even though these can not be taken for granted.

A.2 Non-Cooperative Tariffs in the Presence of NEs only

We have to distinguish two cases: i) The case of partial specialization, and ii) the case of full specialization.

A.2.1 Partial Specialization

According to Figure 1, there are three different possibilities that have to be considered: (i) The area in the middle of the skilled labor to capital endowment box, (ii) the north-west of the skilled labor to capital endowment box, and (iii) the south-east of the skilled labor to capital endowment box.

The area in the middle of the endowment box

In the middle of the skilled labor to capital endowment box, the number of firms is given by the skilled labor endowment constraints, $n_i = S_i$. Further, $q_i = 1$, as the homogeneous good is tradeable without costs and both countries are assumed to produce z-goods. This implies that unskilled labor wages are equalized and equal to one, $w_{Li} = 1$. The price for x-good varieties is thus determined by the elasticity of substitution, $p_i = \frac{\epsilon}{\epsilon-1}$. Now the quantities of x-variety production can be determined and are given by:

$$x_{ii} = \frac{(\epsilon - 1)\alpha}{\epsilon \left[S_i + S_j \left(\tau t_{ji}\right)^{1-\epsilon}\right]}. \tag{A6}$$

$$x_{ji} = \frac{(\epsilon - 1)\alpha\tau^{1-\epsilon} t_{ji}^{-\epsilon}}{\epsilon \left[S_i + S_j \left(\tau t_{ji}\right)^{1-\epsilon}\right]}. \tag{A7}$$

The skilled labor wage rate is given by the zero-profit constraint (Equation (13)):

$$w_{Si} = \frac{[S_j t_{ji}\tau^2 + (\tau t_{ji})^\epsilon (S_i(1+t_{ij})\tau + S_j t_{ij}^\epsilon + S_j(\tau t_{ij})^\epsilon)]\alpha}{(S_i t_{ij}\tau + S_j(\tau t_{ij})^\epsilon)(S_j t_{ji}\tau + S_i(\tau t_{ji})^\epsilon)\epsilon}. \tag{A8}$$

Now the income can be calculated in both countries:

$$E_i = L_i + \frac{\alpha}{\epsilon} + \frac{S_i\tau\alpha}{\epsilon(S_i t_{ij}\tau + S_j(\tau t_{ij})^\epsilon)} + \frac{S_j\tau\alpha(t_{ji}(\epsilon-1)-\epsilon)}{\epsilon(S_j t_{ji}\tau + S_i(\tau t_{ij})^\epsilon)}. \tag{A9}$$

The indirect utility function, given by Equation (18), can now be stated in terms of the parameters:

$$\begin{aligned} V_i &= L_i + \frac{S_i\tau\alpha}{\epsilon(S_i t_{ij}\tau + S_j(\tau t_{ij})^\epsilon)} + \frac{S_j\tau\alpha(-t_{ji} + (t_{ji}-1)\epsilon)}{\epsilon(S_j t_{ji}\tau + S_i(\tau t_{ji})^\epsilon)} \\ &+ \frac{\alpha \ln[(\tau t_{ji})^{-\epsilon}(S_j t_{ji}\tau + S_i(\tau t_{ji})^\epsilon)(\frac{\epsilon-1}{\epsilon})^{\epsilon-1}]}{\epsilon-1} + \frac{\alpha}{\epsilon} - \alpha + \alpha\ln(\alpha). \end{aligned} \tag{A10}$$

The first derivative with respect to t_{ji} is given by:

$$\begin{aligned} &\frac{1}{\epsilon\left(S_j t_{ji}\tau\left(\frac{\epsilon}{\epsilon-1}\right)^\epsilon + S_i\left(\frac{t_{ji}\tau\epsilon}{\epsilon-1}\right)^\epsilon\right)}\left(S_j t_{ji}^{-1-\epsilon}\tau\alpha\left(\frac{\epsilon}{\epsilon-1}\right)^{-\epsilon}\left(-t_{ji}^{1+\epsilon}\epsilon\times\right.\right. \\ &\times\left(\frac{\epsilon}{\epsilon-1}\right)^{2\epsilon} + \frac{1}{\epsilon-1}\left(\tau^{-\epsilon}(\epsilon-1)\left(S_i\left(\frac{\epsilon}{\epsilon-1}\right)^{-\epsilon} + \right.\right. \\ &\left.\left.+S_j t_{ji}\tau\left(\frac{t_{ji}\tau\epsilon}{\epsilon-1}\right)^{-\epsilon}\right)^{-1}\left(S_i t_{ji}^{1+\epsilon}\tau^\epsilon(\epsilon-1)\left(\frac{\epsilon}{\epsilon-1}\right)^\epsilon\right. \\ &\left.\left.\left.\left.+S_j t_{ji}\tau\epsilon\left(\frac{\epsilon}{\epsilon-1}\right)^\epsilon - S_i\epsilon\left(\frac{t_{ji}\tau\epsilon}{\epsilon-1}\right)^\epsilon(-t_{ji} + (-1+t_{ji})\epsilon)\right)\right)\right)\right) \stackrel{!}{=} 0. \end{aligned} \tag{A11}$$

This expression is not analytical solvable for t_{ji}. However for $\epsilon = 2$ the FOC simplifies to:

$$\frac{S_j\tau\alpha\left(-32t_{ji}^3+\frac{8S_jt_{ji}\tau-8S_i(2(t_{ji}-1)-t_{ji})t_{ji}^2\tau^2+4S_it_{ji}^3\tau^2}{\left(\frac{S_i}{4}+\frac{S_j}{4t_{ji}\tau}\right)\tau^2}\right)}{8t_{ji}^3\left(4S_jt_{ji}\tau+4S_it_{ji}^2\tau^2\right)}\stackrel{!}{=}0. \tag{A12}$$

This equation is quadratic in t_{ji} and therefore can be solved analytically:

$$\begin{aligned} t_{ji} &= \frac{-S_j+2\tau S_i\pm\sqrt{S_j^2+2\tau S_iS_j+4\tau^2S_i^2}}{3\tau S_i} \\ &= \frac{-1+2\tau\tilde{S}\pm\sqrt{1+2\tau\tilde{S}+4\tau^2\tilde{S}^2}}{3\tau\tilde{S}}, \end{aligned} \tag{A13}$$

where $\tilde{S}=\frac{S_i}{S_j}$. Further:

$$(t_{ji}-1) = \frac{-1-\tau\tilde{S}\pm\sqrt{1+2\tau\tilde{S}+4\tau^2\tilde{S}^2}}{3\tau\tilde{S}}. \tag{A14}$$

As $(t_{ji}-1)$ is restricted to be no less than -1, only the solution with the addition of the square root is a feasible solution. I now investigate the sign of $-1-\tau\tilde{S}+\sqrt{1+2\tau\tilde{S}+4\tau^2\tilde{S}^2}$:

$$\lim_{\tau\to1}\left[-1-\tau\tilde{S}+\sqrt{1+2\tau\tilde{S}+4\tau^2\tilde{S}^2}\right]=-1-\tilde{S}+\sqrt{1+2\tilde{S}+4\tilde{S}^2}. \tag{A15}$$

$$\lim_{\tau\to\infty}\left[-1-\tau\tilde{S}+\sqrt{1+2\tau\tilde{S}+4\tau^2\tilde{S}^2}\right]=\infty. \tag{A16}$$

$$\lim_{\tilde{S}\to0}\left[-1-\tau\tilde{S}+\sqrt{1+2\tau\tilde{S}+4\tau^2\tilde{S}^2}\right]=0. \tag{A17}$$

$$\lim_{\tilde{S}\to\infty}\left[-1-\tau\tilde{S}+\sqrt{1+2\tau\tilde{S}+4\tau^2\tilde{S}^2}\right]=\infty. \tag{A18}$$

This shows that the $(t_{ji}-1)$ is non-negative, implying that it is never optimal to subsidize imports and that the non-cooperative tariff rate is positive for almost all endowment configurations considered, except the special case where one country has no skilled labor at all.

The derivatives of t_{ji} with respect to $\tilde{S}$ and τ are:

$$\frac{\partial t_{ji}}{\partial\tilde{S}}=\frac{-1-\tilde{S}\tau+\sqrt{1+2\tilde{S}\tau(1+2\tilde{S}\tau)}}{3\tilde{S}^2\tau\sqrt{1+2\tilde{S}\tau(1+2\tilde{S}\tau)}}>0. \tag{A19}$$

$$\frac{\partial t_{ji}}{\partial\tau}=\frac{-1-\tilde{S}\tau+\sqrt{1+2\tilde{S}\tau(1+2\tilde{S}\tau)}}{3\tilde{S}\tau^2\sqrt{1+2\tilde{S}\tau(1+2\tilde{S}\tau)}}>0. \tag{A20}$$

$\tilde{S}$	Non-Cooperative Tariff Rates ϵ 2	4	6	8	Social Optimal Tariff Rates ϵ 2	4	6	8
0.1	5.31	9.85	11.40	10.25	-48.59	-21.28	-11.06	-5.76
0.3	12.60	16.82	14.23	11.58	-46.25	-16.42	-6.85	-3.28
0.5	17.10	19.60	14.97	11.86	-44.44	-13.89	-5.53	-2.68
0.7	20.70	20.12	15.30	11.98	-43.04	-12.45	-4.91	-2.42
0.9	22.14	20.75	15.48	12.40	-41.92	-11.54	-4.55	-2.28

τ=1.2, $\tilde{S}=S_i/S_j$

These tariffs are calculated for endowments corresponding to the middle of the endowment box in Figure 1.

Table 3: Non-Cooperative Tariffs for various ϵ's and national firms only

The calculations so fare assumed $\epsilon = 2$. As analytical solution for $\epsilon \neq 2$ are not attainable, I calculated the non-cooperative tariff rates for various ϵ's found to be empirical relevant (see for example Feenstra, 1994, and Markusen, 2002). The results are given in Table 3.

