CORPORATE TAXATION OF HETEROGENEOUS FIRMS

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Nil difficile volenti.
Cicero

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Therefore, this is for you.

Contents

Preface

Overview – Corporate Taxation and Integration Strategies of Firms

Are governments in charge of the world economy?

With ever increasing economic integration and the increasing mobility of firms, the authority of single governments over their national economies has declined in the last decades (i.e., forces of world markets became more powerful). Due to this diffusion of power in the world economy, the international competitiveness of governments has become a key concern in policy debates.[1]

Because policy makers consider mobile multinational firms (MNEs) the most profitable and productive ones, attracting these firms has become a dominant concern of governments. Many factors determine corporate production locations, such as factor price differences or market sizes. However, high attention is given to the impact of corporate tax rates, because these are policy instruments and can be influenced by governments directly.[2]

Because MNEs extract the gains associated with their presence in the economy, the best reply of governments concerning tax environments may be to seek for international coordination between governments.[3]

Competition is brought to governments due not only to the mobility of firms but also to the market and surrounding conditions. In addition, the objectives of the governments are essential. Although firms are mobile and, therefore, can distort national tax bases, competitive tax setting does not necessarily have to be optimal for governments acting as benevolent planners.

Recent models have developed corporate tax rates consistent with a race-to-the-bottom scenario due to this competition.[4] These tax rates are inefficiently low and negative effects on the tax bases of other countries are ignored by governments when selecting lower tax rates to be optimal from their national perspective.

Several proposals for tax reforms have already been considered (e.g., by the German Council of Economic Advisors) because of this international competition.[5] A review of the development of corporate taxation has revealed that corporate tax harmonization has become conventional in the European Union and that the major economies in the Organization for Economic Cooperation and Development (OECD)

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[1] See Strange (1996) for a survey.
[2] See Devereux and Griffith (2003) or Hines (1999) for a survey.
[3] As suggested by Hanson (2001).
[4] See Mintz (1999) or Eichner and Runkel (2006) for a survey on a race-to-the-bottom in corporate tax rates.
[5] See German Council of Economic Advisors (2006).

have reduced their tax rates greatly in the past thirty years. Nevertheless, tax harmonization but not a race-to-the-bottom scenario involving zero taxation by these governments can be considered empirically.[6]

Facing these challenges for government policies due to the growing presence of mobile firms, this work is the author's contribution to the debate on corporate taxation of heterogeneous firms. Hence, not only MNEs are considered in the following models but also innovation noted in the literature described by the heterogeneity of firm-productivity is incorporated in all three settings. By allowing for heterogeneous firms, productivity differences are considered as a reason for high-productivity firms to set up foreign plants. Different integration strategies may arise and it is focused on the interaction of firm-productivity, trade, and international integration. Furthermore, because governments act as benevolent planners and their actions also are driven by governmental considerations other than relying on competitive governmental structures, a pure competitive governmental view of the world involving zero taxation is inconsistent with previously described evidence.[7]

Chapters 1 and 2 deal with corporate taxation of heterogeneous firms producing differentiated goods in a two-country setting with differing exogenously given market sizes, wage-level differences between both countries, transport costs, and endogenous market entry of firms depending on their productivity in which, these firms produce intermediate and final goods. Not only taxation but also the herein described factors are determinants in corporate production locations and, therefore, determinants in the tax basis in the jurisdiction of each government.

In chapter 1, both governments levy taxes on firms' profits to provide public infrastructure. If combined tax revenue is high enough, public infrastructure can be afforded. This results in declining transport costs associated with modified choices of the integration strategies of mobile firms. If provision of public infrastructure and its impact do not have negative implications on welfare in both jurisdictions, it is provided jointly by both governments. For this reason, in this analysis, both governments act as social planners. Only if provision of public infrastructure is

[6] E.g. compare to OECD (2005).
[7] Additionally also shown by Chennels and Griffith (1997).

welfare optimal for the representative households in both countries is profit taxation selected. Furthermore, welfare implications of this analysis are based on the distribution of firms over productivity levels, taken into account by both governments when levying profit taxes.

Hence, considering this analysis, coordination may be a best-reply considering the development of the world economy if governments use tax revenue to provide public infrastructure.

In contrast, in a scenario with tax competition, only under provision of public infrastructure is induced.[8] Because this approach does not imply competitive governmental objectives, efficient tax rates can be selected by both governments when providing public infrastructure with combined tax revenue. Due to differing market and surrounding conditions in both countries, the governments select different levels of corporate tax rates as optimal in both jurisdictions.

In chapter 2, governments can levy taxes on the profits of firms to provide a lump-sum transfer to households in their own jurisdictions. However, they only levy them if doing so induces national welfare gains.

In contrast to chapter 1, this does not result in declining transport costs and can never induce a welfare gain in the larger country in the model. Hence, the optimal corporate tax rate in Country A is zero and this is independent of the corporate tax rate in Country B. The government in B can anticipate zero taxation in A, and therefore, can select an optimal corporate tax rate and depreciation possibilities unilaterally when maximizing national welfare. Therefore, optimality depends on market conditions and the distribution of firms over productivity levels; but it is independent of tax competition between governments.

Chapter 3 also deals with two governments levying profit taxes. In contrast to chapters 1 and 2, in chapter 3, taxes are only levied on profits of MNEs earned in the country other than the country of origin of the single MNE (i.e., withholding taxes are levied on these profits). The wage-level in both countries is identical in this setting, relative country sizes are varied within this analysis, and the mass of firms entering both markets depends on selected tax rates. Hence, the mass of firms supplying both markets is determined endogenously. Additionally, firms producing differentiated

[8] Compare to Davies and Eckel (2007).

goods only produce final goods (i.e., integration strategies of these heterogeneous firms are not as complex as in chapters 1 and 2 because intermediate goods do not exist in this analysis). Hence, only domestic producers, exporting firms, or horizontal MNEs exist; and either country can be the location of origin of any single firm. As in chapter 2, both governments act as benevolent planners, providing lump-sum transfers to households in their own jurisdictions when levying taxes on profits. In chapter 3, therefore, best-response tax rates are derived in contrast to chapter 2 in which the optimal tax rate of one country is determined by exogenous factors.

In chapter 3, competition brought to the single governments acting as benevolent planners when levying withholding taxes on profits of MNEs is emphasized. Hence, no other prevailing approach of governmental competition concerning tax bases is selected. This analysis rather focuses on a less competitive policy instrument. By levying withholding taxes on the profits of MNEs, governments do not compete for the same tax base (i.e., only the foreign earned profits of MNEs are taxed by the foreign government). Hence, the analysis focuses on the profits that are not taxed in their country of origin. This is independent of the selected integration strategy. However, because the selected tax rate of the other government influences welfare of the representative household in the home country, the government in the home country reacts with another withholding tax rate. The reason for this implication on welfare in the home country is that the mass of firms entering the market is influenced by the other withholding tax rate and vice versa. To observe these implications on welfare in both jurisdictions, best-response tax rates from the point of view of single governments as well as from a social planner's perspective are derived.

Analyzing the tax setting of single governments, maximizing welfare in their own jurisdictions results in inefficient levels of tax rates due to the governmental competition brought to them, although both governments do not directly compete in terms of their tax bases when levying withholding taxes.

In contrast, the analysis from a social planner's perspective results in international coordination and efficient tax rates from a world welfare perspective. Through coordination, governments can avoid the prisoner's dilemma in the tax competition game.[9] Therefore, coordination is a best reply for markets that work beneficially and efficiently.

The following chapters contain the author's contribution to the debate on corporate taxation and its efficiency between more and less competitive governmental motives in an increasingly more economically integrated world.[10] The chapters may also be read independently.

[9] This follows from Nash (1951).
[10] Note, that Chapter 3 is based on joint work with Hanne Elisabeth Ehmer.

Chapter 1

Profit Taxation of Heterogeneous Firms with Provision of Public Infrastructure for Differentiated Goods

1.1 Introduction

Corporate expansion to foreign markets is a phenomenon that has occurred for at least two centuries. Early on, economic motives for cross-border activities of enterprises were mostly associated with the organization of supply networks to serve European markets from abroad. Since then, multinational enterprises (MNEs) have gained importance quite dramatically; and the economic motives for corporate expansion to foreign markets have become far more complex than in old times. Firms now exploit comparative advantages across host countries and plant locations to organize production networks across borders. New markets have emerged and economies of scale have materialized so that manifold motives for cross-border firm organization can be distinguished.

New trade theory on MNEs[11] posits the importance of the jointness of input in firm setup and transport cost savings, which are associated with multi-plant production within MNEs. Such firms have gained importance quite obviously. For instance, between 1990 and 2001, the sales of foreign affiliates of MNEs grew a lot faster than goods exports. In 2001, foreign affiliates of MNEs earned 11% of world gross domestic product (GDP) and contributed 35% to world trade of goods.[12]

As mentioned before, the motives of MNEs for foreign direct investments (FDI) and their modes of organization are quite diverse.[13] Low-cost seeking versus market-seeking motives are important, but they rarely generate purely vertical or purely horizontal MNE integration strategies empirically.[14] Recent theoretical work acknowledges complex integration strategies that combine vertical integration strategies, such as those associated with intermediate goods production, and the vertical slicing of production chains across international borders[15] with horizontal ones, such as export platform set-up.[16]

Furthermore, a recent innovation in the literature is the incorporation of heterogeneous firms into the models of MNE activities. Due to international trade and

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[11] Surveys of the literature include Markusen (2002) and Barba Navaretti and Venables (2004).
[12] As in UNCTAD (2002).
[13] Evidence also is found in UNCTAD (1998).
[14] Literature about vertical integration strategies includes Helpman (1984, 1985). Literature about horizontal integration strategies includes Markusen (1984) and Markusen and Venables (1998). Empirical evidence that integration strategies are more complex include Hanson, Mataloni, and Slaughter (2005) and Feinberg and Keane (2006).
[15] As in Yeaple (2003) and Grossman, Helpman, and Szeidl (2006).
[16] As shown by Ekholm, Forslid, and Markusen (2007).

FDI, in recent work, firms of heterogeneous productivity have been introduced in models of imperfect competition.[17] In previous models, firms were assumed to be identical. Allowing for heterogeneous firms gives rise to productivity differences as a reason for (ex-post) sorting of high-productivity firms into setting up foreign plants. Heterogeneous firms also allow for different integration strategies to be considered to determine production locations, whereas identical firms have the same preferences concerning their production locations.

Some models of taxation with imperfect competition surely already exist. However, in most of them taxation of identical firms is analyzed.[18] Recently, theoretical work concerning taxation with heterogeneous firms has surfaced, in which researchers claim inefficiently low tax rates, resulting in under provision of public goods because of tax competition.[19]

A single government is only interested in maximizing its own national welfare. It does not consider that its lower tax rate, which attracts more productive firms, lowers tax revenues of countries with higher tax rates. For this reason, also other governments react with lower tax rates. Consequently, inefficiently low tax rates from a world welfare perspective emerge.[20] This tax setting behavior with tax competition actually can be seen as a race-to-the-bottom scenario due to the profit-shifting activities of MNEs.[21]

Therefore, not only has the economic importance of MNEs risen in the last decades, but this development also influences governments' decisions about corporate taxation. Surely, other factors are also important to firms concerning the location of corporate investments (e.g., wage differences between countries), which suggests that governments must be careful about their use. Nevertheless, noting empirical studies, corporate taxes are relevant for firms.[22]

This chapter outlines a model of corporate taxation in the presence of MNEs in which it may be efficient for governments to use positive corporate taxation. Firms are heterogeneous in their productivity and engage in imperfect competition. They produce intermediate and final goods so that various simple, as well as complex,

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[17] Examples are Melitz (2003), Ghironi and Melitz (2005), and Davies and Eckel (2007).
[18] Examples in literature include Baldwin and Krugman (2004).
[19] Davies and Eckel (2007) provide this approach. Further work on inefficiently low capital tax rates and under provision of public goods due to tax competition is Haufler (2001).
[20] As in Hines (1999).
[21] As in Mintz (1999).
[22] As in Hines (1999).

integration strategies may arise here.[23] This is supported by the empirical evidence mentioned previously.

The model deals with two countries: The North is the home country of heterogeneous firms; the South is a country with a relatively lower wage level. Every single production activity of heterogeneous firms can be run in both countries.[24] Also, a simple setting with all production activities located in the North is possible. For this reason, a heterogeneous firm must not necessarily be a multinational.

By assumption, the wage level in the South is lower than in the North. For this reason, production costs for intermediate and final goods are lower there, too. However, to produce at cheaper costs in the South, firms must invest to set-up production plants there. These fixed costs do not occur when producing in the North, and their size differs, depending on shifting intermediate or final good production to the South. However, transportation can result in additional costs to a firm. Therefore, it may be optimal to avoid them at extra fixed costs associated with foreign plant set-up in the South. For this reason, the key parameters of the basic setting of this model are the size of transport costs, factor price differences, the relative size of fixed costs for MNE activities, firm productivities, and the market shares of final goods consumption.[25]

A host of factors influencing the choice of location for corporate investments is introduced into this model. These factors have already been identified as being important in general. The key factors relevant here, however, are corporate taxes, which influence decisions in firms about their integration strategies.

Governments act as benevolent planners and can anticipate the impact of profit taxes on integration strategies. Accordingly, Northern and Southern tax rates are determined endogenously in this model; and their impact on integration strategies and welfare are discussed. Double taxation of profits is not possible in this setting.[26] By levying taxes, a government is only interested in its own national welfare; but combined tax revenues from both governments are used to finance public

[23] Concerning possible integration strategies of firms this model is very much based on Grossman, Helpman, and Szeidl (2006).
[24] As in Grossman, Helpman, and Szeidl (2006).
[25] As in Grossman, Helpman, and Szeidl (2006).
[26] An example in literature is Egger et al. (2006a).

infrastructure.[27] Therefore, transport costs for goods produced by the heterogeneous firms decrease endogenously in the model because of taxation. Even though tax rate differentials can occur in this model, inefficiently low tax rates do not arise because governments take the impact of their own tax rate on the foreign tax base into account.

This theoretical analysis is structured in the following way:
Section 1.2 outlines the model and derives optimal integration strategies of firms in the differentiated sector. These depend on relative size of fixed costs for plant set-up, factor price differences, relative market size, firm productivities, and transport costs.
Subsequently, we introduce profit taxation and study its impact on the optimal integration strategies.
Section 1.3 concludes the analysis and illustrates impact of profit taxation on integration strategies and welfare.

1.2 Optimal profit taxation of heterogeneous firms with provision of public infrastructure

1.2.1 Some general features of the model set-up

The following partial analysis describes the optimal integration strategies of heterogeneous firms based on the theoretical framework of Grossman, Helpman and Szeidl (2006), with particular emphasis on the role of profit taxation.
This analysis studies the optimal tax policy of governments when providing public infrastructure for differentiated goods, depending on the integration strategies chosen by heterogeneous firms.
We set-up a simple model with two countries: North (N) and South (S). The former is developed, the latter less developed. While factors are assumed to be immobile across national borders, goods are not. However, factor price equalization does not emerge due to the presence of transport costs. With regard to integration strategies, firms choose between two options: concentrating final production in one country and serving consumers world-wide from there (exporting) or engaging in multi-plant final

[27] An example of a model with public infrastructure analyzing its impact on trade patterns, industrial location, and welfare, is Martin and Rogers (1995), even though their setting is totally different from this one and it does not deliver optimal tax rates.

production and serving consumers locally through domestic and foreign subsidiaries (multinational activity). In the parsimonious framework chosen, labor is the only factor used in production and in firm or plant set-up.
One industry produces a homogeneous good x_0; the other industry produces differentiated goods.

The homogeneous good is supplied under perfect competition. N is more productive in this sector than S. For this reason, there exists a gap between wages (w) in N and S. It is assumed that one unit of labor is needed to fabricate one of these goods in N. However, $\frac{1}{w} > 1$ units of labor are needed in S to produce one unit of the homogeneous good. We focus on parameter configurations which ensure that the homogeneous good is produced in both countries in equilibrium and traded across national borders. The price of the homogeneous good is chosen as the numéraire. Consequently, $w^N = 1 > w^S = w$ arises, where w^i is the wage rate in country i, $i \in \{N, S\}$ and transport costs for the homogeneous good exist.[28]

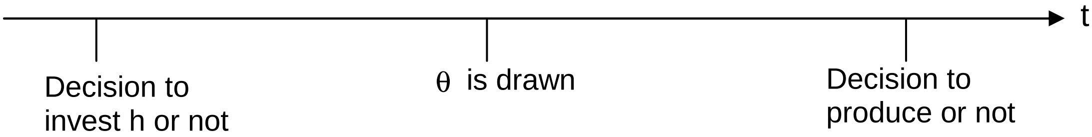
The differentiated good is supplied under monopolistic competition. Each firm acts as a monopolist in supplying its variety. The price elasticity of demand between varieties is $\varepsilon > 1$ so that firms charge a fixed mark-up over marginal costs. Due to monopolistic competition, the price will be lower than the monopoly price because, otherwise, the firms would loose an over proportionate amount of demand for their varieties.

We assume that these firms are heterogeneous in productivity, that they only can be founded in N, and that firm headquarters are not internationally mobile. For this reason, all headquarters are located in N (e.g., because of the unfavorable institutional environment in S) and they are all owned by N.
To enter the differentiated industry, an amount of h Northern units of labor, which are sunk costs, must be invested. These are firm set-up costs. With this investment, a firm in the heterogeneous sector gets to know its own potential productivity level (θ). Then, the firm can decide if it wants to enter the market. Firms in the differentiated sector can be diverse in their productivity so, if they decide to enter the market after

[28] As in Grossman, Helpman, and Szeidl (2006).

investing h, they can make positive profits.[29] However, before investing h, all heterogeneous firms have the same expectations about their profits. For this reason, all heterogeneous firms are the same ex ante. If ex ante zero profits are expected, no more firms are willing to enter the differentiated sector. The productivity level drawn by a firm is a random variable (graphic 1.1).

Graphic 1.1:



In addition, it is assumed that not only are production costs less in S than in N but also that its market for differentiated goods (M^S) is much smaller than the differentiated goods market in N (M^N).

1.2.2 The utility function of a representative household

All households have the same preferences and their utility function depends on a homogeneous good x_0 and the sub-utility of consumption of differentiated goods X. Each household consumes goods of either sector and, in formal accounts, its utility function may be written as:

$$U_i = x_0 + X, \quad i \in \{N, S\} \tag{1.1}$$

where $$X = \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{\alpha} dj\right] \qquad 0 < \alpha < 1,\ 0<\mu<1 \text{ and } \mu < \alpha \tag{1.2}$$

Consequently, the utility of the representative household increases if more varieties of the differentiated product are available. These love for variety preferences[30] exist for the consumption of differentiated goods. The elasticity of substitution between two of these varieties is constant: $\frac{1}{(1-\alpha)}$. All varieties in the differentiated sector are non-perfect substitutes for one another, as α<1. But as α>0, they are somehow substitutable. μ is a constant with 0<μ<α<1 and reflects the preference for the differentiated industry over the homogeneous industry in the utility function of the

[29] As in Helpman, Melitz, and Yeaple (2004).
[30] As in Krugman (1979) and Dixit and Stiglitz (1977).

representative household. X shows the sub-utility of consumption of the differentiated output, where $x^i(j)$ features the consumption in i of the j-th variety in this industry.[31]

Thus, the utility function of a representative household is linear in x_0 and non-linear in differentiated goods. This implies that the demand for differentiated products depends on prices of differentiated goods but not on earnings.

1.2.3 The heterogeneous firms

As mentioned before, heterogeneous firms arise in the differentiated industry and locate their immobile headquarters in the North. Irrespective of their integration strategies, these firms sell their products to each market.

This analysis discusses the optimal integration strategies of these firms, which depend on the firm productivity levels. An integration strategy is defined by the choice of the location of intermediate and final goods production. In the following sections the choice for an integration strategy is influenced not only by transport costs but also by taxation on profits.

To begin, in this analysis a firm in the differentiated industry with productivity θ produces final goods according to the production function $\theta F(m, a)$. The amount of intermediate input used is denoted by m, and a is the level of final good activity. Both are measured in units of labor input. F(m, a) is an increasing, concave function with constant returns to scale. Furthermore, the elasticity of substitution between m and a is not greater than 1. $c(p_m, p_a)$ describes the unit cost function, referring to F(m, a), where the price of input i at the location of final goods production is denoted by p_i, $i \in \{m, a\}$. Taking stock, $c(p_m, p_a)/\theta$ describes the per-unit variable costs of production of a firm with productivity θ at a particular location.[32]

Households only consume final goods.

A firm producing intermediate goods in S has to bear extra fixed costs of g for communication and supervision because the headquarters of MNEs are located in N. Likewise, MNEs incur additional fixed costs of f if they produce final goods in S. These fixed costs are measured in labor units of the home country. Therefore, it is assumed that fixed costs do not exist in N.[33]

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[31] As in Grossman, Helpman, and Szeidl (2006).
[32] As in Grossman, Helpman, and Szeidl (2006).
[33] As in Grossman, Helpman, and Szeidl (2006).

However, as already discussed, wages in S are lower than in N. It is assumed that production of one unit of the intermediate or final goods requires one unit of local labor at the place of production but that the intermediate goods have to be transported to the location of final production, if the latter are manufactured elsewhere. However, per-unit variable costs of manufacturing differentiated final or intermediate goods in S are lower than those of manufacturing these goods in N. Because $w^S=w<1=w^N$, S has a comparative advantage in manufacturing differentiated goods.

Table 1.1:[34]

Intermediate production m	Final good production a	Fixed costs	Per-unit variable costs
in N	in N	0	$c(1, 1) / \theta$
in N	in S	f	$c(1, w) / \theta$
in S	in N	g	$c(w, 1) / \theta$
in S	in S	f+g	$c(w, w) / \theta$

Table 1.1 shows that the optimality of integration strategies depends on per-unit variable costs $c(p_m,p_a)$ and the fixed costs of a firm in the differentiated industry. Furthermore, the total factor productivity of a firm is elemental for optimal integration strategy.

Additionally, these strategies also depend on market size, the level of transport costs, and taxes.

In the following, strategies depend on the location of intermediate and final goods production, where can be produced in S as well as in N.

1.2.4 Iceberg transport costs

Now, iceberg transport costs (d) are introduced. This implies that an exporting firm has to ship more than one unit of the final goods so that one unit of the goods arrives at the location of foreign consumers. Transport costs for final goods are identical

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[34] See Grossman, Helpman, and Szeidl (2006).

across countries and differentiated products, and they are proportional to the extent of shipments.[35]

In the following, section the size of transport costs is relatively high: ($d=d_H$).

1.2.5 Analysis with high transport costs and without taxation

Let us first describe the case in which transport costs for final goods are high and taxes are zero. By assumption, transport of intermediate goods is free.[36]

Compared to production in N, setting up foreign production plants in S induces additional fixed costs for a firm. However, its per-unit variable costs can be reduced when shifting production activities to S.[37]

Subsequently, the variation in firm productivity levels θ in the differentiated industry will be observed more precisely.[38]

A firm would also never conduct activities in more than one plant per country. Such a strategy would unnecessarily incur additional costs.

To illustrate optimal integration strategies depending on the productivity level of a firm, we compare profits across alternative integration strategies. Consistent with the preferences depicted in (1.1) and (1.2), every manufacturing firm of this industry faces the following demand function in each country i, $i \in \{N, S\}$:[39]

$$x^i(j) = M^i \alpha [p_i(j)\mu]^{1/(\alpha-1)} \tag{1.3}$$

$x^i(j)$ describes the total demand in one country for the differentiated good of a single firm. This demand depends on market size M^i, $i \in \{N, S\}$. Furthermore, it depends on the substitutability of differentiated products among each other, α, on μ, which reflects the preference for the differentiated industry over the homogeneous industry by the representative household, and on $p_i(j)$, which is the effect of the price of the individual firm on x^i. Hence demand from a single household for differentiated goods is independent of income.