The social optimal tariff rate is given by:

$$t_{ji}^{SO} = \frac{-1 + \tau\tilde{S} \pm \sqrt{1 + \tau\tilde{S} + \tau^2\tilde{S}^2}}{3\tau\tilde{S}}. \tag{A21}$$

Further:

$$(t_{ji}^{SO} - 1) \quad = \quad \frac{-1 - 2\tau\tilde{S} \pm \sqrt{1 + \tau\tilde{S} + \tau^2\tilde{S}^2}}{3\tau\tilde{S}}. \tag{A22}$$

As $(t_{ji}^{SO} - 1)$ is restricted to be no less than -1, again only the solution with the addition of the square root is a feasible solution. The sign of $-1 - 2\tau\tilde{S} + \sqrt{1 + \tau\tilde{S} + \tau^2\tilde{S}^2}$ can be determined by studying the limit behavior:

$$\lim_{\tau\to 1} \left[-1 - 2\tau\tilde{S} + \sqrt{1 + \tau\tilde{S} + \tau^2\tilde{S}^2}\right] = -1 - 2\tilde{S} + \sqrt{1 + \tilde{S} + \tilde{S}^2}. \tag{A23}$$

$$\lim_{\tau\to \infty} \left[-1 - 2\tau\tilde{S} + \sqrt{1 + \tau\tilde{S} + \tau^2\tilde{S}^2}\right] = -\infty. \tag{A24}$$

$$\lim_{\tilde{S}\to 0} \left[-1 - 2\tau\tilde{S} + \sqrt{1 + \tau\tilde{S} + \tau^2\tilde{S}^2}\right] = 0. \tag{A25}$$

$$\lim_{\tilde{S}\to \infty} \left[-1 - 2\tau\tilde{S} + \sqrt{1 + \tau\tilde{S} + \tau^2\tilde{S}^2}\right] = -\infty. \tag{A26}$$

These calculations reveal that the social optimal tariff is non-positive. Hence, either it is zero, or the social optimal policy is to subsidize imports.

The area in the north-west and south-east of the endowment box

In the north-west of the skilled labor to capital endowment box country 1 is very skilled labor abundant. This leads to a factor price of zero for skilled labor and a positive capital rental rate. The reverse is true for country 2, where skilled labor is scare and therefore $w_{S2} > 0$ and $w_{K2} = 0$. In the south-east we have the same results but with reversed rolls of the countries.

The only change for the formula of the non-cooperative tariff is therefore the exchange of S_i by K_i:

$$
\begin{aligned}
t_{ji} &= \frac{-S_j + 2\tau K_i \pm \sqrt{S_j^2 + 2\tau K_i S_j + 4\tau^2 K_i^2}}{3\tau K_i} \\
&= \frac{-1 + 2\tau \tilde{K}_i \pm \sqrt{1 + 2\tau \tilde{K}_i + 4\tau^2 \tilde{K}_i^2}}{3\tau \tilde{K}_i},
\end{aligned} \tag{A27}
$$

and for the other country we now have to explicitly state t_{ij}:

$$
\begin{aligned}
t_{ij} &= \frac{-K_j + 2\tau S_i \pm \sqrt{K_j^2 + 2\tau S_i K_j + 4\tau^2 S_i^2}}{3\tau S_i} \\
&= \frac{-\tilde{K}_j + 2\tau \tilde{S} \pm \sqrt{\tilde{K}_j^2 + 2\tau \tilde{S} \tilde{K}_j + 4\tau^2 \tilde{S}^2}}{3\tau \tilde{S}},
\end{aligned} \tag{A28}
$$

where $\tilde{S} = \frac{S_i}{S_j}$, $\tilde{K}_i = \frac{K_i}{S_j}$ and $\tilde{K}_j = \frac{K_j}{S_j}$.

Again, the only feasible solutions is the one with the addition of the square bracket. The signs of $-S_j - \tau K_i + \sqrt{S_j^2 + 2\tau K_i S_j + 4\tau^2 K_i^2}$ and $-K_j - \tau S_i + \sqrt{K_j^2 + 2\tau S_i K_j + 4\tau^2 S_i^2}$ are again non-negative (the limits for the second expression can be derived analogous to the ones given below):

$$
\lim_{K_i \to 0} \left[-S_j - \tau K_i \pm \sqrt{S_j^2 + 2\tau K_i S_j + 4\tau^2 K_i^2} \right] = 0. \tag{A29}
$$

$$
\lim_{K_i \to \infty} \left[-S_j - \tau K_i \pm \sqrt{S_j^2 + 2\tau K_i S_j + 4\tau^2 K_i^2} \right] = \infty. \tag{A30}
$$

$$
\begin{aligned}
\lim_{S_i \to 0} \quad & \left[-(S - S_i) - \tau K_i \pm \sqrt{(S - S_i)^2 + 2\tau K_i (S - S_i) + 4\tau^2 K_i^2} \right] = \\
& = -S - K_i \tau + \sqrt{S^2 + 2K_i S \tau + 4K_i^2 \tau^2} > 0.
\end{aligned} \tag{A31}
$$

$$
\lim_{S_i \to \infty} \left[-(S - S_i) - \tau K_i \pm \sqrt{(S - S_i)^2 + 2\tau K_i (S - S_i) + 4\tau^2 K_i^2} \right] = \infty. \tag{A32}
$$

The derivative with respect to capital endowments is given by:

$$\frac{\partial t_{ji}}{\partial K_i} = -\frac{S_j\left(S_j + K_i\tau - \sqrt{S_j^2 + 2S_jK_i\tau + 4K_i^2\tau^2}\right)}{3K_i^2\tau\sqrt{S_j^2 + 2S_jK_i\tau + 4K_i^2\tau^2}} > 0. \tag{A33}$$

$$\frac{\partial t_{ij}}{\partial K_j} = \frac{-1 + \frac{K_j + S_i\tau}{\sqrt{K_j^2 + 2K_jS_i\tau + 4S_i^2\tau^2}}}{3S_i\tau} < 0. \tag{A34}$$

$$\frac{\partial t_{ij}}{\partial K_j}\frac{\partial K_j}{\partial K_i} = \frac{-1 + \frac{K_j + S_i\tau}{\sqrt{K_j^2 + 2K_jS_i\tau + 4S_i^2\tau^2}}}{3S_i\tau}(-1) > 0. \tag{A35}$$

Changes of the non-cooperative tariffs t_{ji} and t_{ij} with respect to skilled labor endowments are described by:

$$\frac{\partial t_{ji}}{\partial S_j} = \frac{-1 + \frac{S_j + K_i\tau}{\sqrt{S_j^2 + 2S_jK_i\tau + 4K_i^2\tau^2}}}{3K_i\tau} < 0. \tag{A36}$$

$$\frac{\partial t_{ij}}{\partial S_i} = -\frac{K_j\left(K_j + S_i\tau - \sqrt{K_j^2 + 2K_jS_i\tau + 4S_i^2\tau^2}\right)}{3S_i^2\tau\sqrt{K_j^2 + 2K_jS_i\tau + 4S_i^2\tau^2}} > 0. \tag{A37}$$

$$\frac{\partial t_{ij}}{\partial S_i}\frac{\partial S_i}{\partial S_j} = \frac{K_j\left(K_j + S_i\tau - \sqrt{K_j^2 + 2K_jS_i\tau + 4S_i^2\tau^2}\right)}{3S_i^2\tau\sqrt{K_j^2 + 2K_jS_i\tau + 4S_i^2\tau^2}} < 0. \tag{A38}$$

The derivative with respect to τ is analogous to the derivative with respect to τ in the previous subsection:

$$\frac{\partial t_{ji}}{\partial \tau} = -\frac{S_j\left(S_j + K_i\tau - \sqrt{S_j^2 + 2S_jK_i\tau + 4K_i^2\tau^2}\right)}{3K_i\tau^2\sqrt{S_j^2 + 2S_jK_i\tau + 4K_i^2\tau^2}} > 0. \tag{A39}$$

$$\frac{\partial t_{ij}}{\partial \tau} = -\frac{K_j\left(K_j + S_i\tau - \sqrt{K_j^2 + 2K_jS_i\tau + 4S_i^2\tau^2}\right)}{3S_i\tau^2\sqrt{K_j^2 + 2K_jS_i\tau + 4S_i^2\tau^2}} > 0. \tag{A40}$$

Similar changes apply to the social optimal tariff rate:

$$\begin{aligned} t_{ji}^{SO} &= \frac{-S_j + \tau K_i \pm \sqrt{S_j^2 + \tau K_i S_j + \tau^2 K_i^2}}{3\tau K_i} \\ &= \frac{-1 + \tau\tilde{K}_i \pm \sqrt{1 + \tau\tilde{K}_i + \tau^2\tilde{K}_i^2}}{3\tau\tilde{K}_i}. \end{aligned} \tag{A41}$$

$$t_{ij}^{SO} = \frac{-K_j + \tau S_i \pm \sqrt{K_j^2 + \tau S_i K_j + \tau^2 S_i^2}}{3\tau S_i}$$
$$= \frac{-\tilde{K}_j + \tau \tilde{S} \pm \sqrt{\tilde{K}_j^2 + \tau \tilde{S} \tilde{K}_j + \tau^2 \tilde{S}^2}}{3\tau \tilde{S}}. \quad (A42)$$

Again, the only feasible solutions is the one with the addition of the square bracket. The signs of $-S_j - 2\tau K_i + \sqrt{S_j^2 + \tau K_i S_j + \tau^2 K_i^2}$ and $-K_j - 2\tau S_i + \sqrt{K_j^2 + \tau S_i K_j + \tau^2 S_i^2}$ are again non-positive (the limits for the second expression can be derived analogous to the ones given below):

$$\lim_{\tau \to 1} \left[-S_j - 2\tau K_i + \sqrt{S_j^2 + \tau K_i S_j + \tau^2 K_i^2} \right]$$
$$= -S_j - 2K_i + \sqrt{S_j^2 + K_i S_j + K_i^2}. \quad (A43)$$

$$\lim_{\tau \to \infty} \left[-S_j - 2\tau K_i + \sqrt{S_j^2 + \tau K_i S_j + \tau^2 K_i^2} \right] = -\infty. \quad (A44)$$

$$\lim_{K_i \to 0} \left[-S_j - \tau K_i \pm \sqrt{S_j^2 + 2\tau K_i S_j + 4\tau^2 K_i^2} \right] = 0. \quad (A45)$$

$$\lim_{K_i \to \infty} \left[-S_j - \tau K_i \pm \sqrt{S_j^2 + 2\tau K_i S_j + 4\tau^2 K_i^2} \right] = -\infty. \quad (A46)$$

$$\lim_{S_j \to 0} \left[-S_j - \tau K_i \pm \sqrt{S_j^2 + 2\tau K_i S_j + 4\tau^2 K_i^2} \right] = -\tau K_i < 0. \quad (A47)$$

$$\lim_{S_j \to \infty} \left[-S_j - \tau K_i \pm \sqrt{S_j^2 + 2\tau K_i S_j + 4\tau^2 K_i^2} \right] = -\frac{3\tau K_i}{2} < 0. \quad (A48)$$

A.2.2 Full Specialization

If the country is fully specialized in homogeneous goods production, the number of firms in the differentiated sector goes to zero. Hence, we assume $n_i = 0$. This implies that both, skilled labor and capital, are not used in that economy. Hence, $w_{Si} = 0$ and $w_{Ki} = 0$. Then it can be shown, that the non-cooperative tariff rate for country i is zero.