Each firm, therefore, maximizes its profits accordingly to:

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[35] As in Grossman, Helpman, and Szeidl (2006).
[36] As in Grossman, Helpman, and Szeidl (2006).
[37] As also in Yeaple (2003) and Helpman, Melitz, and Yeaple (2004).
[38] As in Grossman, Helpman, and Szeidl (2006).
[39] See derivation I in Appendix 1.4.

$$\pi = p_N(j)x^N(j) + p_S(j)x^S(j) - x^N(j)\frac{c_N}{\theta} - x^S(j)\frac{c_S}{\theta} - k \qquad (1.4)$$

Here $p_N(j)x^N(j) + p_S(j)x^S(j)$ denotes total sales, $(x^N(j)\frac{c_N}{\theta} + x^S(j)\frac{c_S}{\theta})$ reflects total costs in both countries, and k are the fixed costs. $\frac{c_N}{\theta}$ and $\frac{c_S}{\theta}$ are per-unit variable costs in N and S, respectively.

This results in the identification of the optimal prices of a firm:[40]

$$p_N(j)_{opt} = \frac{1}{\alpha}\frac{c_N}{\theta}, \quad p_S(j)_{opt} = \frac{1}{\alpha}\frac{c_S}{\theta} \qquad (1.5)$$

As shown here, the optimal price of a firm is independent of demand, respectively, on market size in N and S. Each market price is defined as $\frac{1}{\alpha}$ times the per-unit variable costs of a firm serving the specific market. Hence, prices entail a fixed markup over marginal costs.

In the following, we allow for transport costs and introduce terms that capture transport costs as well as variable (marginal) production costs.

Generally, profits may be formulated as follows:[41]

$$\pi^*_{a,b} = \frac{\overline{X^N}\Theta}{dC_{a,b}(j,r)} + \frac{\overline{X^S}\Theta}{dC_{a,b}(j,r)} - k_{a,b}\text{, with } a \in \{N,S\} \text{ and } b \in \{N,S\} \qquad (1.6)$$

Firm profits depend on its integration strategy, where a is the determinant of the location of intermediate goods production and b of final goods production. Hence, intermediate as well as final differentiated goods can be produced either in N or in S or in both countries. Depending on the location of production of a and b, different possible fixed costs ($k_{a,b}$) are taken into account in the profit function of a firm. If intermediate goods are produced in S, $k_{a,b}$ has size g; if final goods are produced in S, $k_{a,b}$ has size f; and if intermediate or final goods are produced in N, fixed costs are zero. Also per-unit variable costs $dC_{a,b}(j, r)$ depend on the locations of intermediate and final production, a and b. As denoted in table 1.1, j is the determinant of the dependency of total per-unit variable costs on per-unit variable costs for intermediate

[40] See derivation II in Appendix 1.4.
[41] See derivation III in Appendix 1.4.
Furthermore, $\Theta = \theta^{\alpha/(1-\alpha)}$, $dC = c^{\alpha/(1-\alpha)}$, $\overline{\overline{X}} = (1-\alpha)\cdot\left(\frac{\alpha}{\mu}\right)^{1/(1-\alpha)}$, $M^N\overline{\overline{X}} = \overline{X^N}$, and $M^S\overline{\overline{X}} = \overline{X^S}$, where $\overline{X^S} < \overline{X^N}$ because the market share of S is smaller than that of N.

goods, measured in units of labor at the production location. Hence, j is $j \in \{1, w\}$; 1 occurs if intermediate goods are produced in N; and w<1 denotes these costs if they are produced in S. Additionally, r is the determinant of the dependency of total per-unit variable costs on per-unit variable costs for final goods, measured in units of labor at the production location. Hence, r is $r \in \{1, w\}$; 1 occurs if final goods are produced in N; and w<1 denotes these costs if they are produced in S. Finally, also transport costs (d) are part of per-unit variable costs and depend on the location of final production. If final goods have to be shipped to serve a market, d >1 occurs; if final goods are produced at the location of consumption, d =1 (no transportation of final goods) is taken into account in the profit function of a firm.

Furthermore, high transport costs exist if:[42]

$$\frac{C(w,1)}{C(w,w)} < d_H \quad \text{or} \quad \frac{C(1,1)}{C(1,w)} < d_H$$

For this reason, the following possible profit functions arise for a firm, depending on its productivity level in a two-country setting with high transport costs:

$$\pi_{N,N} = \frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_H C(1,1)} \tag{1.I}$$

This strategy N,N with profit function $\pi_{N,N}$ describes concentration of intermediate and final goods production in the home country, N. A firm operates in the Southern market by exporting the differentiated products. For this reason, supplying the Southern market is more expensive. This strategy minimizes fixed costs but produces with relative high per-unit variable costs C(1,1) because factor prices in N are higher than in S.

$$\pi_{N,NS} = \frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{C(1,w)} - f \tag{1.II}$$

Firms choosing strategy N,NS supply the Northern market by producing intermediate and final goods in N. Intermediate goods from N are shipped to S, where final goods production takes place to serve consumers in S locally. In this case, MNE activity in final goods eliminates all trade in final goods. With this strategy, medium high fixed costs of f are incurred. On the other hand, the firm can save per-unit variable costs when supplying S compared to (1.I).

[42] See Grossman, Helpman, and Szeidl (2006).

A strategy N,S with the profit function $\pi_{N,S}$ is no alternative to N,NS in the case with high transport costs.

$$\pi_{N,S} = \frac{\overline{X^N}\Theta}{d_H C(1,w)} + \frac{\overline{X^S}\Theta}{C(1,w)} - f \tag{1.II'}$$

Even though the fixed costs and the costs of supplying S are identical when selecting one of these two strategies, this strategy can be eliminated because of the costs of operating in the Northern market. Supplying to N under strategy N,NS, a firm produces intermediate as well as final goods in N. Consequently, the only difference to strategy N,S is that the per-unit variable costs of supplying N are lower. This is due to the high transport costs to supply the Northern market when selecting N,S instead of N,NS. For this reason, this strategy never is reasonable if high transport costs exist. If transport costs vary, it also is possible that N,S is the better strategy; but one of these strategies always dominates the other.

$$\pi_{S,N} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{d_H C(w,1)} - g \tag{1.III}$$

In this case, intermediate goods are produced in S and final goods in N. For this reason, this strategy can also be seen as “partial globalization”.[43] Intra-firm trade exists. Transport costs arise when supplying S because final goods are produced in N.

Similar to strategy N,NS, a firm in this case has to bear medium high fixed costs, here denoted by g, because intermediate goods are manufactured in S and final goods in N. However, adequate ranking of strategies N,NS and S,N cannot be determined without an exact identification of the level of the different fixed costs f and g and of the per-unit variable costs.

$$\pi_{S,NS} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g \tag{1.IV}$$

Firms choosing strategy S,NS supply to S by producing intermediate and final goods there. To satisfy Northern demand, these firms produce intermediate goods in S, ship them to N at zero transport costs, produce final goods in N, and sell them there. In this case, international trade in final goods does not occur. Strategy S,NS is associated with fixed costs of f and g. Hence, these firms save high per-unit variable

[43] Grossman, Helpman, and Szeidl (2006).

costs, including trade costs. Because of the higher fixed costs associated with this strategy, S,NS only is reasonable for highly productive firms that face a high demand. Table 1.2 is a summary of the here described diverging factors determining profit functions.

Table 1.2:

Strategy a,b	**Meaning**	**Marginal costs of serving consumers in N**	**Marginal costs of serving consumers in S**	**Fixed costs $k_{a,b}$**
N,N	Intermediate good production in N; final good production in N	C(1,1)	d_HC(1,1)	0
N,S	Intermediate good production in N; final good production in S	d_HC(1,w)	C(1,w)	f
N,NS	Intermediate good production in N; final good production in N and S	C(1,1)	C(1,w)	f
S,N	Intermediate good production in S; final good production in N	C(w,1)	d_HC(w,1)	g
S,NS	Intermediate good production in S; final good production in N and S	C(w,1)	C(w,w)	f and g

Alternative strategies to S,NS are S,S and NS,NS. Their costs of supplying to S and the fixed costs of these strategies match those of $\pi_{S,NS}$, but the per-unit variable costs for supplying the Northern market are higher. In this scenario, with high transport costs, per-unit variable costs are lower with S,NS than with S,S or NS,NS; fixed costs are the same. Therefore, firms will never choose S,S or NS,NS.

Theoretically, two further integration strategies, namely NS,N and NS,S, are possible. However, these strategies are never reasonable. A firm will only produce intermediate goods in both N and S (associated with extra fixed costs for intermediate production) if high transport costs for intermediate goods exist. If this is the case, it will only make sense to produce final products in both countries as well to save on transport costs.[44]

Hence (1.I), (1.II), (1.III) and (1.IV) are the only relevant strategies if transport costs are high.[45]

In this case, a pure trade-off between fixed costs and per-unit variable costs exists. Transportation of final goods to N is never optimal because of the size of d_H. This can be seen from $\frac{C(w,1)}{C(w,w)} < d_H$.

The lowest per-unit variable costs to satisfy demand in each market, therefore, can be achieved with local production of final goods. Strategies that are chosen in this setting where final goods are not only produced locally are S,N and N,N. If g is very small, S,N is a possible optimal strategy even though high transport costs exist. Also, N,N belongs to the set of optimal strategies. However, both of these strategies are chosen by more unproductive firms because they cannot afford high fixed costs.

A firm produces intermediate goods at only one location because transportation is free.[46] A firm producing intermediate goods in N also produces final goods there to satisfy Northern demand because transportation of final goods from S is relatively costly. Therefore, it is not attractive for a firm.

This can be considered by $\frac{C(1,1)}{C(1,w)} < d_H$.

A firm producing intermediate goods in S has two possibilities. Either it only produces final goods in N, or it ships some of them to N to serve the North and the intermediate goods for S stay in S so that final goods for every market are produced locally. The optimal strategy for a firm depends on its productivity and fixed costs. Therefore, the following integration strategies are possibly relevant: N,N; N,NS; S,N; S,NS.

Graphic 1.2 shows $\pi_{N,N}$ and $\pi_{S,NS}$ depending on productivity Θ.

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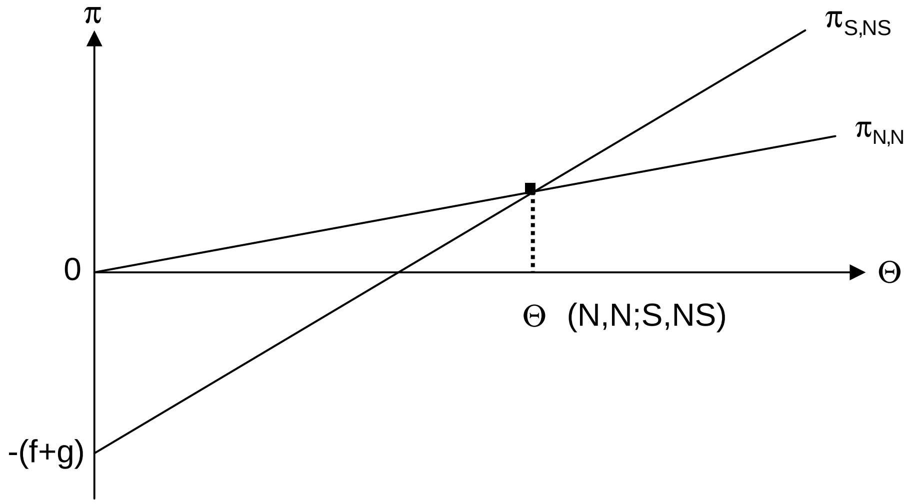
[44] All seven possible strategies with transport costs for final goods are shown in IV in Appendix 1.4, where the size of transport costs is the determinant of the set of optimal strategies.

[45] If, and only if, high transport costs exist, this set of optimal integration strategies is chosen. This can be seen in derivation V in Appendix 1.4.

[46] As in Grossman, Helpman, and Szeidl (2006).

Graphic 1.2:[47]

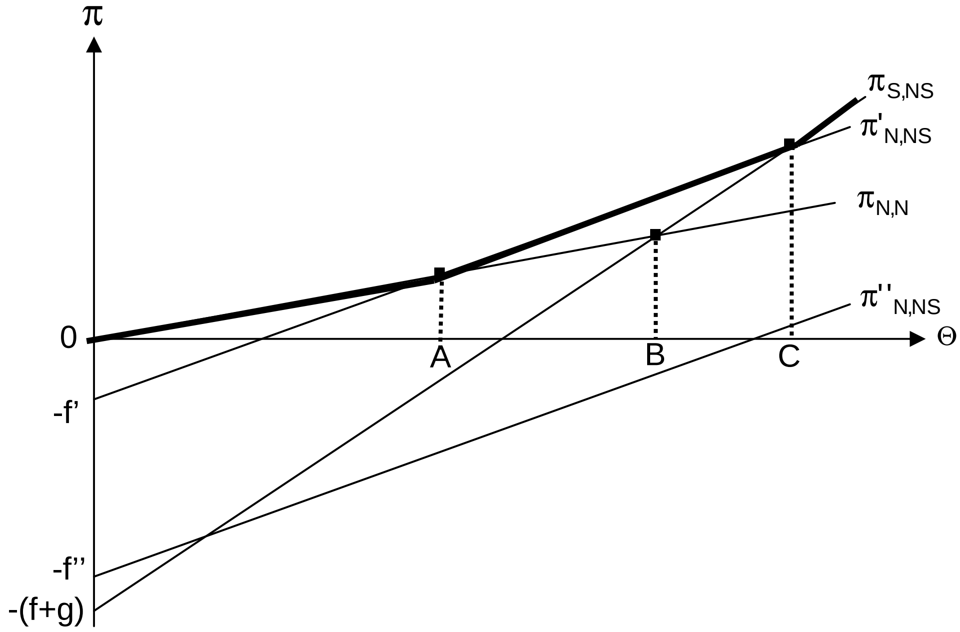


Firms will always choose the integration strategy with the highest attainable positive profit at a given level of Θ. $\pi_{S,NS}$ is associated with fixed costs f and g, while $\pi_{N,N}$ is associated with zero fixed costs. However, the variable production costs under N,N are higher than those under S,NS. Therefore, $\pi_{N,N}$ is higher than $\pi_{S,NS}$ if productivity is lower than a critical level Θ(N,N; S,NS) and is lower than $\pi_{S,NS}$ at $\Theta > \Theta$(N,N; S,NS). $\pi_{N,N}$ and $\pi_{S,NS}$ intercept at Θ(N,N; S,NS).

The profit function $\pi_{N,NS}$ now can be added to this analysis. $\pi_{N,NS}$ is associated with fixed costs f. The variable production costs under N,NS are higher than those under S,NS and lower than those under N,N. Graphic 1.3 shows alternative possibilities for this strategy. Therefore, $\pi_{N,N}$ is higher than $\pi'_{N,NS}$ if productivity is lower than a critical level A and is lower than $\pi'_{N,NS}$ at Θ>A. $\pi_{N,N}$ and $\pi'_{N,NS}$ intercept at A. $\pi_{S,NS}$ is lower than $\pi'_{N,NS}$ if productivity is lower than a critical level C and is higher than $\pi'_{N,NS}$ at Θ>C. $\pi_{S,NS}$ and $\pi'_{N,NS}$ intercept at C. Another possibility for the profit function corresponding to strategy N,NS is $\pi''_{N,NS}$. In this case, $\pi''_{N,NS}$ is lower than $\pi_{N,N}$ and $\pi_{S,NS}$. Only $\pi_{N,N}$ and $\pi_{S,NS}$ then intercept at B in the graphic.

[47] Own construction on the basis of Grossman, Helpman, and Szeidl (2006).

Graphic 1.3:[48]



$A = \Theta(N,N;N,NS)$; $B = \Theta(N,N;S,NS)$; $C = \Theta(N,NS;S,NS)$

For N,NS to be an optimal strategy, it is necessary that the intersection of $\pi_{N,NS}$ and $\pi_{S,NS}$ lies above the intersection of $\pi_{N,N}$ and $\pi_{S,NS}$, at $\Theta(N,N;S,NS)$, resulting in[49]

$$\frac{g}{f} \geq \frac{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{C(1,w)}}{\left(\frac{\overline{X^S}}{C(1,w)} - \frac{\overline{X^S}}{d_H C(1,1)}\right)} = \gamma_H \ . \tag{1.7}$$

This condition has to hold so that N,NS is an optimal strategy for a firm. As shown in graphic 1.3, low-productivity firms locate all production activities at home; high-productivity firms produce intermediate goods only in S and final goods in N and S; and, if $\pi_{N,NS}$ runs like $\pi'_{N,NS}$, firms with intermediate productivity levels manufacture intermediate goods in N and final goods in N and S.

[48] Own construction on the basis of Grossman, Helpman, and Szeidl (2006).
[49] See derivation VI in Appendix 1.4.

Just as $\pi_{N,NS}$ can be added to the analysis in graphic 1.2, this is also possible with $\pi_{S,N}$. $\pi_{S,N}$ is associated with fixed costs g. The variable production costs under S,N are higher than those under S,NS and lower than those under N,N.

For S,N to become an optimal strategy, it is necessary that the intersection of $\pi_{S,N}$ and $\pi_{S,NS}$ lies above the intersection of $\pi_{N,N}$ and $\pi_{S,NS}$. Using the same approach as in the previous analysis for $\pi_{N,NS}$, the following condition must hold for S,N to become an optimal strategy:[50]

$$\frac{g}{f} \leq \frac{\dfrac{\overline{X^N}}{C(w,1)} + \dfrac{\overline{X^S}}{d_H C(w,1)} - \dfrac{\overline{X^N}}{C(1,1)} - \dfrac{\overline{X^S}}{d_H C(1,1)}}{\dfrac{\overline{X^S}}{C(w,w)} - \dfrac{\overline{X^S}}{d_H C(w,1)}} = \gamma_L \tag{1.8}$$

If (1.8) holds, firms with low productivity levels locate all production activities at home, highly productive firms produce intermediate goods in S and final goods in N and S, and firms with intermediate levels of productivity manufacture intermediate goods in S and final goods in N.

From (1.7) and (1.8) it can be seen that, if $\gamma_L < \frac{g}{f} < \gamma_H$ is true, only two optimal strategies exist: Either all firms only produce in N, or intermediate goods are produced in S and final goods are produced in both locations. The assumption that the elasticity of substitution between intermediate and final goods production is not greater than 1 ensures that $\gamma_L < \gamma_H$ holds.[51]

For $\pi_{N,NS}$ or $\pi_{S,N}$ to be a dominate integration strategy either $\frac{g}{f} \leq \gamma_L$ or $\frac{g}{f} \geq \gamma_H$ must hold true. Because this is not possible at the same time, only one of the strategies, S,N or N,NS, can be optimal, depending on the size of the fixed costs relation. In graphic 1.3 $\pi'_{N,NS}$ is a possible optimal strategy for a firm, depending on its productivity. This means that $\frac{g}{f} \geq \gamma_H$ must be true. Then, the fixed costs for a final goods producing plant in S are relatively lower than the fixed costs for an intermediate goods producing plant there.

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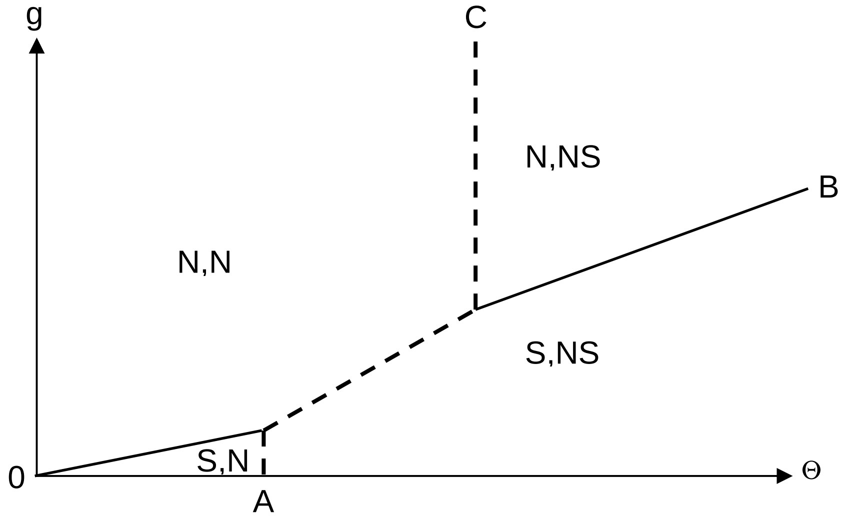
50 See derivation VII in Appendix 1.4.

51 $\gamma_L < \gamma_H$ is considered if, and only if, $\frac{1}{C(w,w)} + \frac{1}{d_H C(1,1)} \succ \frac{1}{d_H C(w,1)} + \frac{1}{C(1,w)}$.

In case S,N, not N,NS, is optimal, $\frac{g}{f} \leq \gamma_L$ holds. This means that the fixed costs for a final goods producing plant in S are relatively higher than the fixed costs for an intermediate goods producing plant in S. Accordingly, whether N,NS or S,N is optimal depends on the fixed costs.[52]

For this reason, another graphical description (graphic 1.4) shows all areas of optimal strategies in one diagram.

Graphic 1.4:[53]



$A = \Theta(S,N;S,NS)$; $B = \Theta(N,NS;S,NS)$; $C = \Theta(N,N;N,NS)$

Graphic 1.4 shows combinations of fixed costs g for intermediate goods and Θ that generate different strategies of integration. In this connection, the level of fixed costs for final goods f is held constant. If f changes, the bold, broken lines will change.[54]
In the section N,N, all activities of a firm are located in N; in section S,N, intermediate goods are produced in S and final goods in N. Section N,NS shows firms that manufacture intermediate goods in N and final goods in N and S. Finally, if the productivity of a firm lies in region S,NS intermediate goods producing activities are shifted to S and final goods are produced in both countries.[55]
Hence, if, depending on the productivity level of a firm, strategies N,N, N,NS, or S,NS are reasonable, fixed costs g are high relative to the given value of f. If, depending on

52 As in Grossman, Helpman, and Szeidl (2006).
53 Own construction on the basis of Grossman, Helpman, and Szeidl (2006).
54 As in Grossman, Helpman, and Szeidl (2006).
55 As in Grossman, Helpman, and Szeidl (2006).

the productivity level of a firm, strategies N,N, S,N, or S,NS are reasonable, fixed costs g are small relative to the given value of f. If, depending on the productivity level of a firm, strategies N,N or S,NS are only reasonable, the fixed costs relation between g and f is medium high.

The five graphical analogues to the analytical cut-off levels separating the optimal integration strategies in graphic 1.4 result from the following:
The cut-offs are calculated by equating the profits of one strategy with those of another strategy and solving for Θ. Four different possibly optimal π exist: $\pi_{N,N}$, $\pi_{N,NS}$, $\pi_{S,N}$, and $\pi_{S,NS}$; and five different cut-off levels arise. The sixth theoretically possible comparison is $\pi_{N,NS}$ with $\pi_{S,N}$. However, as already discussed, these two strategies cannot be equated because they are never optimal at the same time if only productivities of firms differ because they arise when different fixed costs relations exist.
Hence, the different cut-off levels are given by [56]

$$\Theta(N,N;N,NS) = \frac{f}{\overline{X^S}\left[\frac{1}{C(1,w)} - \frac{1}{d_H C(1,1)}\right]}. \tag{1.a}$$

This cut-off level between sections N,N and N,NS is independent of g. For this reason, it is represented by a vertical line in graphic 1.4.
From graphic 1.3 it is known that N,NS is the optimal strategy for firms with intermediate levels of productivity, if $\frac{g}{f} \geq \gamma_H$ holds. If Θ is smaller than Θ(N,N;N,NS), N,N is optimal. If Θ is greater, then N,NS is the optimal strategy. Firms with the exact productivity of Θ(N,N;N,NS) are just indifferent between the production of all goods at home and the production of intermediate goods in N and of final goods in N and S because their profits are the same in both cases.

$$\Theta(N,N;S,N) = \frac{g}{\overline{X^N}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^S}\left[\frac{1}{d_H C(w,1)} - \frac{1}{d_H C(1,1)}\right]} \tag{1.b}$$

[56] See derivation VIII in Appendix 1.4.