The social optimal tariff rate can be deduced in a similar manner as before. At the end of the day we are left with:

$$t_{ji}^{SO} = \frac{\epsilon - 1}{\epsilon}, \quad (A49)$$

implying

$$(t_{ji}^{SO} - 1) = -\frac{1}{\epsilon} < 0. \quad (A50)$$

A.3 Non-Cooperative Tariffs in the Presence of NEs and Horizontal MNEs

In the presence of NEs and horizontal MNEs the firm structure can be determined by the factor market constraints for skilled labor and capital, i.e. equations (9) and (11):

$$\begin{aligned} n_i &= 2S_i - K_i. \\ h_i &= K_i - S_i. \end{aligned} \tag{A51}$$

A country which is very capital abundant will therefore only run horizontal MNEs, whereas a very skilled labor abundant country will be dominated from exporting firms. The possible firm structures are depicted in the skilled labor to capital endowment box in Figure 2 and Table 1.

Again unskilled labor rewards are equalized and equal to one. The price for x-goods is therefore still given by $p_i = \frac{\epsilon}{\epsilon - 1}$.

For the further calculations I have to distinguish which firms are active, that is, where we are in the endowment box.

A.3.1 Full Specialization

Here we only have to derive the social optimal tariff rate in the case of a fully specialized country, as all other calculations are just as in the scenario with national firms only.

The procedure is as before: Factor prices are calculated from the zero-profit conditions and then used together with the definition of the price indices and the market clearing conditions in the income equation. Afterwards, the quantities of the homogeneous goods can be calculated. Now, all variables in the indirect utility function are expressed in terms of parameters and we can take the derivative with respect to the tariff rate. In the case where one country is fully specialized in homogeneous goods production and the other country runs national firms as well as horizontal MNEs, the social optimal tariff rate is given by:

$$\begin{aligned} t_{ji}^{SO} &= \frac{K_j(1+\tau) - S_j(2+\tau)}{3(K_j - S_j)\tau} \\ &\pm \frac{\sqrt{(K_j - 2S_j)^2 - (K_j^2 - 3S_jK_j + 2S_j^2)\tau + (S_j - K_j)^2\tau^2}}{3(K_j - S_j)\tau}. \end{aligned} \tag{A52}$$

Using the restriction for coexistence of national and horizontal MNEs in country

j, namely $S_j = \kappa K_j$, where $0.5 < \kappa < 1$, and taking limits with respect to the boundaries of κ, we find that only the solution with the positive square root is feasible and that the social optimal tariff rate is negative (Note that the first two equations give the limits for the case of the positive square root.)

$$\lim_{\kappa \to 0.5} \Big[\frac{-1 + \tau(\kappa - 1) + 2\kappa - \sqrt{(1-2\kappa)^2 + \tau^2(\kappa-1)^2 + \tau(\kappa(3-2\kappa)-1)}}{3\tau(\kappa-1)} \Big] = \frac{2}{3}. \tag{A53}$$

$$\lim_{\kappa \to 1} \Big[\frac{-1 + \tau(\kappa - 1) + 2\kappa - \sqrt{(1-2\kappa)^2 + \tau^2(\kappa-1)^2 + \tau(\kappa(3-2\kappa)-1)}}{3\tau(\kappa-1)} \Big] = \frac{1}{2}. \tag{A54}$$

$$\lim_{\kappa \to 0.5} \Big[\frac{-1 + \tau(\kappa - 1) + 2\kappa + \sqrt{(1-2\kappa)^2 + \tau^2(\kappa-1)^2 + \tau(\kappa(3-2\kappa)-1)}}{3\tau(\kappa-1)} \Big] = 0. \tag{A55}$$

$$\lim_{\kappa \to 1} \Big[\frac{-1 + \tau(\kappa - 1) + 2\kappa + \sqrt{(1-2\kappa)^2 + \tau^2(\kappa-1)^2 + \tau(\kappa(3-2\kappa)-1)}}{3\tau(\kappa-1)} \Big] = -\infty. \tag{A56}$$

A.3.2 Partial Specialization

The Middle of the Endowment Box (Area I)

In the area in the middle of the skilled labor to capital endowment box national firms and horizontal MNEs coexist in both countries. The amount of production of one x-variety is therefore given by:

$$x_{ii} = \frac{(\epsilon - 1)\alpha}{\epsilon[S_i - S_j + K_j + (2S_j - K_j)(\tau t_{ji})^{1-\epsilon}]}. \tag{A57}$$

$$x_{ji} = \frac{(\epsilon - 1)\alpha \tau^{1-\epsilon} t_{ji}^{-\epsilon}}{\epsilon[S_i - S_j + K_j + (2S_j - K_j)(\tau t_{ji})^{1-\epsilon}]}. \tag{A58}$$

Factor rewards can be calculated from the zero-profit conditions:

$$w_{Ki} = \frac{(\tau - (\tau t_{ij})^{\epsilon})\alpha}{\epsilon[(K_i - 2S_i)\tau t_{ij} + (S_i - S_j - K_i)(\tau t_{ij})^{\epsilon}]}. \tag{A59}$$

$$w_{Si} = \frac{a}{b}, \tag{A60}$$

where $a = ((2S_j - K_j)t_{ji}\tau(-2\tau + (\tau t_{ij})^\epsilon) + (\tau t_{ji})^\epsilon((2S_j - 2K_j + K_i t_{ij} - 2S_i(1 + t_{ij})) + (2S_i - 2S_j - K_i + K_j)(\tau t_{ij})^\epsilon))\alpha$ and $b = ((-2S_i + K_i)\tau t_{ij} + (S_i - S_j - K_i)(\tau t_{ij})^\epsilon)((2S_j - K_j)\tau t_{ji} + (S_i - S_j + K_j)(\tau t_{ji})^\epsilon)\epsilon$.

Income is now given by:

$$\begin{aligned} E_i &= L_i + \frac{(2S_j - K_j)(t_{ji} - 1)\tau\alpha}{(2S_j - K_j)\tau t_{ji} + (S_i - S_j + K_j)(\tau t_{ji})^\epsilon} + \frac{K_i\alpha}{(S_j - S_i + K_i)\epsilon} \\ &- \frac{(2S_i - K_i)(S_j + K_i + S_i(t_{ij} - 1) - K_i t_{ij})\tau\alpha}{(S_i - S_j - K_i)((2S_i - K_i)\tau t_{ij} + (S_j - S_i + K_i)(\tau t_{ij})^\epsilon)\epsilon} \\ &+ \frac{S_i((2S_j - K_j)\tau t_{ji} + (2S_i - 2S_j - K_i + K_j)(\tau t_{ji})^\epsilon)\alpha}{(S_i - S_j - K_i)(S_i - S_j + K_j)(\tau t_{ji})^\epsilon\epsilon - (S_j - S_i + K_i)(2S_j - K_j)\tau t_{ji}\epsilon}. \end{aligned} \tag{A61}$$

$$\begin{aligned} V_i &= L_i + \frac{(2S_j - K_j)(t_{ji} - 1)\tau\alpha}{(2S_j - K_j)\tau t_{ji} + (S_i - S_j + K_j)(\tau t_{ji})^\epsilon} \\ &+ \frac{S_i\alpha}{\epsilon}\left(\frac{1}{S_i - S_j + K_j + (2S_j - K_j)(\tau t_{ji})^{1-\epsilon}}\right. \\ &+ \left.\frac{-2\tau + (\tau t_{ij})^\epsilon}{(K_i - 2S_i)\tau t_{ij} + (S_i - S_j - K_i)(\tau t_{ij})^\epsilon}\right) \\ &- \frac{K_i((\tau t_{ij})^\epsilon - \tau)\alpha}{(K_i - 2S_i)\tau t_{ij}\epsilon + (S_i - S_j - K_i)(\tau t_{ij})^\epsilon} + \alpha(\ln\alpha - 1) \\ &+ \frac{\alpha}{\epsilon - 1}\ln\left[(S_i - S_j + K_j + (2S_j - K_j)(\tau t_{ji})^{1-\epsilon})\left(\frac{\epsilon - 1}{\epsilon}\right)^{\epsilon - 1}\right]. \end{aligned} \tag{A62}$$

The first derivative with respect to t_{ji} leads to:

$$\frac{a}{b} \overset{!}{=} 0, \tag{A63}$$

where $a = (2S_j - K_j)\tau\alpha(-(2S_j - K_j)(t_{ji} - 1)\tau t_{ji}\epsilon + (\tau t_{ji})^\epsilon(-S_i t_{ji} + S_i t_{ji}\epsilon - (S_i - S_j + K_j)(t_{ji} - 1)\epsilon^2))$ and $b = t_{ji}((2S_j - K_j)\tau t_{ji} + (S_i - S_j - K_j)(\tau t_{ji})^\epsilon)^2\epsilon$.