This cut-off level between sections N,N and S,N depends on g and is represented by a line through the origin. At levels of Θ that exceed Θ(N,N;S,N), S,N is optimal; for lower levels, N,N is optimal.

$$\Theta(N,N;S,NS) = \frac{f+g}{\overline{X^N}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^S}\left[\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right]} \tag{1.c}$$

This cut-off level between sections N,N and S,NS depends on g and starts from a negative intercept. Because of the per-unit variable costs, it is steeper than Θ(N,N;S,N). At levels of Θ that exceed Θ(N,N;S,NS), S,NS is optimal; for lower levels, N,N is optimal.

$$\Theta(N,NS;S,NS) = \frac{g}{\overline{X^N}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^S}\left[\frac{1}{C(w,w)} - \frac{1}{C(1,w)}\right]} \tag{1.d}$$

This cut-off level between sections N,NS and S,NS again depends on g and is represented by a line through the origin. Because of the per-unit variable costs, it is steeper than Θ(N,N;S,N). At levels of Θ that exceed Θ(N,NS;S,NS), S,NS is optimal; for lower levels, N,NS is the better strategy for a firm. The higher fixed costs g are, the higher firm productivity must be for intermediate goods production in S to be profitable.

$$\Theta(S,N;S,NS) = \frac{f}{\overline{X^S}\left[\frac{1}{C(w,w)} - \frac{1}{d_H C(w,1)}\right]} \tag{1.e}$$

This cut-off level between sections S,N and S,NS is independent of g. For this reason, it is represented by a vertical line in graphic 1.4. If the level of Θ is lower than Θ(S,N;S,NS), then S,N is optimal. If the level of Θ exceeds Θ(S,N;S,NS), then S,NS is the optimal strategy for a firm.

Because of the high transport costs, firms choose this strategy (S,NS) to produce final goods locally. Hence, in final goods production, these are horizontal firms.[57] These highly productive firms shift most production activities to S, where per-unit costs are lower, to generate the highest possible reduction of variable per-unit costs.[58] Due to high transport costs, final goods for the Northern market are produced

[57] As in Markusen and Venables (1998).
[58] As in Grossman, Helpman, and Szeidl (2006).

in N to maximize profits. The fraction of firms choosing this strategy depends on the productivity of the firms. It increases if g falls and then becomes independent of g.
MNE activities for final goods production only arise to the right of the bold, broken line in graphic 1.4. The smaller g, the greater this fraction of firms will be.
If g is very high, the fraction of firms producing final goods in N and S is independent of g; whereas the fraction of them choosing strategy N,NS or S,NS depends on the size of g. The fraction of firms choosing strategy S,N increases if g is small and productivity of a firm is greater than zero. In the graphical analogue to the cut-off level $\Theta(S,N;S,NS)$ in graphic 1.4, this fraction becomes independent of g.[59]

If firms have an intermediate productivity level Θ, namely that $\Theta(S,N;S,NS) < \Theta < \Theta(N,N;N,NS)$, then the fixed costs for a production plant in S for final goods are only borne if the fixed costs for intermediate goods producing plants g are small. Accordingly, these firms either shift intermediate production activities to S and produce final goods in both countries, due to high transport costs; or they produce intermediate and final goods only in N, if $\gamma_L < \frac{g}{f} < \gamma_H$ holds.[60] For positive values of given fixed costs for intermediate goods g, the most unproductive firms locate all production activities in N and export their final goods to the Southern market, whereas transport costs are high.
Consequently, a reduction of fixed costs, as well as a reduction of barriers to trade, or transport costs, is influential in determining optimal integration strategies for firms and encourages their economic outcome.

1.2.6 Analysis with high transport costs, profit taxation and provision of public infrastructure for differentiated goods

In the following, the governments set profit taxes in a first stage and cannot rescind their offers by assumption. Then, firms decide upon their optimal integration strategies, which are taken into account by the governments when setting tax rates. A government chooses a tax rate, $t_i \; i \in \{N,S\}$, to tax profits of firms. The resulting tax revenue is spent for public infrastructure for differentiated goods. Governments take the utility of the representative household in their jurisdiction into account when deciding to levy profit taxes or not (i.e., the utility of the representative household

[59] As in Grossman, Helpman, and Szeidl (2006).
[60] As in Yeaple (2003).

may not decline when selecting t_i>0 compared to its utility without profit taxation). The provision of this public infrastructure at least induces fixed costs of R, where d depends on R. If public infrastructure for differentiated goods is provided, d declines, influencing the utility of the households.

By assumption, without investment of tax revenue in public infrastructure for differentiated goods, transport costs are high if R is zero. Furthermore, taxes reduce profits of a firm. Transport costs influence the set of optimal integration strategies and they influence the location of the graphical analogues to the cut-off levels shown in graphic 1.4. The set of optimal strategies differs depending on the height of d because the higher d becomes, the more local production is reasonable. Also, profit taxes influence the location of these graphical analogues to the cut-off levels in graphic 1.4 because they are determinants of the profitability of alternative modes of firm integration. If tax revenue is used to finance provision of public infrastructure for firms in the differentiated sector, this influences d and, therefore, the set of optimal integration strategies, if R is invested. Tax rates are set in such a way that the set of optimal integration strategies from the point of view of the governments and the firms stays the same. Furthermore, households do not gain utility through consumption of the public good directly; but prices for differentiated goods depend on d, which is influenced by R.

1.2.6.1 The problem of the governments

In this section, cases are analyzed in which the governments of both N and S can levy taxes t_N and t_S, which are taken into account in the profit functions of the firms. In this setting, taxes are paid on firm profits either in N or in S. The location of tax payment depends on the location of final goods production for firms. Intermediate goods production is not taxed. In this setting, double taxation is not the problem of the analysis.[61]

Governments select profit taxes to finance public infrastructure for differentiated goods; consequently, social welfare in their jurisdictions may not decline. Social welfare is defined by the utility of the representative household in the jurisdiction of a government as described in section 1.2.2. Furthermore, by assumption, the highest possible productivity level, Θ_{max}=1, always is part of the integration strategy, with most of its total production in S. We also assume a uniform distribution function for

[61] As in Egger et al. (2006a).

firms over productivity levels in this analysis. If public infrastructure for differentiated goods is provided, this influences d. Therefore, the utility of households resident in the jurisdiction of a government rises, where not only d influences the utility of households.

Here, the price for the homogeneous product is $p_0=1$. Prices for differentiated products are denoted by $p_i(j)$, where p is the price for variety j in country i, $i \in \{N; S\}$.

As already shown in section 1.2.2, the utility of a representative household in country i, $i \in \{N; S\}$, is given by:

$$U_i = x_0 + X \tag{1.1}$$

$$\text{where } X = \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x(j)^{\alpha} dj\right] \qquad 0 < \alpha < 1,\ 0<\mu<1 \text{ and } \mu < \alpha \tag{1.2}$$

This alternatively can be denoted by:[62]

$$V_i = m_i + (1-\alpha)\cdot\mu^{1/(\alpha-1)} \int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)} dj \tag{1.9}$$

The utility of a representative household increases in m_i and declines in $p_i(j)$.

For a government to decide to provide a positive amount of public infrastructure and, therefore, to select $t_i>0$, the previously shown utility of households in its country may not decline. Also, the size of the combined tax revenue of both governments must be high enough to afford $R>0$.

To show welfare implications, optimal integration strategies with taxation must be examined.

1.2.6.2 Integration strategies with profit taxation

If $t_i>0$ is selected by the governments, firms can anticipate that d will decline because the governments only select $t_i>0$ if tax revenue is high enough so that R can be afforded. If R is invested, d declines from high (d_H) to low (d_L).

For this reason, firms select other integration strategies to be reasonable instead of those with high transport costs.

Low transport costs can be described in the following way:[63]

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[62] See derivation IX in Appendix 1.4.
[63] See derivation X in Appendix 1.4.

$1 < d_L < \frac{C(1,1)}{C(1,w)}$

In this case, the optimal profit functions of the firms, depending on their productivity, are $\pi_{N,N}$, $\pi_{N,S}$, $\pi_{S,N}$, and $\pi_{S,S}$. A trade-off between fixed costs for production plants in S and the reduction of per-unit variable costs in shifting production activities to S is shown.[64] These profit functions also depend on the size of fixed costs, market size, per-unit variable costs, and the degree of taxation:

$$\pi_{N,N} = \frac{\overline{X^N}\Theta}{C(1,1)}(1-t_N) + \frac{\overline{X^S}\Theta}{d_L C(1,1)}(1-t_N) \qquad (1.I')$$

This strategy, N,N, is identical to the one with high transport costs. However, the variable per-unit costs for products supplied in the Southern market are lower than those with high transport costs because $d_L<d_H$. Furthermore, the decline of these costs depends on the size of the Southern market; but, in this setting, $M^N > M^S$. Referring to lower transport costs, the slope of $\pi_{N,N}$ is steeper than in the previous analysis with high transport costs; but a higher tax rate, t_N, reduces the slope of $\pi_{N,N}$. For this reason, the slope of $\pi_{N,N}$ depends on exact parameter configurations and cannot be compared with the slope of $\pi_{N,N}$ with high transport costs in general.

If a firm selects strategy N,N, all its taxes on profits are paid in N because all final goods are produced there. t_N reduces the profits of a firm. The degree of the reduction depends on the tax rate chosen by the Northern government.

$$\pi_{N,S} = \frac{\overline{X^N}\Theta}{d_L C(1,w)}(1-t_S) + \frac{\overline{X^S}\Theta}{C(1,w)}(1-t_S) - f \qquad (1.II'')$$

The per-unit variable costs for products in the Northern market decline for firms selecting this as their optimal strategy in comparison to the analysis with high transport costs in which they selected $\pi_{N,NS}$. The decline of these costs is induced by a smaller d; therefore, another optimal integration strategy concerning the Northern markets supply is chosen. Furthermore, the size of the decline of these costs depends on the size of the Northern market. Not only has the size of d decreased, but this has also induced firms to select $\pi_{N,S}$ instead of $\pi_{N,NS}$ as an optimal profit function. Also, the slope of $\pi_{N,S}$ instead of $\pi_{N,NS}$ is steeper than in the analysis with

[64] As in Helpman, Melitz, and Yeaple (2004) and Yeaple (2003).

high transport costs, referring to the per-unit variable costs; the higher the degree of taxation, the more gradual the slope of $\pi_{N,S}$ becomes. For this reason, the slope of $\pi_{N,S}$ depends on exact parameter configurations and cannot be compared with the slope of $\pi_{N,NS}$ with high transport costs in general.

If a firm selects strategy N,S, taxes on profits are paid in S because all final goods are produced there. When choosing strategy N,S, the degree of reduction in firm profits depends on the tax rate chosen by the Southern government. Furthermore, fixed costs f are incurred in S.

A further profit function is:

$$\pi_{S,N} = \frac{\overline{X^N}\Theta}{C(w,1)}(1-t_N) + \frac{\overline{X^S}\Theta}{d_L C(w,1)}(1-t_N) - g \tag{1.III´}$$

This strategy, S,N, is identical to the one with high transport costs. However the variable per-unit costs for products supplied in the Southern market are lower than with high transport costs because $d_L<d_H$. Furthermore, the decline of these costs depends on the size of the Southern market; but, in this setting, $M^N > M^S$. Referring to the lower d, the slope of $\pi_{S,N}$ is steeper than in the previous analysis with high transport costs; a higher t_N reduces the slope of $\pi_{S,N}$. For this reason, the slope of $\pi_{S,N}$ depends on exact parameter configurations and cannot be compared with the slope of $\pi_{S,N}$ with high transport costs in general.

Again, if a firm selects strategy S,N, all its taxes on profits are paid in N because all final goods are produced there. When choosing strategy S,N, the degree of reduction in firm profits depends on the tax rate chosen by N.

$$\pi_{S,S} = \frac{\overline{X^N}\Theta}{d_L C(w,w)}(1-t_S) + \frac{\overline{X^S}\Theta}{C(w,w)}(1-t_S) - f - g \tag{1.IV´}$$

The per-unit variable costs for products in the Northern market decline for firms selecting this as their optimal strategy in comparison to the analysis with high transport costs in which they selected $\pi_{S,NS}$. The decline of these costs is induced by a smaller d; therefore, another optimal integration strategy concerning the Northern markets supply is chosen. Furthermore, the size of the decline of these costs depends on the size of the Northern market. Not only has the size of d decreased, but this has also induced firms to select $\pi_{S,S}$ instead of $\pi_{S,NS}$ as an optimal profit function. Also, the slope of $\pi_{S,S}$ instead of $\pi_{S,NS}$ is steeper than in the analysis with high transport costs, referring to the per-unit variable costs; the higher the degree of taxation, the more gradual the slope of $\pi_{S,S}$ becomes. For this reason, it can be seen that the slope of $\pi_{S,S}$ depends on exact parameter configurations and cannot be compared with the slope of $\pi_{S,S}$ with high transport costs in general.