Again for $\epsilon = 2$ this expression can be solved analytically for t_{ji}:

$$\begin{aligned} t_{ji} &= \frac{K_j + 2S_i\tau + 2K_j\tau - 2S_j(1 + \tau)}{(3S_i - 4S_j + 4K_j)\tau} \\ &\pm \frac{\sqrt{(-2S_j + K_j)^2 + 2(2S_j - K_j)(S_i - 2S_j + 2K_j)\tau + 4(S_i - S_j + K_j)^2\tau^2}}{(3S_i - 4S_j + 4K_j)\tau}. \\ &= \frac{\tilde{K}_j + 2\tilde{S}\tau + 2\tilde{K}_j\tau - 2(1 + \tau)}{(3\tilde{S} - 4 + 4\tilde{K}_j)\tau} \\ &\pm \frac{\sqrt{a}}{(3\tilde{S} - 4 + 4\tilde{K}_j)\tau}. \end{aligned} \tag{A64}$$

where $a = (1-4\tau(1-\tau))\tilde{K}_j^2 - 4(\tau(2\tau-3)+1)\tilde{K}_j + (4\tau(1-2\tau))\tilde{S} + 2\tau(4\tau-1)\tilde{K}_j\tilde{S} + 4\tau^2\tilde{S}^2 + 4(\tau(\tau-1)+1)$.

Using the restriction between the capital and skilled labor endowment in a country, namely $S_i = \kappa K_i$, where $0.5 < \kappa < 1$ and taking limits for $(t_{ji}-1)$ with respect to the remaining factor endowments reveals, that only the solution with the positive part of the square root is a feasible solution:

$$\lim_{K_i \to 0} \Big[\frac{K_j + 2K_j\tau + 2\kappa K_i\tau - 2\kappa K_j(1+\tau)}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} + \frac{\sqrt{2K_j\tau(-1+2\kappa)(-2K_j(-1+\kappa)+\kappa K_i) + (K_j - 2\kappa K_j)^2 + 4\tau^2(K_j+\kappa K_i - \kappa K_j)^2}}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} - 1 \Big]$$
$$= \frac{\sqrt{K_j^2(1+2\tau(-1+\kappa)-2\kappa)^2} - (K_j(1+2\tau(-1+\kappa)-2\kappa))}{4\tau K_j(-1+\kappa)} - 1 \geq 0. \tag{A65}$$

This limit goes to $+\infty$ if $\kappa = 1$ and to 0 for $\kappa = 0.5$.

$$\lim_{K_i \to \infty} \Big[\frac{K_j + 2K_j\tau + 2\kappa K_i\tau - 2\kappa K_j(1+\tau)}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} + \frac{\sqrt{2K_j\tau(-1+2\kappa)(-2K_j(-1+\kappa)+\kappa K_i) + (K_j - 2\kappa K_j)^2 + 4\tau^2(K_j+\kappa K_i - \kappa K_j)^2}}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} - 1 \Big]$$
$$= \frac{1}{3}. \tag{A66}$$

$$\lim_{K_j \to 0} \Big[\frac{K_j + 2K_j\tau + 2\kappa K_i\tau - 2\kappa K_j(1+\tau)}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} + \frac{\sqrt{2K_j\tau(-1+2\kappa)(-2K_j(-1+\kappa)+\kappa K_i) + (K_j - 2\kappa K_j)^2 + 4\tau^2(K_j+\kappa K_i - \kappa K_j)^2}}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} - 1 \Big]$$
$$= \frac{1}{3}. \tag{A67}$$

$$\lim_{K_j \to \infty} \Big[\frac{K_j + 2K_j\tau + 2\kappa K_i\tau - 2\kappa K_j(1+\tau)}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} + \frac{\sqrt{2K_j\tau(-1+2\kappa)(-2K_j(-1+\kappa)+\kappa K_i) + (K_j - 2\kappa K_j)^2 + 4\tau^2(K_j+\kappa K_i - \kappa K_j)^2}}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} - 1 \Big]$$
$$= -\frac{1+2\tau(-1+\kappa)-2\kappa+\sqrt{(1-2\tau+2(-1+\tau)\kappa)^2}}{4\tau(1-\kappa)} \geq 0. \tag{A68}$$

This limit goes to 0 for $\kappa = 0.5$ and to $+\infty$ for $\kappa = 1$.

$$\lim_{K_i \to 0} \Big[\frac{K_j + 2K_j\tau + 2\kappa K_i\tau - 2\kappa K_j(1+\tau)}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)}$$
$$- \frac{\sqrt{2K_j\tau(-1+2\kappa)(-2K_j(-1+\kappa)+\kappa K_i)+(K_j-2\kappa K_j)^2+4\tau^2(K_j+\kappa K_i-\kappa K_j)^2}}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} - 1\Big]$$
$$= \frac{\sqrt{K_j^2(1+2\tau(-1+\kappa)-2\kappa)^2} - K_j(1+2\tau(-1+\kappa)-2\kappa)}{4\tau K_j(-1+\kappa)} \leq -1. \tag{A69}$$

As the expression $K_j(1+2\tau(-1+\kappa)-2\kappa)$ is negative for $0.5 < \kappa < 1$, we can simplify to $\frac{-2K_j(1+2\tau(-1+\kappa)-2\kappa)}{4\tau K_j(-1+\kappa)} = \frac{-2+4\tau-4\tau\kappa+4\kappa}{4\tau(-1+\kappa)}$. For $\kappa = 0.5$ this expression is equal to -1. The first derivative with respect to κ is given by $-\frac{1}{2\tau(-1+\kappa)^2}$. Hence, a higher κ is associated with a limit smaller than -1.

$$\lim_{K_i \to \infty} \Big[\frac{K_j + 2K_j\tau + 2\kappa K_i\tau - 2\kappa K_j(1+\tau)}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)}$$
$$- \frac{\sqrt{2K_j\tau(-1+2\kappa)(-2K_j(-1+\kappa)+\kappa K_i)+(K_j-2\kappa K_j)^2+4\tau^2(K_j+\kappa K_i-\kappa K_j)^2}}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} - 1\Big]$$
$$= -1. \tag{A70}$$

$$\lim_{K_j \to 0} \Big[\frac{K_j + 2K_j\tau + 2\kappa K_i\tau - 2\kappa K_j(1+\tau)}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)}$$
$$- \frac{\sqrt{2K_j\tau(-1+2\kappa)(-2K_j(-1+\kappa)+\kappa K_i)+(K_j-2\kappa K_j)^2+4\tau^2(K_j+\kappa K_i-\kappa K_j)^2}}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} - 1\Big]$$
$$= -1. \tag{A71}$$

$$\lim_{K_j \to \infty} \Big[\frac{K_j + 2K_j\tau + 2\kappa K_i\tau - 2\kappa K_j(1+\tau)}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)}$$
$$- \frac{\sqrt{2K_j\tau(-1+2\kappa)(-2K_j(-1+\kappa)+\kappa K_i)+(K_j-2\kappa K_j)^2+4\tau^2(K_j+\kappa K_i-\kappa K_j)^2}}{\tau(-4K_j(-1+\kappa)+3\kappa K_i)} - 1\Big]$$
$$= \frac{\sqrt{(1+2\tau(-1+\kappa)-2\kappa)^2} - (1+2\tau(-1+\kappa)-2\kappa)}{4\tau(-1+\kappa)} \leq -1. \tag{A72}$$

As the expression $(1+2\tau(-1+\kappa)-2\kappa)$ is negative for $0.5 < \kappa < 1$, I can simplify to $\frac{-2(1+2\tau(-1+\kappa)-2\kappa)}{4\tau(-1+\kappa)} = \frac{-2+4\tau-4\tau\kappa+4\kappa}{4\tau(-1+\kappa)}$. This is the same expression as before and therefore the limit is less or equal to -1.

These derivations reveal that (i) only the solution with the positive part of the square root is a feasible solution, as $(t_{ji}-1)$ is restricted to be greater than -1, and (ii) that the non-cooperative tariff rate is non-negative.

The derivative with respect to K_i is given by:

$$\frac{\partial t_{ji}}{\partial K_i} = \frac{a}{b} \overset{?}{\gtrless} 0, \tag{A73}$$

where $a = \kappa K_j(\tau K_i(3 - 4\tau(\kappa - 1) - 6\kappa) + K_j(-3 + 4\tau(2 + \tau) + 12\kappa - 8\tau(3 + \tau)\kappa + 4(-3 + \tau(4 + \tau))\kappa^2) + (-3 - 2\tau(\kappa - 1) + 6\kappa) \times \sqrt{4K_i^2\tau^2\kappa^2 + K_j^2(1 - 2\tau + 2(\tau - 1)\kappa)^2 + 2K_iK_j\tau\kappa(-1 + 4\tau + 2\kappa - 4\tau\kappa)})$ and $b = \tau(4K_j(\kappa - 1) - 3\kappa K_i)^2 \times \sqrt{2\tau K_j(2\kappa - 1)(-2K_j(\kappa - 1) + K_i\kappa) + (K_j - 2K_j\kappa)^2 + 4\tau^2(K_j + K_i\kappa - K_j\kappa)^2}$.

A quite similar expression can be derived for the change in the non-cooperative tariff t_{ji} when K_j rises:

$$\frac{\partial t_{ji}}{\partial K_j} = \frac{a}{b} \overset{?}{\gtrless} 0, \tag{A74}$$

where $a = \kappa K_i(\tau\kappa K_i(-3 + 4\tau(\kappa - 1) + 6\kappa) + K_j(3 - 4\tau(2 + \tau) - 12\kappa + 8\tau(3 + \tau)\kappa - 4(-3 + \tau(4 + \tau))\kappa^2) + (+3 + 2\tau(\kappa - 1) - 6\kappa) \times \sqrt{4K_i^2\tau^2\kappa^2 + K_j^2(1 - 2\tau + 2(\tau - 1)\kappa)^2 + 2K_iK_j\tau\kappa(-1 + 4\tau + 2\kappa - 4\tau\kappa)})$ and b is the same as in Equation (A73).

Trade cost changes have to following effect on the non-cooperative tariff:

$$\frac{\partial t_{ji}}{\partial \tau} = -\frac{K_j(2\kappa - 1)a}{b} \overset{?}{\gtrless} 0, \tag{A75}$$

where $a = K_j - 2K_j\tau - 2K_j\kappa - K_i\tau\kappa + 2K_j\tau\kappa + \sqrt{2K_j\tau(2\kappa - 1)(-2K_j(\kappa - 1) + \kappa K_i) + (K_j - 2K_j\kappa)^2 + 4\tau^2(K_j + \kappa K_i - \kappa K_j)^2}$, and $b = \tau^2(4K_j(\kappa - 1) - 3K_i\kappa) \times \sqrt{2K_j\tau(2\kappa - 1)(-2K_j(\kappa - 1) + \kappa K_i) + (K_j - 2\kappa K_j)^2 + 4\tau^2(K_j + \kappa K_i - \kappa K_j)^2}$.

It is hard to determine the signs of these derivatives in general. However for some special cases, there are clear results. If $\kappa = 1$ we are back in the case with only national firms. For $\kappa = 0.5$, we are left with horizontal MNEs only. In this case the tariff rate does not change the equilibrium outcome, it is an irrelevant policy. The derivative with respect to K_i is then given by $\frac{\partial t_{ji}}{\partial K_i} = \frac{4K_j}{(3K_i+4K_j)^2} > 0$. The first derivative with respect to K_j is negative, $\frac{\partial t_{ji}}{\partial K_j} = \frac{-4K_i}{(3K_i+4K_j)^2} < 0$. Trade costs do not matter as horizontal MNEs do not engage in trade per definition. For these two extreme cases the same results occur: A larger differentiated goods sector at home leads to a higher non-cooperative tariff whereas the increased importance of the x-sector abroad leads to a lower non-cooperative tariff.

In the case of complete equal countries, absolute endowments of capital or skilled labor no longer determine the level of the non-cooperative tariff. The only parameters that drive the result in this case are the level of trade costs and κ, the relative endowment of skilled labor and capital. The derivative with respect to κ is given by $\frac{\partial t_{ji}}{\partial \kappa} = \frac{a}{b} > 0$, where $a = -7 + \tau(16 + 4\tau - 11\kappa) + 14\kappa + (-7 + 2\tau)\sqrt{4\tau^2 + (2\kappa - 1)^2 - 2\tau(\kappa - 2)(2\kappa - 1)}$ and $b = \tau(\kappa - 4)^2 \times \sqrt{4\tau^2 + (2\kappa - 1)^2 - 2\tau(\kappa - 2)(2\kappa - 1)}$. The derivative with respect to trade costs can be written as $\frac{\partial t_{ji}}{\partial \tau} = -\frac{a}{b} > 0$, where $a = (2\kappa - 1)(1 + \tau(\kappa - 2) - 2\kappa + \sqrt{4\tau^2 + (2\kappa - 1)^2 - 2\tau(\kappa - 2)(2\kappa - 1)}$ and $b = \tau^2(\kappa - 4) \times \sqrt{4\tau^2 + (1 - 2\kappa)^2 - 2\tau(\kappa - 2)(2\kappa - 1)}$.

By means of simulation analysis in the allowed and reasonable parameter space (i.e. $0.5 < \kappa < 1$ and $1 < \tau < 5$, where the upper bound on transport costs seems to be justified by economic reasonability, even though results seem not to change for higher τ's, and various K_i/K_j ratios and absolute endowments), I find that $\frac{\partial t_{ji}}{\partial \tau} > 0$, $\frac{\partial t_{ji}}{\partial K_i} > 0$ and $\frac{\partial t_{ji}}{\partial K_j} < 0$.

Next I compare the non-cooperative tariffs for the cases with horizontal MNEs, denoted by t^h_{ji}, and without horizontal MNEs, referred to as t^n_{ji}. The difference between the non-cooperative tariff rates is given by:

$$\begin{aligned}\Delta t &= t^n_{ji} - t^h_{ji} = \frac{1}{3S_i(3S_i - 4S_j + 4K_j)\tau}\Bigg(- 4(S_j - K_j)\Big(- S_j \\ &+ \sqrt{S_j^2 + 2\tau S_i S_j + 4\tau^2 S_i^2}\Big) + S_i\Big((-S_j + K_j)(-3 + 2\tau) \\ &+ 3\sqrt{S_j^2 + 2\tau S_i S_j + 4\tau^2 S_i^2} \\ &- 3\sqrt{(-2S_j + K_j)^2 + 2\tau(2S_j - K_j)(S_i - 2S_j + 2K_j) + 4\tau^2(S_i - S_j + K_j)^2}\Big)\Bigg). \end{aligned} \tag{A76}$$

First of all I set this expression equal to zero and solve it for S_i:

$$S_i = -\frac{4(-S_j + 2\tau S_j)}{-3 + 8\tau} < 0. \tag{A77}$$

From this I can conclude that Δt can only be zero if S_i is negative, which is not allowed per definitionem. I now have to investigate whether the difference is positive or negative. As the result that the non-cooperative tariff can only be zero if the skilled labor endowment is negative holds without restrictions, I restrict myself to show that the difference is positive for the case of equal countries. In this case the difference simplifies to (where I again use $S_i = \kappa K_i$):

$$\begin{aligned}\Delta t &= \frac{1}{3\tau(-4 + \kappa)}\Bigg(7 - 4\sqrt{1 + 2\tau + 4\tau^2} + 2\tau(-1 + \kappa) \\ &+ \Big(-7 + \sqrt{1 + 2\tau + 4\tau^2}\Big)\kappa + 3\sqrt{(1 - 2\tau)^2 + 2(-2 + 5\tau)\kappa - 4(-1 + \tau)\kappa^2}\Bigg). \end{aligned} \tag{A78}$$

If $\kappa = 1$ no horizontal national firms exist, and therefore $\Delta t = 0$. For $\kappa = 0.5$, where only horizontal MNEs exist, $\Delta t > 0$ for all feasible t. As the difference is a continuous function and can not approach zero for feasible parameter values, this fact establishes that the difference is positive in the investigated case.

Again, results for $\epsilon \neq 2$ where calculated numerically and are summarized in Table 4.

The social optimal tariff rate for $\epsilon = 2$ is given by t_{ji}^{SO}:

$$\begin{aligned} t_{ji}^{SO} &= \frac{K_j + S_i\tau + K_j\tau - S_j(2+\tau)}{3(S_i - S_j + K_j)\tau} \\ &\pm \frac{\sqrt{3(2S_j - K_j)(S_i - S_j + K_j)\tau + (K_j + (S_i + K_j)\tau - S_j(2+\tau))^2}}{3(S_i - S_j + K_j)\tau}. \end{aligned} \tag{A79}$$

Using again the restriction between the capital and skilled labor endowment in a country, and taking limits for $(t_{ji} - 1)$ with respect to the remaining factor endowments, shows that (i) only the solution with the positive square root is a feasible one and (ii) the social optimal tariff rate is negative, i.e., imports should also be subsidized in the presence of horizontal MNEs.

$$\begin{aligned} &\lim_{K_i \to 0} \Big[\frac{K_j + \tau K_j + \kappa\tau K_i - \kappa K_j(2+\tau)}{3\tau(K_j + \kappa K_i - \kappa K_j)} \\ &+ \frac{\sqrt{3\tau(K_j + \kappa K_i - \kappa K_j)(2\kappa K_j - K_j) + (K_j - (2+\tau)\kappa K_j + \tau(K_j + \kappa K_i))^2}}{3\tau(K_j + \kappa K_i - \kappa K_j)} - 1 \Big] \\ &= -1 + \frac{1 + \tau - (2+\tau)\kappa + \sqrt{(1-2\kappa)^2 + \tau^2(-1+\kappa)^2 + \tau(-1 + (3-2\kappa)\kappa)}}{3\tau(1-\kappa)} \leq -\frac{1}{3}. \end{aligned} \tag{A80}$$

The limit goes to $-1/3$ for $\kappa = 0.5$ and to $-1/2$ for $\kappa = 1$.

$$\begin{aligned} &\lim_{K_i \to \infty} \Big[\frac{K_j + \tau K_j + \kappa\tau K_i - \kappa K_j(2+\tau)}{3\tau(K_j + \kappa K_i - \kappa K_j)} \\ &+ \frac{\sqrt{3\tau(K_j + \kappa K_i - \kappa K_j)(2\kappa K_j - K_j) + (K_j - (2+\tau)\kappa K_j + \tau(K_j + \kappa K_i))^2}}{3\tau(K_j + \kappa K_i - \kappa K_j)} - 1 \Big] \\ &= -\frac{1}{3}. \end{aligned} \tag{A81}$$

$$\begin{aligned} &\lim_{K_j \to 0} \Big[\frac{K_j + \tau K_j + \kappa\tau K_i - \kappa K_j(2+\tau)}{3\tau(K_j + \kappa K_i - \kappa K_j)} \\ &+ \frac{\sqrt{3\tau(K_j + \kappa K_i - \kappa K_j)(2\kappa K_j - K_j) + (K_j - (2+\tau)\kappa K_j + \tau(K_j + \kappa K_i))^2}}{3\tau(K_j + \kappa K_i - \kappa K_j)} - 1 \Big] \\ &= -\frac{1}{3}. \end{aligned} \tag{A82}$$