If a firm selects strategy S,S, taxes on profits are paid in S because final goods are produced there. When choosing strategy S,S, the degree of reduction in firm profits depends on the tax rates chosen by the Southern government. Furthermore, fixed costs f and g are incurred in S.

This set of strategies is only chosen by firms if d is low and if the firms select the welfare optimal set of integration strategies because their choice is also influenced by t_i.

From the formal description of the profit functions, it can be seen that they are all steeper than in the previous analysis with high transport costs, referring to d. Additionally, the higher t_i is, the more gradual are the profit functions.

The cut-off levels between two strategies also are shown in the previous section with high transport costs. However, because d now is low, another set of integration strategies is reasonable and cut-off levels additionally depend on t_i.[65]

$$\Theta(N,N;N,S) = \frac{f}{\left[\frac{\overline{X^N}}{d_L C(1,w)} + \frac{\overline{X^S}}{C(1,w)}\right](1-t_S) - \left[\frac{\overline{X^S}}{d_L C(1,1)} + \frac{\overline{X^N}}{C(1,1)}\right](1-t_N)} \qquad (1.a´)$$

$\Theta(N,N;N,S)$ is independent of g. For this reason, it is represented by a vertical line in the graphical analysis below (graphic 1.5).

In comparison to the analysis with high transport costs in graphic 1.4 this cut-off level changes from $\Theta(N,N;N,NS)$ to $\Theta(N,N;N,S)$. Only referring to lower transport costs, the line representing this cut-off level shifts a bit inward if the additional earnings in the Northern market resulting from changing strategy N,NS to N,S are higher than

[65] See derivation XI in Appendix 1.4.

the loss in savings in the Southern market because of a lower d. The more inward the line representing this cut-off level shifts, the lower firm productivity must be, to deselect N,N as the preferred strategy of a firm.

However, the higher the tax rate selected by the Southern government, the more the line representing this cut-off level shifts back outward. The higher the tax rate selected by the Northern government, the more the line representing this cut-off level shifts inward.

$$\Theta(N,N;S,N) = \frac{g}{\left[\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(w,1)} - \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)} \qquad (1.b')$$

In comparison to the analysis with high transport costs in graphic 1.4, the line representing this cut-off level becomes steeper, induced by lower transport costs.

The higher the tax rate selected by the Northern government, the more gradually the line representing this cut-off level runs.

$$\Theta(N,N;S,S) = \frac{f+g}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)} \qquad (1.c')$$

In comparison to the analysis with high transport costs in graphic 1.4, this cut-off level changes from $\Theta(N,N;S,NS)$ to $\Theta(N,N;S,S)$. With lower transport costs, the line representing this cut-off level becomes steeper if the additional earnings in the Northern market from changing strategy S,NS to S,S are higher than the loss in savings in the Southern market because of a lower d. The steeper the line representing this cut-off level runs, the lower firm productivity must be, to deselect N,N as the preferred strategy of a firm.

The higher the tax rate selected by the Southern government, the more gradually the line representing this cut-off level runs; and the higher the tax rate selected by the Northern government, the more steeply it runs.

$$\Theta(N,S;S,S) = \frac{g}{\left[\frac{\overline{X^N}}{d_L C(w,w)} - \frac{\overline{X^N}}{d_L C(1,w)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{C(1,w)}\right](1-t_S)} \qquad (1.d')$$

Because of the per-unit variable costs, this cut-off level is steeper than Θ(N,N;S,N). In comparison to the analysis with high transport costs in graphic 1.4, this cut-off

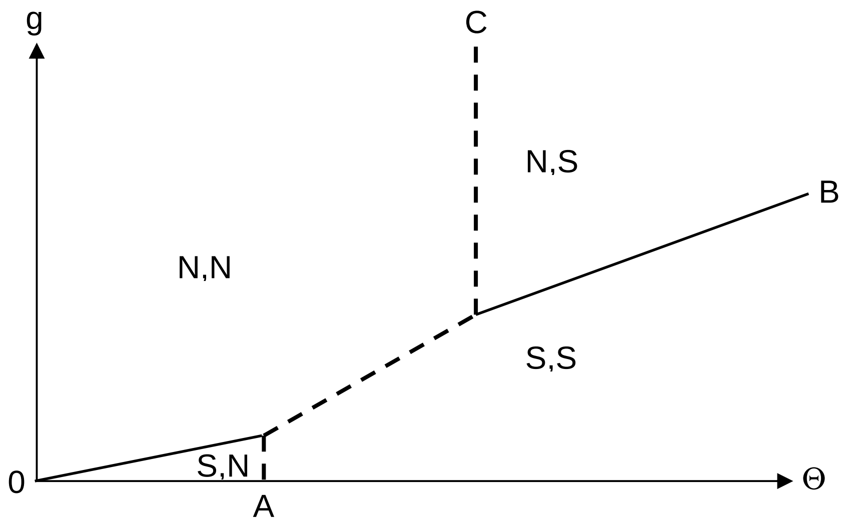
level changes from $\Theta(N,NS;S,NS)$ to $\Theta(N,S;S,S)$. If, due to lower transport costs, the additional earnings in the Northern market are higher than the loss in savings because of the by d induced change in optimal strategies, the line representing this cut-off level runs more steeply. The steeper the line representing this cut-off level, the lower firm productivity must be to select S,S as the preferred strategy of a firm.
However, the higher the tax rate selected by the Southern government, the more gradually the line representing this cut-off level runs.

$$\Theta(S,N;S,S) = \frac{f}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)} \qquad (1.e')$$

$\Theta(S,N;S,S)$ is independent of g. For this reason, it is represented by a vertical line in the graphical analysis below (graphic 1.5).
In comparison to the analysis with high transport costs in graphic 1.4, this cut-off level changes from $\Theta(S,N;S,NS)$ to $\Theta(S,N;S,S)$. With lower transport costs the line representing this cut-off level shifts a bit inward if the additional earnings in the Northern market from changing strategy S,NS to S,S are higher than the loss in savings in the Southern market because of a lower d. The more inward the line representing this cut-off level shifts, the lower firm productivity must be to select S,S as the preferred strategy of a firm.
However, the higher the tax rate selected by the Southern government, the more the line representing this cut-off level shifts back outward; the higher the tax rate selected by the Northern government, the more the line representing this cut-off level shifts inward.

By combining all five graphical analogues to the aforementioned cut-off levels, the representation of optimal firm integration strategies shown in graphic 1.5 is obtained. In comparison to graphic 1.4, with high transport costs, the set of optimal integration strategies changes. Whether, the vertical lines representing cut-off levels shift somewhat inward or outward and the other cut-off levels representing lines run more steeply or gradually than in graphic 1.4 cannot be said in general. They depend on exact parameter configurations.

Graphic 1.5:[66]



$A = \Theta(S,N;S,S)$; $B = \Theta(N,S;S,S)$; $C = \Theta(N,N;N,S)$

This graphical description is an example of the vertical lines shifting somewhat inward and the other cut-off level representing lines running more steeply than in graphic 1.4. Firms change their optimal integration strategies in response to the size of transport costs. The new set of optimal integration strategies selected delivers a higher economic outcome than the previous set with high transport costs only referring to d.

Referring to graphic 1.5, an increasing fraction of firms invests in MNE activities for final goods production if fixed costs for intermediate goods production sink. The lower transport costs are, the less productive firms must be to manufacture final goods in S because the per-unit variable costs decline if high transport costs decline. Transport costs, in sum, are higher to supply the Northern market than to supply the Southern market because $M^N>M^S$. For this reason, it is true that the smaller transport costs for final goods are, the more economic integrated strategies are chosen by the more productive firms.

If a firm invests in any activity in S, per-unit costs decrease. This increases the demand for output and, consequently, the willingness to produce the other goods there, too. This is also identified as “unit-cost complementarity”.[67] Consequently, if g

[66] Own construction on the basis of Grossman, Helpman, and Szeidl (2006).
[67] Grossman, Helpman, and Szeidl (2006).

or f decline, the fraction of firms that invest in production plants in S for intermediate and final goods increases because of the "unit-cost complementarity".[68]

This graphical description is only an example of how the lines representing the cut-off levels may possibly run. Theoretically, a utility loss from profit taxation and its impacts also does not arise if the lines representing the cut-off levels in graphic 1.5 run further on the right hand side than those in graphic 1.4. This depends on exact values for the following variables:

- the decreased d_L relative to d_H and the corresponding tax rates t_N and t_S;
- the decreased C, which only is relevant for the Northern jurisdiction when selecting strategy N,S or S,S; and
- the distribution of the firms over the integration strategies.

Furthermore, the following question must be answered:

Which tax rates are selected by N and S if they can anticipate reactions of firms?

1.2.6.3 The decisions of the governments with combined provision of public infrastructure for differentiated goods

For the governments to select $t_i>0$, combined tax revenue must be at least high enough to finance R.

Furthermore, for a government to decide to provide public infrastructure, it must consider the utility of the representative household. In each government jurisdiction, the utility of the representative household with provision of public infrastructure for differentiated goods must be at least as high as its utility in the $t_i=0$ scenario. As shown before the utility of each household is described by:

$$V_i = m_i + (1-\alpha)\cdot\mu^{1/(\alpha-1)}\int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)}\,dj \tag{1.9}$$

If taxes are levied, α and μ do not change.

The impact of t_i on m_i is different for N and S. All firms enter the market in N and, by assumption, belong to households in N. Accordingly, levying t_i lets m_N decline because the firm profits are part of the income of the Northern households. Additionally, introducing $t_i>0$ also induces a change in optimal integration strategies. This does not lower the labor income of the households in the original production

[68] Grossman, Helpman, and Szeidl (2006).

location because they can work in the homogeneous sector. For this reason, taxation in either country does not influence income in S.

In the setting of this model, effects on income – which are only induced by t_i for households in N – only influence the consumption of the homogeneous good. Consumption of differentiated goods only depends on prices. This negative impact on the utility of the representative Northern household must be compensated through positive impacts from consumption of differentiated goods.

Furthermore, the degree of taxation does not influence the mass of firms entering the market in the North because of profit taxation if $0<t_N<1$. Firms that decide to enter the market at least make zero profits. This is not changed if governments tax firm profits in the described manner. Therefore, the only restriction is that $t_N<1$ always holds true because firms invest before entering the market. With this investment, a firm gets to know its productivity level and, therefore, decides to enter the market or not. If a firm makes positive profits, it enters the market; but, if $t_N=1$ holds true, then any firm will always make zero profits, will never invest to get to know its productivity, and will never enter the differentiated market. This will not be in the interest of the government. The tax rate in S does not influence market entry either because the least productive firms entering the market choose strategy N,N, which is not influenced by t_S anyhow.

One must consider that the prices of a single firm do not change in response to taxes. These are only influenced by transport costs. For this reason, it is clear that:[69]

$$p_i(j)_{opt}= \frac{1}{\alpha}\left(\frac{dC}{\Theta}\right)^{(\alpha-1)/-\alpha} \qquad (1.10)$$

Transport costs are passed on to households; taxes must be paid by the firms.

As has already been said, taxation itself is not passed on to households through raising prices. However, as taxation induces low transport costs, because tax revenue is spent for public infrastructure for differentiated goods, prices are influenced because of the lower d and because other integration strategies become reasonable for firms. Therefore, also the outputs of the single firms are influenced because demand for differentiated goods only depends on prices.

[69] See derivation XII in Appendix 1.4.

Optimal integration strategies now are N,N, S,N, N,S, and S,S instead of N,N, S,N, N,NS, and S,NS when transport costs are high. This induces the following changes in prices for differentiated goods in both markets:
First, if firms select strategy N,N, their optimal prices for differentiated goods in the Northern market are defined by $\frac{1}{\alpha}\left(\frac{C(1,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$. These prices are the same as those without public good provision.

If firms select strategy N,N, their optimal prices for differentiated goods in the Southern market are defined by $\frac{1}{\alpha}\left(\frac{d_L C(1,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$, whereas the optimal prices of these firms for differentiated goods in the Southern market with high transport costs are defined by $\frac{1}{\alpha}\left(\frac{d_H C(1,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$. Because $d_L < d_H$, prices with public good provision in the Southern market are lower than those without.