	Non-Cooperative Tariff Rates				Differences			
	σ				σ			
$\tilde{S}/\tilde{K}$	2	4	6	8	2	4	6	8
0.1/1.1	4.69	6.49	6.01	5.18	0.62	3.36	5.03	5.07
0.3/1.1	11.33	12.96	10.55	8.53	1.27	3.86	3.68	3.05
0.5/1.1	15.64	15.88	12.31	9.74	1.46	3.17	2.66	2.12
0.7/1.1	18.59	17.52	13.22	10.36	1.48	2.60	2.08	1.62
0.9/1.1	20.73	18.56	13.79	10.74	1.42	2.19	1.69	1.31
0.1/1.3	3.81	3.98	3.26	2.67	1.50	5.87	7.78	7.58
0.3/1.3	9.48	9.05	7.04	5.62	3.12	7.77	7.19	5.96
0.5/1.3	13.41	12.05	9.13	7.19	3.69	7.01	5.84	4.67
0.7/1.3	16.27	14.01	10.44	8.17	3.80	6.11	4.86	3.81
0.9/1.3	18.42	15.38	11.34	8.83	3.72	5.37	4.14	3.21
0.1/1.5	3.22	2.90	2.25	1.84	2.09	6.96	8.79	8.44
0.3/1.5	8.17	7.01	5.31	4.20	4.43	9.81	8.92	7.38
0.5/1.5	11.78	9.76	7.28	5.71	5.32	9.30	7.69	6.15
0.7/1.5	14.50	11.71	8.64	6.75	5.57	8.41	6.66	5.23
0.9/1.5	16.62	13.17	9.64	7.50	5.52	7.58	5.84	4.54
0.1/1.7	2.79	2.28	1.73	1.37	2.52	7.57	9.31	8.88
0.3/1.7	7.20	5.74	4.28	3.36	5.40	1.08	9.95	8.22
0.5/1.7	10.52	8.22	6.06	4.74	6.58	10.84	8.91	7.12
0.7/1.7	13.10	10.09	7.38	5.75	6.98	10.03	7.92	6.23
0.9/1.7	15.17	11.54	8.40	6.53	6.98	9.21	7.08	5.51
0.1/1.9	2.46	1.89	1.40	1.10	2.85	7.98	9.64	9.15
0.3/1.9	6.44	4.87	3.58	2.80	6.16	11.96	10.65	8.78
0.5/1.9	9.52	7.11	5.20	4.06	7.58	11.95	9.77	7.80
0.7/1.9	11.97	8.87	6.45	5.02	8.10	11.25	8.85	6.96
0.9/1.9	13.96	10.28	7.44	5.78	8.18	10.47	8.04	6.26

τ=1.2, $\tilde{S}=S_i/S_j$, $\tilde{K}=K_j/S_j$

Differences gives the difference in the non-cooperative tariff rates for the scenario with only national firms and with national and horizontal MNEs.

These tariffs are calculated for endowments corresponding to the middle of the endowment box (Area I) in Figure 2.

Table 4: Non-Cooperative Tariffs of country i for various ϵ's and national firms and horizontal MNEs

$$\lim_{K_j\to\infty}\Big[\frac{K_j+\tau K_j+\kappa\tau K_i-\kappa K_j(2+\tau)}{3\tau(K_j+\kappa K_i-\kappa K_j)} \tag{A83}$$

$$+\frac{\sqrt{3\tau(K_j+\kappa K_i-\kappa K_j)(2\kappa K_j-K_j)+(K_j-(2+\tau)\kappa K_j+\tau(K_j+\kappa K_i))^2}}{3\tau(K_j+\kappa K_i-\kappa K_j)}-1\Big]$$

$$=-\frac{1+2\tau(-1+\kappa)-2\kappa+\sqrt{(1-2\kappa)^2+\tau^2(-1+\kappa)^2+\tau(-1+(3-2\kappa)\kappa)}}{3\tau(1-\kappa)}\leq-\frac{1}{3}.$$

The limit goes to $-1/3$ for $\kappa = 0.5$ and to $-1/2$ for $\kappa = 1$.

$$\lim_{K_i\to 0}\Big[\frac{K_j+\tau K_j+\kappa\tau K_i-\kappa K_j(2+\tau)}{3\tau(K_j+\kappa K_i-\kappa K_j)} \tag{A84}$$

$$-\frac{\sqrt{3\tau(K_j+\kappa K_i-\kappa K_j)(2\kappa K_j-K_j)+(K_j-(2+\tau)\kappa K_j+\tau(K_j+\kappa K_i))^2}}{3\tau(K_j+\kappa K_i-\kappa K_j)}-1\Big]$$

$$=\frac{-1-2\tau(-1+\kappa)+2\kappa+\sqrt{(1-2\kappa)^2+\tau^2(-1+\kappa)^2+\tau(-1+(3-2\kappa)\kappa)}}{3\tau(-1+\kappa)}\leq-1.$$

For $\kappa = 0.5$ the limit goes to -1 and for $\kappa = 1$ it reaches $-\infty$ (computed as the limit approaching $\kappa = 1$ from smaller values).

$$\lim_{K_i\to\infty}\Big[\frac{K_j+\tau K_j+\kappa\tau K_i-\kappa K_j(2+\tau)}{3\tau(K_j+\kappa K_i-\kappa K_j)} \tag{A85}$$

$$-\frac{\sqrt{3\tau(K_j+\kappa K_i-\kappa K_j)(2\kappa K_j-K_j)+(K_j-(2+\tau)\kappa K_j+\tau(K_j+\kappa K_i))^2}}{3\tau(K_j+\kappa K_i-\kappa K_j)}-1\Big]$$

$$=-1.$$

$$\lim_{K_j\to 0}\Big[\frac{K_j+\tau K_j+\kappa\tau K_i-\kappa K_j(2+\tau)}{3\tau(K_j+\kappa K_i-\kappa K_j)} \tag{A86}$$

$$-\frac{\sqrt{3\tau(K_j+\kappa K_i-\kappa K_j)(2\kappa K_j-K_j)+(K_j-(2+\tau)\kappa K_j+\tau(K_j+\kappa K_i))^2}}{3\tau(K_j+\kappa K_i-\kappa K_j)}-1\Big]$$

$$=-1. \tag{A87}$$

$$\lim_{K_j\to\infty}\Big[\frac{K_j+\tau K_j+\kappa\tau K_i-\kappa K_j(2+\tau)}{3\tau(K_j+\kappa K_i-\kappa K_j)} \tag{A88}$$

$$-\frac{\sqrt{3\tau(K_j+\kappa K_i-\kappa K_j)(2\kappa K_j-K_j)+(K_j-(2+\tau)\kappa K_j+\tau(K_j+\kappa K_i))^2}}{3\tau(K_j+\kappa K_i-\kappa K_j)}-1\Big]$$

$$=\frac{-1-2\tau(-1+\kappa)+2\kappa+\sqrt{(1-2\kappa)^2+\tau^2(-1+\kappa)^2+\tau(-1+(3-2\kappa)\kappa)}}{3\tau(-1+\kappa)}\leq-1.$$

Where the conclusion that the limit is less or equal to -1 follows, from the limit calculations $K_i \to 0$.

This social optimal import subsidy is compared with the social optimal subsidy in the case of national firms only and with the case of the social optimal tariff rate in the scenario with full specialization and national and horizontal firms. As can be seen from Table 5, the subsidy is lower with horizontal MNEs and partial specialization as compared to the other two cases.

	Social Optimal Tariff Rates Partial Specialization				Differences $t^{SO}_{ji,n}$-$t^{SO}_{ji,nh}$				Social Optimal Tariff Rates Full Specialization				Differences $t^{SO}_{ji,f}$-$t^{SO}_{ji,p}$			
	σ				σ				σ				σ			
$\tilde{S}/\tilde{K}$	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8
0.1/1.1	-47.89	-17.94	-7.87	-3.77	-1.50	-3.34	-3.20	-1.99	-48.44	-20.92	-10.63	-5.44	-1.35	-2.98	-2.77	-1.67
0.3/1.1	-44.90	-14.45	-5.79	-2.80	-1.35	-1.97	-1.06	-0.48	-48.44	-20.92	-10.63	-5.44	-3.54	-6.47	-4.84	-2.64
0.5/1.1	-43.25	-12.64	-4.99	-2.46	-1.20	-1.24	-0.54	-0.22	-48.44	-20.92	-10.63	-5.44	-5.19	-8.28	-5.65	-2.98
0.7/1.1	-41.98	-11.58	-4.56	-2.28	-1.06	-0.87	-0.34	-0.14	-48.44	-20.92	-10.63	-5.44	-6.47	-9.34	-6.07	-3.15
0.9/1.1	-40.98	-10.89	-4.30	-2.18	-0.94	-0.65	-0.24	-0.10	-48.44	-20.92	-10.63	-5.44	-7.46	-10.03	-6.33	-3.26
0.1/1.3	-43.90	-13.29	-5.26	-2.57	-4.69	-7.99	-5.80	-3.18	-45.38	-14.62	-5.88	-2.83	-1.14	-1.33	-0.62	-0.26
0.3/1.3	-42.14	-11.70	-4.61	-2.30	-4.11	-4.71	-2.24	-0.97	-45.38	-14.62	-5.88	-2.83	-2.90	-2.92	-1.27	-0.53
0.5/1.3	-40.85	-10.81	-4.28	-2.17	-3.60	-3.08	-1.25	-0.52	-45.38	-14.62	-5.88	-2.83	-4.19	-3.81	-1.60	-0.67
0.7/1.3	-39.88	-10.24	-4.07	-2.09	-3.16	-2.21	-0.84	-0.34	-45.38	-14.62	-5.88	-2.83	-5.16	-4.38	-1.81	-0.75
0.9/1.3	-39.12	-9.84	-3.93	-2.03	-2.80	-1.70	-0.62	-0.25	-45.38	-14.62	-5.88	-2.83	-5.91	-4.78	-1.94	-0.80
0.1/1.5	-40.64	-10.67	-4.23	-2.15	-7.95	-10.60	-6.83	-3.61	-41.45	-11.20	-4.42	-2.23	-0.81	-0.53	-0.19	-0.08
0.3/1.5	-39.40	-9.98	-3.98	-2.05	-6.84	-6.43	-2.87	-1.22	-41.45	-11.20	-4.42	-2.23	-2.04	-1.22	-0.44	-0.18
0.5/1.5	-38.52	-9.55	-3.83	-2.00	-5.92	-4.34	-1.70	-0.70	-41.45	-11.20	-4.42	-2.23	-2.93	-1.65	-0.59	-0.23
0.7/1.5	-37.86	-9.26	-3.73	-1.95	-5.18	-3.19	-1.17	-0.48	-41.45	-11.20	-4.42	-2.23	-3.59	-1.95	-0.69	-0.27
0.9/1.5	-37.34	-9.04	-3.66	-1.92	-4.58	-2.50	-0.89	-0.35	-41.45	-11.20	-4.42	-2.23	-4.11	-2.16	-0.76	-0.30
0.1/1.7	-37.50	-9.11	-3.68	-1.93	-11.08	-12.17	-7.38	-3.82	-37.96	-9.30	-3.75	-1.96	-0.46	-0.19	-0.06	-0.03
0.3/1.7	-36.81	-8.83	-3.59	-1.90	-9.44	-7.58	-3.26	-1.38	-37.96	-9.30	-3.75	-1.96	-1.14	-0.47	-0.16	-0.06
0.5/1.7	-36.32	-8.65	-3.53	-1.87	-8.13	-5.24	-2.00	-0.81	-37.96	-9.30	-3.75	-1.96	-1.64	-0.65	-0.22	-0.08
0.7/1.7	-35.95	-8.51	-3.49	-1.86	-7.09	-3.94	-1.42	-0.57	-37.96	-9.30	-3.75	-1.96	-2.01	-0.78	-0.26	-0.10
0.9/1.7	-35.66	-8.41	-3.46	-1.84	-6.27	-3.13	-1.09	-0.43	-37.96	-9.30	-3.75	-1.96	-2.30	-0.89	-0.29	-0.11
0.1/1.9	-34.64	-8.08	-3.35	-1.80	-13.95	-13.20	-7.71	-3.95	-34.77	-8.12	-3.36	-1.81	-0.14	-0.04	-0.01	-0.05
0.3/1.9	-34.43	-8.02	-3.33	-1.79	-11.82	-8.40	-3.52	-1.48	-34.77	-8.12	-3.36	-1.81	-0.34	-0.11	-0.03	-0.01
0.5/1.9	-34.28	-7.97	-3.31	-1.79	-10.16	-5.92	-2.21	-0.90	-34.77	-8.12	-3.36	-1.81	-0.49	-0.15	-0.05	-0.01
0.7/1.9	-34.17	-7.94	-3.30	-1.78	-8.87	-4.51	-1.60	-0.64	-34.77	-8.12	-3.36	-1.81	-0.61	-0.19	-0.06	-0.02
0.9/1.9	-34.08	-7.91	-3.29	-1.78	-7.84	-3.63	-1.25	-0.50	-34.77	-8.12	-3.36	-1.81	-0.70	-0.21	-0.07	-0.03

τ=1.2, $\tilde{S}=S_i/S_j$, $\tilde{K}=K_j/S_j$

t^{SO}_{ji} represents the social optimal tariff rate in the case of partial specialization and national and horizontal MNEs. $t^{SO}_{ji,n}$ denotes the social optimal tariff rate in the case of partial specialization and the presence of national firms only. $t^{SO}_{ji,f}$ denotes the social optimal tariff rate in the case of full specialization and national and horizontal MNEs.

These tariffs are calculated for endowments corresponding to the middle of the endowment box (Area I) in Figure 2.

Table 5: Social Optimal Tariffs of country i for various ϵ's and national firms and horizontal MNEs

Large Skilled Labor Endowment Differences (Areas II and III)

In Area II there are no national firms in country 2. Therefore, there is no non-cooperative tariff for country 1. A comparison with the case of only national is therefore not possible.

In Area III country 1 only runs horizontal MNEs. However, for the non-cooperative tariff we are left with the same expression as in Area I. So again the non-cooperative tariff is lower in Area III as compared with the case where no MNEs are allowed.

Large Differences in Country Size (Areas IV and V)

In Area IV there are no horizontal multinational firms headquartered in country 1. This, however, does not change the non-cooperative tariff for country 1 as compared to the situation where also horizontal MNEs based in country 1 exist.

If country 1 is the large country (Area V), capital is too scarce in country 2 to run a multinational network. In this case the non-cooperative tariff of country 1 is equal to the non-cooperative therefore when MNEs are not allowed at all.

Large Capital Endowment Differences (Areas VI and VII)

If country 1 is very capital scarce, than it does not pay to run horizontal MNEs. The capital abundant country 2 on the other hand totally specializes in horizontal FDI (Area VI). In this case an non-cooperative tariff, as in Area II, can not be determined, as the tariff policy is irrelevant.

If country 1 is very capital abundant and country 2 very capital scarce (Area VII), the non-cooperative tariff rate is equal to the case with only national firms and $w_{K1} = w_{S2} = 0$, i.e. Equation (A27) applies.

A.4 Non-Cooperative Tariffs in the Presence of NEs and Vertical MNEs

Figure 3 and Table 2 show the firm structure when national firms and vertical MNEs are allowed. In order to determine the firm structure, I first focus on the factor market clearing conditions for capital and skilled labor, i.e. equations (9) and (11) respectively:

$$K_i \geq n_i + v_i \quad \perp \quad w_{Ki} \geq 0, \tag{A89}$$

$$S_i \geq n_i + (1+\delta)v_i \quad \perp \quad w_{Si} \geq 0. \tag{A90}$$

If $K_i > S_i$, then country i will only run national firms and w_{Ki} will be zero. The number of national firms is therefore determined by the endowment with skilled labor, i.e. $n_i = S_i$. This relationship is represented by the 45°-line starting from the bottom left corner (0_1) in Figure 3.

If skilled labor is the abundant factor, $S_i > K_i$, I have to distinguish two cases: (i) both resource constraints hold with equality (Areas II and IV in Figure 3), (ii) skilled labor is very abundant, so that the factor price is driven to zero, i.e. $w_{Si} = 0$ (Areas III and V in Figure 3).

A.4.1 Case I (Areas II and IV)

Partial Specialization

In the first case the number of firms is given by $v_i = \frac{S_i - K_i}{\delta}$ and $n_i = \frac{(1+\delta)K_i - S_i}{\delta}$. The dotted line with the slope $1+\delta$ starting from the bottom left corner (0_1) restricts the area where both factor market clearing conditions can hold with equality. If $S_i > (1+\delta)K_i$, then $w_{Si} = 0$ and we are in the second case. However, I have to check if the coexistence of national and vertical MNEs in the are spanned from the 45°-line and the line with slope $(1+\delta)$ is a feasible equilibrium solution. For this purpose I first solve for the factor prices from the zero-profit conditions (13) and (14):

$$w_{Ki} + w_{Si} = \frac{p_i(x_{ii} + x_{ij})}{\epsilon} \tag{A91}$$

$$w_{Ki} + (1+\delta)w_{Si} = \frac{p_j(x_{jj} + x_{ji})}{\epsilon}. \tag{A92}$$

Using $p_i = p_j = \frac{\epsilon}{\epsilon - 1}$, $x_{ii} = p_i^{-\epsilon} s_i^{\epsilon-1} \alpha$, $x_{ij} = p_i^{-\epsilon} \tau^{1-\epsilon} t_{ij}^{-\epsilon} s_j^{\epsilon-1} \alpha$ and Equation (A91), I can state w_{Ki} in terms of w_{Si} and parameters:

$$w_{Ki} = \frac{\left(\frac{\epsilon}{\epsilon-1}\right)^{-\epsilon} \alpha \left(s_i^{\epsilon-1} + \tau^{1-\epsilon} t_{ij}^{-\epsilon} s_j^{\epsilon-1}\right)}{\epsilon - 1} - w_{Si}. \tag{A93}$$

Plugging in this expression in (A92) and using $v_i = \frac{S_i - K_i}{\delta}$, $n_i = \frac{(1+\delta)K_i - S_i}{\delta}$ and $n_j = S - S_i$, I can solve for w_{Si}:

$$\left(\frac{\epsilon}{\epsilon-1}\right)^{-\epsilon} \alpha \left(s_i^{\epsilon-1} + \tau^{1-\epsilon} t_{ij}^{-\epsilon} s_j^{\epsilon-1}\right) + \delta(\epsilon - 1) w_{Si} = \left(\frac{\epsilon}{\epsilon-1}\right)^{-\epsilon} \alpha \left(s_j^{\epsilon-1} + \tau^{1-\epsilon} t_{ji}^{-\epsilon} s_i^{\epsilon-1}\right) \Rightarrow$$

$$
\begin{aligned}
(\epsilon-1)\delta w_{Si} &= \left(\frac{\epsilon}{\epsilon-1}\right)^{-\epsilon}\alpha\left(s_j^{\epsilon-1}(1-t_{ij}^{-\epsilon}\tau^{1-\epsilon})-s_i^{\epsilon-1}(1-t_{ji}^{-\epsilon}\tau^{1-\epsilon}\right)\Rightarrow \\
(\epsilon-1)\delta w_{Si} &= \left(\frac{\epsilon}{\epsilon-1}\right)^{-\epsilon}\alpha\left(\frac{1-t_{ij}^{-\epsilon}\tau^{1-\epsilon}}{p_j^{1-\epsilon}(n_j+v_i+n_i(\tau t_{ij})^{1-\epsilon})}\right. \\
&- \left.\frac{1-t_{ji}^{-\epsilon}\tau^{1-\epsilon}}{p_i^{1-\epsilon}(n_i+(n_j+v_i)(\tau t_{ji})^{1-\epsilon})}\right)\Rightarrow \\
w_{Si} &= \frac{\alpha}{\epsilon}\left(\frac{1-\tau^{1-\epsilon}t_{ij}^{-\epsilon}}{\delta(S-S_i)+S_i-K_i+(K_i-S_i+K_i\delta)(\tau t_{ij})^{1-\epsilon}}\right. \\
&- \left.\frac{1-\tau^{1-\epsilon}t_{ji}^{-\epsilon}}{K_i-S_i+K_i\delta+(\delta(S-S_i)+S_i-K_i)(\tau t_{ji})^{\epsilon}}\right) \qquad \text{(A94)}
\end{aligned}
$$

Setting this expression equal to zero and solving for S_i leads to:

$$S_i = aS + bK_i, \qquad \text{(A95)}$$

where

$$a = \frac{\tau^2 t_{ji}\delta + \tau^{2\epsilon}(t_{ij}t_{ji})^{\epsilon}\delta - \tau^{1+\epsilon}t_{ij}^{\epsilon}(1+t_{ji})\delta}{\tau^{\epsilon}t_{ij}^{\epsilon}(\tau^{\epsilon}t_{ji}^{\epsilon}(\delta-2)-\tau(1+t_{ji})(\delta-1))+\tau(\tau^{\epsilon}(1+t_{ij})t_{ji}^{\epsilon}-\tau(t_{ij}+t_{ji}-t_{ji}\delta))},$$

$$b = \frac{\tau^{1+\epsilon}t_{ij}^{\epsilon}(1+t_{ji})+\tau^{1+\epsilon}(1+t_{ij})t_{ji}^{\epsilon}(1+\delta)-\tau^{2\epsilon}(t_{ij}t_{ji})^{\epsilon}(2+\delta)-\tau^2(t_{ij}+t_{ji}+t_{ij}\delta)}{\tau^{\epsilon}t_{ij}^{\epsilon}(\tau^{\epsilon}t_{ji}^{\epsilon}(\delta-2)-\tau(1+t_{ji})(\delta-1))+\tau(\tau^{\epsilon}(1+t_{ij})t_{ji}^{\epsilon}-\tau(t_{ij}+t_{ji}-t_{ji}\delta))}.$$

If $t_{ij} = t_{ji}$ this expression simplifies to:

$$S_i = \frac{-2K_i - \delta K_i + \delta S}{\delta - 2} = -\frac{\delta S}{2-\delta} + \frac{2+\delta}{2-\delta}K_i. \qquad \text{(A96)}$$

This relationship between S_i and K_i is plotted as dotted line with a slope of $\frac{2+\delta}{2-\delta}$ from the bottom left corner (0_1) in Figure 3. I here assume that $\delta < 2$, i.e. that the additional skilled labor requirement for running a vertical MNE network is less than 3 times larger than running a domestic firm. We see that the requirement of positive factor prices restricts the area where national and vertical MNEs coexist to the areas II and IV. Note, that the intersection with the 45°-line is exactly at $S_i = S/2$. The more general case when $t_{ij} \neq t_{ji}$ is hard to plot graphically. What we can learn is that in the case of vertical MNEs, the non-cooperative tariff does depend on the tariff from the other country.