Second, if firms select strategy S,N, their optimal prices for differentiated goods in the Northern market are defined by $\frac{1}{\alpha}\left(\frac{C(w,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$. These prices stay the same as those without public good provision.
If firms select strategy S,N, their optimal prices for differentiated goods in the Southern market are defined by $\frac{1}{\alpha}\left(\frac{d_L C(w,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$, whereas the optimal prices of these firms for differentiated goods in the Southern market with high transport costs are defined by $\frac{1}{\alpha}\left(\frac{d_H C(w,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$. Because $d_L < d_H$, prices with public good provision in the Southern market are lower than those without.

Third, if firms select strategy N,S, their optimal prices for differentiated goods in the Northern market are defined by $\frac{1}{\alpha}\left(\frac{d_L C(1,w)}{\Theta}\right)^{(\alpha-1)/-\alpha}$, whereas the optimal prices of these firms for differentiated goods in the Northern market with high transport costs are defined by $\frac{1}{\alpha}\left(\frac{C(1,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$ when N,NS is selected as the optimal integration strategy. Because transport costs decrease with provision of public infrastructure, $\frac{1}{\alpha}\left(\frac{d_L C(1,w)}{\Theta}\right)^{(\alpha-1)/-\alpha} < \frac{1}{\alpha}\left(\frac{C(1,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$ holds true. For this reason, the prices of these firms are lower for consumers in the Northern market than in the analysis with high transport costs.

If firms select strategy N,S, their optimal prices for differentiated goods in the Southern market are defined by $\frac{1}{\alpha}\left(\frac{C(1,w)}{\Theta}\right)^{(\alpha-1)/-\alpha}$. These prices are the same as those without public good provision because the Southern market's demand also is supplied with these prices when firms select strategy N,NS with high transport costs.

Fourth, if firms select strategy S,S, their optimal prices for differentiated goods in the Northern market are defined by $\frac{1}{\alpha}\left(\frac{d_L C(w,w)}{\Theta}\right)^{(\alpha-1)/-\alpha}$, whereas the optimal prices of these firms for differentiated goods in the Northern market with high transport costs are defined by $\frac{1}{\alpha}\left(\frac{C(w,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$ when S,NS is selected as the optimal integration strategy. Because transport costs decrease with provision of public infrastructure, $\frac{1}{\alpha}\left(\frac{d_L C(w,w)}{\Theta}\right)^{(\alpha-1)/-\alpha} < \frac{1}{\alpha}\left(\frac{C(w,1)}{\Theta}\right)^{(\alpha-1)/-\alpha}$ holds true. For this reason, the prices of these firms are lower for consumers in the Northern market than in the analysis with high transport costs.

If firms select strategy S,S, their optimal prices for differentiated goods in the Southern market are defined by $\frac{1}{\alpha}\left(\frac{C(w,w)}{\Theta}\right)^{(\alpha-1)/-\alpha}$. These prices are the same as those without public good provision because demand in the Southern market also is supplied with these prices when firms select strategy S,NS with high transport costs.

Summarizing, firms selecting strategies N,N or S,N in both analyses, with either low or high d, supply the Northern market at the same prices and the Southern market at lower prices if tax revenue is invested in public good provision for differentiated goods. Firms selecting strategies N,S and S,S instead of N,NS and S,NS in the previous analysis supply the demand of the Northern market to lower prices, whereas the prices in the South stay the same as in the analysis without taxation and with d_H.

This section describes the impact of taxation on prices if the firms if a firm selects the corresponding strategy to previous analysis without taxation and with d_H (i.e., selecting N,N with low transport costs if they selected N,N with high transport costs, selecting S,N with low transport costs if they selected S,N with high transport costs, selecting N,S with low transport costs if they selected N,NS with high transport costs, and selecting S,S with low transport costs if they selected S,NS with high transport costs).

However, optimal taxation depends on the impact of t_i on the utility of the representative household in the jurisdiction of a government. For example, if the fixed costs relation is medium high some firms selecting S,NS in the analysis with high transport costs may find it reasonable to select N,N if its choice is influenced by taxation. This decision again depends on the productivity level of a firm. In this case, prices of differentiated goods from these firms will increase in both jurisdictions. This possibility depends on the exact tax rates in both countries, which induce a shift of the graphical analogues to the cut-off levels in the previous graphical analysis either in one direction or into the other. For this reason, the impact of taxation on the utility of the representative household from differentiated goods depends on the distribution of the firms over the integration strategies. If the prices of these firms do not increase either, the impact of taxation on utility of the representative household from differentiated goods cannot decline in this model, where both governments know the distribution of the firms over the integration strategies when selecting tax rates. If the total impact of taxation does not result in a decline in utility in both jurisdictions both governments select $t_i>0$, as long as total tax revenue is high enough that R can be afforded and public infrastructure is provided.

This description shows all effects of taxation on the households' utility depending on the parameter configurations in general.

Precisely, this is shown in the case of the fixed costs relation being medium high.

In other words, if $\gamma_{L2} < \frac{g}{f} < \gamma_{H2}$ holds true, only strategies N,N or S,S are optimal. If transport costs decrease, taxation is introduced into the model and the set of optimal integration strategies changes. The range of parameters for which $\gamma_{L2} < \frac{g}{f} < \gamma_{H2}$ holds true has changed in comparison to the analysis without taxation and with high transport costs.

Now, N,N and S,S are the only optimal strategies only if the fixed costs relation is given by[70]

$$\gamma_{L2} = \frac{\left[\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_L C(w,1)} - \frac{\overline{X^N}}{C(1,1)} - \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)} < \frac{g}{f} \quad \text{and} \tag{1.11}$$

$$\frac{g}{f} < \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^N}}{d_L C(1,w)} - \frac{\overline{X^S}}{C(1,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{d_L C(1,w)} + \frac{\overline{X^S}}{C(1,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)} = \gamma_{H2}\,. \tag{1.12}$$

Given this situation, a minimum utility of $V_i$new = $V_i$old must hold true for that t_i>0 is selected, as has already been described.

For this reason, the Southern government is confronted with following utility functions

$$V_S new = m_S + (1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(N,N;S,S)} p_S(j)^{\alpha/(\alpha-1)} dj + \int_{\Theta(N,N;S,S)}^{\Theta_{max}} p_S(j)^{\alpha/(\alpha-1)} dj\right] \text{ and} \tag{1.9a}$$

$$V_S old = m_S + (1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(N,N;S,NS)} p_S(j)^{\alpha/(\alpha-1)} dj + \int_{\Theta(N,N;S,NS)}^{\Theta_{max}} p_S(j)^{\alpha/(\alpha-1)} dj\right]. \tag{1.9b}$$

[70] See derivation XIII and XIV in Appendix 1.4.

This results in

$$\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}\pm[E]^{1/2}=(1-t_S)_{1/2}. \tag{1.13}$$

Only if parameter configurations are ensured for which $0<(1-t_S)<1$ holds true, can $0<t_S<1$ be selected by the Southern government.[71] E is positive; and only then can $0<t_S<1$ possibly be reasonable, where optimal taxation depends on exact parameter configurations. However, not every configuration lets equation (1.13) become reasonable for $0<t_S<1$. If $0<\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}\pm[E]^{1/2}<1$ is true, an optimal tax rate $0<t_S<1$ can be derived from equation (1.13).[72]

If $0<\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}\pm[E]^{1/2}<1$ does not hold true, the optimal tax rate in S is zero.

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[71] See derivation XV in Appendix 1.4. Furthermore,

$$E=-\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2d_L C(1,1)}-\frac{1}{2C(w,w)}\right]}{\left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}{(f+g)}\right)^2 D}$$

and $D=\Bigg((1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}$.

$$\left[\frac{1}{2C(w,w)}-\left[\frac{1}{2C(w,w)}+\left[\frac{1}{2d_H C(1,1)}-\frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)}-\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]\right]\Bigg).$$

[72] See derivation XVI in Appendix 1.4.

As can be seen, the optimal Southern tax rate depends on the Northern tax rate. For this reason, the reaction of t_S on t_N must be examined. It must be considered that in contrast to income m_N in N income m_S in S is independent of t_N and t_S:

$$\frac{\partial(1-t_S)}{\partial(1-t_N)}=\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]} \tag{1.14}$$

Accordingly, $\frac{\partial(1-t_S)}{\partial(1-t_N)}$ is never negative.

If taxation itself is reasonable, $\frac{\partial(1-t_S)}{\partial(1-t_N)}$ is positive (i.e., if the tax rate in N increases, the tax rate in S increases; and if the tax rate in N declines, the tax rate in S declines). Because of this correlation, the governments can set tax rates in such a way that combined tax revenue is high enough to finance R.

As can be seen from derivation (1.13), whether profit taxation in S is reasonable depends on the parameter configurations. The optimal tax rate $0<t_S<1$, if it exists, is positively correlated with t_N, as can be seen from derivation (1.14).

The same analysis can be done from the Northern government's perspective, which is confronted with the following utility functions

$$V_N new = m_N new + (1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(N,N;S,S)} p_N(j)^{\alpha/(\alpha-1)}dj + \int_{\Theta(N,N;S,S)}^{\Theta_{max}} p_N(j)^{\alpha/(\alpha-1)}dj\right] \text{ and} \tag{1.9c}$$

$$V_N old = m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(N,N;S,NS)} p_N(j)^{\alpha/(\alpha-1)}dj + \int_{\Theta(N,N;S,NS)}^{\Theta_{max}} p_N(j)^{\alpha/(\alpha-1)}dj\right]. \tag{1.9d}$$

This results in

$$\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} \pm [K]^{1/2} = (1-t_N)_{1/2}\,. \qquad (1.15)$$

Only if parameter configurations are ensured for which $0<(1\text{-}t_N)<1$ holds true, can $0<t_N<1$ be selected by the Northern government.[73] In contrast to the analysis for the South, in which E is positive anyhow, K can be either positive or negative. Only if K is positive, can $0<t_N<1$ be reasonable, because optimal taxation depends on exact parameter configurations and not every configuration lets equation (1.15) become reasonable for $0<t_N<1$. If $0<\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} \pm [K]^{1/2}<1$ is true, an optimal tax rate $0<t_N<1$ can be derived from equation (1.15).[74]

If $0<\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} \pm [K]^{1/2}<1$ does not hold true, the optimal tax rate in N is zero.

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[73] See derivation XVII in Appendix 1.4. Furthermore,

$$K = -\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)}-\frac{1}{2d_L C(w,w)}\right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}B}$$ and

$$B = \left(m_N new - m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \cdot \left[\frac{1}{2d_L C(w,w)} - \left[\frac{1}{2C(w,1)}+\left[\frac{1}{2C(1,1)}-\frac{1}{2C(w,1)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)}-\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]\right]\right).$$

[74] See derivation XVIII in Appendix 1.4.

As can be seen from equation (1.15) the optimal Northern tax rate depends on the Southern tax rate. For this reason, the reaction of t_N on t_S must be examined. It must be considered that income $m_N$new depends on t_N and t_S and that t_N and t_S depend on one another:[75]

$$\frac{\partial(1-t_N)}{\partial(1-t_S)} = \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]} \pm (\upsilon) \tag{1.16}$$

and υ is defined by

$$\upsilon = -\frac{1}{2}\left[- \frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)}\right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}} \right]^{1/2} (B)^{-3/2} \cdot \left(\frac{\partial m_N new}{\partial(1-t_S)} + \frac{\partial m_N new}{\partial(1-t_N)}\frac{\partial(1-t_N)}{\partial(1-t_S)}\right)$$

The effect of υ is new compared to the analysis for S, because income in N is influenced by taxation.

First, income of households in N depends on taxation in N and S.

Therefore $\left[- \frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)}\right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}} \right]$ is always positive. If income in N is so negatively influenced by taxation that B becomes negative, taxation

[75] See derivation XIX in Appendix 1.4.

no longer is reasonable from the point of view of the Northern government. In terms of finding an optimal $0<t_N<1$, this case is neglected previously in equation (1.15) with the condition that K may not be negative. Otherwise, the negative impact of taxation on income cannot be compensated by the positive impact on prices.

Second, if B is positive, taxation can be reasonable. Again, this depends on exact parameter configurations.