Suppose for now, that we are in Area II, and that t_{ij} is set at a rate so that for the investigated t_{ji} 's we stay in Area II, that is, the firm regime does not change and all factor prices in country i are positive. Preceding as before and assuming

$\epsilon = 2$ leads than to the following formula for the non-cooperative tariff:

$$\begin{aligned} t_{ji} &= \frac{1}{3\tau(S_i - K_i + S_j\delta)(S_i - K_i(1+\delta))}\Bigg(S_i^2 + S_i^2\tau + 2S_iS_j\delta + 2S_iS_j\delta\tau \\ &+ S_j^2\delta^2 + K_i^2(1+\tau+\tau\delta) \pm \Big[((S_i - K_i)^2(1+\tau) + (S_i - K_i)(-K_i\tau \\ &+ 2S_j(1+\tau))\delta + S_j(S_j - 2K_i\tau)\delta^2)^2 - 3\tau(S_i - K_i - S_j\delta)^2(S_i - K_i + 2S_j\delta) \\ &\times (S_i - K_i(1+\delta))\Big]^{0.5} - K_i(2S_j\delta(1+\tau+\tau\delta) + S_i(2+\tau(2+\delta)))\Bigg). \end{aligned} \tag{A97}$$

In order to ensure coexistence of national firms and vertical MNEs, $K_i(1+\delta) > S_i > K_i$ has to hold. If I assume that S_i approaches in value K_i, then vertical MNEs vanish. In this case the formula (A97) reduces to (A27).

If on the other hand S_i tends to $K_i(1+\delta)$ national firms based in country i loose their importance. In this case the non-cooperative tariff rate t_{ji} simplifies to:

$$\begin{aligned} (t_{ji} - 1) &= \left[\lim_{S_i \to K_i(1+\delta)} \frac{1}{3\tau(S_i - K_i + S_j\delta)(S_i - K_i(1+\delta))}\right] \\ &\times (S_j + K_i)^2\delta^2 \pm (S_j + K_i)^2\delta^2. \end{aligned} \tag{A98}$$

The second expression can either be zero or positive. The first expression approaches zero in the denominator. However, to ensure coexistence $K_i(1+\delta) > S_i > K_i$, and therefore the first term is negative. Hence, the non-cooperative tariff can get negative if vertical MNEs are present. This indeed means that the country headquartering the vertical MNEs subsidizes imports from abroad, which partly consists of imports from his own vertical MNEs and partly consists of imports from foreign national exporting firms.

The social optimal tariff rate is given by:

$$\begin{aligned} t_{ji} &= \frac{1}{3\tau(S_i - K_i(1+\delta))}\Bigg(S_i - K_i + S_i\tau - K_i\tau + S_j\delta - K_i\tau\delta \qquad \text{(A99)} \\ &\pm \sqrt{-3\tau(S_i - K_i + S_j\delta)(S_i - K_i(1+\delta)) + [S_i(1+\tau) + S_j\delta - K_i(1+\tau+\tau\delta)]^2}. \end{aligned}$$

Full Specialization

Calculating the case for a country that does not host plants for the Area II and IV in the presence of vertical outward FDI from country i to country j and national firms only in country j, we arrive at the following expression for the non-cooperative tariff rate:

$$t_{ji} = \frac{-(S_i + S_j)\delta \pm \sqrt{-S_i^2\tau + 2S_i(S_i + S_j)\tau\delta + (S_i + S_j)^2\delta^2}}{S_i\tau}. \tag{A100}$$

It can easily be seen that only the solution with the positive square root is a feasible solution. Using ($S = S_i + S_j$) and taking limits with respect to S_i leads us to:

$$\begin{aligned}\lim_{S_i \to \infty} \left[\frac{-S\delta + \sqrt{-S_i^2\tau + 2S_iS\tau\delta + S^2\delta^2}}{S_i\tau} - 1\right] &= -1 + \left(-\frac{1}{t_{ji}}\right)^{\frac{1}{2}} \\ = -1 + \frac{t_{ji}}{(-t_{ji})^{\frac{3}{2}}} < 0. \end{aligned} \tag{A101}$$

The limit $S_i \to 0$ is not well defined. However, plotting the function for a large range of relevant parameters reveals, that it is likely to go to zero. Hence, the non-cooperative tariff rate is non-positive.

The social optimal tariff rate is given by:

$$t_{ji}^{SO} = \frac{-(S_i + S_j)\delta + \pm\sqrt{-S_i^2\tau + S_i(2S_i + S_j)\tau\delta + (S_i + S_j)^2\delta^2}}{S_i\tau}. \tag{A102}$$

Again only the solution with the positive square root is a feasible solution. Comparing t_{ji} and t_{ji}^{SO}, we see that $t_{ji}^{SO} < t_{ji}$.

A.4.2 Case II (Areas III and V)

In the second case we are left with $K_i = n_i + v_i$. Now the factor market clearing equations alone are no longer enough to determine the firm structure. But as we know that $w_{Si} = 0$ the zero-profit conditions simplify to:

$$w_{Ki} = \frac{p_i(x_{ii} + x_{ij})}{\epsilon} \tag{A103}$$

$$w_{Ki} = \frac{p_j(x_{jj} + x_{ji})}{\epsilon}, \tag{A104}$$

which immediately leads to $x_{ii} + x_{ij} = x_{jj} + x_{ji}$. Plugging in leads to:

$$p_i^{-\epsilon}s_i^{\epsilon-1}\alpha + p_i^{-\epsilon}\tau^{1-\epsilon}t_{ij}^{-\epsilon}s_j^{\epsilon-1}\alpha = p_j^{-\epsilon}s_j^{\epsilon-1}\alpha + p_j^{-\epsilon}\tau^{1-\epsilon}t_{ji}^{-\epsilon}s_i^{\epsilon-1}\alpha. \tag{A105}$$

Using the fact that $n_j = S_j$ and the relationship $n_i = K_i - v_i$, we can write:

$$\frac{(K_i - v_i) + (S_j + v_i)(\tau t_{ji})^{1-\epsilon}}{S_j + v_i + (K_i - v_i)(\tau t_{ij})^{1-\epsilon}} = \left(\frac{1 - \tau^{1-\epsilon}t_{ij}^{-\epsilon}}{1 - \tau^{1-\epsilon}t_{ji}^{-\epsilon}}\right)^{-1} \Rightarrow \tag{A106}$$

$$v_i = \frac{(\tau t_{ij})^\epsilon (S_j(1+t_{ji})\tau + (K_i - S_j)(\tau t_{ji})^\epsilon) + \tau((K_i - S_j)\tau t_{ji} - K_i(1+t_{ij})(\tau t_{ji})^\epsilon)}{(\tau t_{ji})^\epsilon(-(1+t_{ij})\tau + 2(\tau t_{ij})^\epsilon) + \tau((t_{ij}+t_{ji})\tau - (\tau t_{ij})^\epsilon(1+t_{ji}))}. \tag{A107}$$

Setting $v_i = 0$, I can solve for S_i, using again $S_j = S - S_i$:

$$S_i = S + \frac{-t_{ij}\tau^2 - (t_{ij}t_{ji})^\epsilon \tau^{2\epsilon} + t_{ji}^\epsilon \tau^{1+\epsilon} + t_{ij}t_{ji}^\epsilon \tau^{1+\epsilon}}{t_{ji}\tau^2 + (t_{ij}t_{ji})^\epsilon \tau^{2\epsilon} - t_{ij}^\epsilon \tau^{1+\epsilon} - t_{ij}^\epsilon t_{ji}\tau^{1+\epsilon}} K_i. \tag{A108}$$

As before, assume that $t_{ij} = t_{ji}$. In this case the expression for v_i simplifies to:

$$v_i = \frac{K_i - S + S_i}{2}. \tag{A109}$$

If v_i equals zero, $S_i = S - K_i$. This relationship is graphically depicted in Figure 3 by the solid line with slope -1 starting from the upper left corner. Therefore only in area III national firms and vertical MNEs can coexist when $w_{Si} = 0$ and $t_{ij} = t_{ji}$.

The calculation of non-cooperative tariff rates in both cases, the partial and the full specialization case, are no longer analytically tractable. This can be easily understood by inspecting the highly non-linear equation for the determination of the number of vertical firms, i.e. Equation (A107). Hence, we present only numerical results for the partial specialization scenario in this case. However, the basic mechanisms are quite the same as in Area IV, so that this short-coming should not be too severe.

Clearly the area right from the main diagonal is the mirror image from the area above the main diagonal due to the symmetric set-up of the model.

In the areas I, VI and VII the results are the same as in the case where only national firms are allowed. The non-cooperative tariff in these areas is therefore identical to the formulas given in equations (A14), (A27) and (A28).