Solving (1.16) with a positive B, the following conditions can be derived:

$$\frac{\partial(1-t_N)}{\partial(1-t_S)} = \left[\frac{\left[\dfrac{\overline{X^N}}{d_L C(w,w)} + \dfrac{\overline{X^S}}{C(w,w)}\right]}{\left[\dfrac{\overline{X^N}}{C(1,1)} + \dfrac{\overline{X^S}}{d_L C(1,1)}\right]} - \left(\frac{1}{2}\left[- \frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\dfrac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\dfrac{1}{2C(1,1)} - \dfrac{1}{2d_L C(w,w)}\right]}{\dfrac{\left[\dfrac{\overline{X^N}}{C(1,1)} + \dfrac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}} \right]^{1/2} (B)^{-3/2} \cdot \frac{\partial m_N new}{\partial(1-t_S)} \right) \right]$$

$$\left[1 + \left(\frac{1}{2}\left[- \frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\dfrac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\dfrac{1}{2C(1,1)} - \dfrac{1}{2d_L C(w,w)}\right]}{\dfrac{\left[\dfrac{\overline{X^N}}{C(1,1)} + \dfrac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}} \right]^{1/2} (B)^{-3/2} \cdot \frac{\partial m_N new}{\partial(1-t_N)} \right) \right]^{-1} \qquad (1.17)$$

or

$$\frac{\partial(1-t_N)}{\partial(1-t_S)}=\left[\left[\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]}\right]+\right.$$

$$\frac{1}{2}\left[-\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)}-\frac{1}{2d_L C(w,w)}\right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}}\right]^{1/2}\left.(B)^{-3/2}\cdot\frac{\partial m_N new}{\partial(1-t_S)}\right]$$

$$\left[1-\frac{1}{2}\left[-\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)}-\frac{1}{2d_L C(w,w)}\right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}}\right]^{1/2}(B)^{-3/2}\cdot\frac{\partial m_N new}{\partial(1-t_N)}\right]^{-1} \qquad (1.18)$$

The tax rates t_N and t_S are always positively correlated so that $0<t_S<1$ is selected by the government in S. For this reason, the governments in S and N will only find a solution for the provision of public infrastructure if $\frac{\partial(1-t_N)}{\partial(1-t_S)}$ is positive, too.

That is, a tax rate $0<t_N<1$ can only be achieved if parameters are configured in such way that either (1.17) or (1.18) yields a positive $\frac{\partial(1-t_N)}{\partial(1-t_S)}$.

For this reason, the following conditions can be derived from (1.17) and (1.18):

a) Condition from (1.17) is

$$\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]}>$$

$$\left(\left[\frac{1}{2}\left[-\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)}-\frac{1}{2d_L C(w,w)}\right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}}\right]\right]^{1/2}(B)^{-3/2}\cdot\frac{\partial m_N new}{\partial(1-t_S)}\right).$$

Otherwise, $\frac{\partial(1-t_N)}{\partial(1-t_S)}>0$ cannot be derived and public infrastructure will not be provided. Then, only (1.18) can possibly deliver a solution.

b) Condition from (1.18) is

$$1>\left[\frac{1}{2}\left[-\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)}-\frac{1}{2d_L C(w,w)}\right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}}\right]\right]^{1/2}(B)^{-3/2}\cdot\frac{\partial m_N new}{\partial(1-t_N)}.$$

Otherwise, $\frac{\partial(1-t_N)}{\partial(1-t_S)}$ will be negative or undefined and public infrastructure will not be provided. Then, only (1.17) can possibly deliver a solution.

Following these conditions, if taxation is reasonable at all, all parameter configurations serve a positive $\frac{\partial(1-t_N)}{\partial(1-t_S)}$. In this case, the governments can set tax rates in such a way that combined tax revenue is high enough to finance R.

Theoretically, a further argument against tax rates being correlated negatively exists. Optimal integration strategies from the point of view of the firms are defined endogenously. This implies that firms consider taxation when selecting their optimal integration strategies. For example, if public infrastructure is provided but t_N is very low and t_S is very high, it may be optimal to select strategy S,NS instead of strategy S,S, even though transport costs are low. This will not be in the interest of benevolent planners because only transport costs, not taxes, are passed on to households. For this reason, when setting tax rates, the governments must take into account that optimal integration strategies from the points of view of the firms will stay the same as the welfare optimal ones.

Furthermore, the utility functions of the representative households in both countries are different because income and prices are not the same in both jurisdictions. For this reason, only by chance will the chosen tax rates of both governments correspond and the governments will not have an incentive to deviate. Instead, if N selects a tax rate given t_S, S will react to t_N again and select another t_S to be optimal. Then again, N can select a higher tax rate without inducing a utility loss of the representative household in its jurisdiction. This will become a dynamic process. For this reason, both governments will cooperate with each other. They will select tax rates t_N and t_S, resulting in combined tax revenue high enough to afford R. A further reaction of selecting an even higher t_i than just to finance R is not induced. Therefore, the possible resulting utility gain can be given to all households by setting t_N and t_S. Then neither jurisdiction has an incentive to deviate.

Further, to achieve these tax rates, the required tax revenue to finance R must be illustrated. If, because of the previous analysis, positive values of t_i are reasonable, the governments must achieve combined tax revenue high enough to cover R. Without governmental actions $\frac{C(1,1)}{C(1,w)} < d_H$ holds true; but because the governments invest R, d declines. Therefore, $\frac{C(1,1)}{C(1,w)} > d_L$ can be achieved. Up to now, only optimal tax rates t_N and t_S have been illustrated, saying that tax revenue is high enough to cover R and that, because firms know that d declines if tax rates are introduced, they change their optimal integration strategies from N,N, N,NS, S,N, and S,NS to N,N, N,S, S,N, and S,S. Because a positive correlation of t_N and t_S holds true, if the governments select $0<t_i<1$, the required total tax revenue can always be achieved to finance R.

This analysis is an exemplary description of the situation when the fixed costs relation for production plants in S is medium high.

For this reason, tax revenue in N is defined in the following way:

$$t_N\left[\int_0^{\Theta(N,N;S,S)}\left[\frac{\overline{X^N}\Theta(j)}{C(1,1)}+\frac{\overline{X^S}\Theta(j)}{d_L C(1,1)}\right]dj\right] \tag{1.19}$$

The formal description of tax revenue in S, then, is described by:

$$t_S\left[\int_{\Theta(N,N;S,S)}^{\Theta_{max}}\left[\frac{\overline{X^N}\Theta(j)}{d_L C(w,w)}+\frac{\overline{X^S}\Theta(j)}{C(w,w)}\right]dj\right] \tag{1.20}$$

Hence, if the fixed costs relation for production plants in S is medium high and it is ensured that the utility of the representative households in both countries does not decline by levying taxes, the optimal tax rates of both governments must ensure combined tax revenue of

$$t_N\left[\int_0^{\Theta(N,N;S,S)}\left[\frac{\overline{X^N}\Theta(j)}{C(1,1)}+\frac{\overline{X^S}\Theta(j)}{d_L C(1,1)}\right]dj\right]+t_S\left[\int_{\Theta(N,N;S,S)}^{\Theta_{max}}\left[\frac{\overline{X^N}\Theta(j)}{d_L C(w,w)}+\frac{\overline{X^S}\Theta(j)}{C(w,w)}\right]dj\right]=R. \tag{1.21}$$

This shows that tax rates are optimal from the perspectives of both governments, that the utility of households at least does not decline when t_i is levied, and that the tax revenues are high enough to provide public infrastructure for differentiated goods because tax revenue is as high as R.

If the described equations hold true and the governments select $0<t_i<1$, the representative household's utility in both jurisdictions increases in comparison to the scenario without taxation. For this reason, depending on parameter configurations, profit taxation by a social planner for N and S to finance combined public infrastructure, can be a reasonable political instrument.

If the described equations do not hold true and $0<t_i<1$ cannot be selected because of the parameter configurations, then profit taxation to finance public good provision is not optimal from the perspective of a social planner. Because combined tax revenue is needed to provide public infrastructure, taxation by a single government is never optimal in this analysis. It only results in optimal profit taxation from a social planners perspective.

1.3 Conclusion

In this analysis, a trade-off between fixed costs and high per-unit variable costs is identified. Firms can choose between different integration strategies. Their headquarters are located in N and they serve the Northern and the Southern market with differentiated products. Every single firm must produce intermediate and final goods for itself; however, firms can choose N, S or both places as location for both production activities. As a result, many different integration strategies can be identified. Their optimality depends on the relative size of fixed costs for MNE activities, the size of transport costs for final goods, the fraction of demand in both markets, the wages in S being relatively low, the productivity of a single firm, and the degree of profit taxation in both governments.

First, the case with high transport costs is analyzed, excluding taxes. Transport of intermediate goods by assumption is free.

Low productive firms choose a strategy that minimizes fixed costs; high productive firms minimize the per-unit variable costs to supply both markets in which the transport costs are considered.

If transport costs for final goods are high, some firms, depending on their productivity, can find it optimal to produce intermediate goods in one country and final goods in both countries locally.

As a result of the analysis with high transport costs for final goods, their impact on the economic outcome becomes apparent: The higher transport costs are, the more firms prefer local production. Therefore, transport costs affect the per-unit variable costs.

Then, we analyze cases in which governments levy profit taxes on final goods production in the differentiated sector. Here, the governments invest tax revenue in public infrastructure for differentiated goods. If tax revenue is high enough to cover costs associated with the provision of public infrastructure for differentiated goods, transport costs decline from high to low endogenously. Therefore, the set of optimal integration strategies of heterogeneous firms changes. Then, when transport costs for final goods are small, no single activity is located at several places. Rather, every single activity, whether intermediate or final production, is located in N or in S. Therefore, profit functions also depend on tax rates.

Through this analysis, optimal tax policies of governments can be economically explained, with comparative advantages on the one hand and elements of the "New Trade Theory"[76] on the other when firms' integration strategies are endogenous. Governments select tax rates in such a way that the utilities of the representative households in their jurisdictions do not decline because, they are benevolent planners. If parameters are configured in such a way that this condition cannot be held optimal tax rates are zero. Levying taxes has several impacts on the utility of households in both countries: They influence prices paid for differentiated goods and income in N, but households do not gain utility through consuming public infrastructure directly. If governments select $0<t_i<1$, because a utility loss does not arise in either jurisdiction, the tax rates are always positively correlated. For this reason, total tax revenue can always be set high enough to provide public infrastructure. Therefore, the level of costs for provision of public infrastructure is not a restriction in deciding whether to levy taxes or not. If taxation is reasonable from the point of view of both governments, costs to finance public infrastructure only influence the exact level of $0<t_i<1$.

Because higher tax revenue than to finance costs for provision of public infrastructure is not required, if $0<t_i<1$ is selected, tax rates can be set in such way that the utility of the representative household can even increase. Because of the lower transport costs induced by taxation, the economic outcome can even increase. The always increasing economic integration is positive from the perspective of both governments; and, in this model, taxation also is reasonable from a world welfare perspective.

However, in using the derived model to achieve optimal tax rates, zero taxation can be the best choice of governments acting as benevolent planners. This depends on exact parameter configurations. Although in these cases zero profit taxation of heterogeneous firms is optimal from the welfare perspective of both governments, it has not been derived in this way in other literature. There, zero taxation is optimal due to a race-to-the-bottom scenario under tax competition.

[76] The first approach in this direction was derived by Krugman (1979).

1.4 Appendix

Derivation I:

$$U_i = x_0 + X,\ i \in \{A,B\}$$

$$X = \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{\alpha}dj\right]$$

$$L = x_0 + \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} (x^i(j)+\beta\varsigma(j))^{\alpha}dj\right] + \lambda\left[m_i - x_0 - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj\right]$$

m=earnings

$$\frac{\partial L}{\partial x_0} = 1-\lambda = 0 \quad \Rightarrow \lambda = 1$$

$$\frac{\partial L}{\partial \lambda} = m_i - x_0 - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj = 0 \quad \Rightarrow x_0 = m_i - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj$$

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} (x^i(j)+\beta\varsigma(j))^{(\alpha-1)}\varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

If $\beta = 0$:

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{(\alpha-1)}\varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

$$\Rightarrow \int_0^{\Theta_{max}}\left[\frac{\alpha}{\mu\alpha^{\alpha}}x^i(j)^{(\alpha-1)} - p_i(j)\right]\varsigma(j)dj = 0$$

$$\Rightarrow \left[\frac{\alpha}{\mu\alpha^{\alpha}}x^i(j)^{(\alpha-1)} - p_i(j)\right]=0$$

$$\Rightarrow x^i(j) = \alpha[p_i(j)\mu]^{1/(\alpha-1)}$$

This $x^i(j)$ is the demand of one household for the variety of a firm in country i.

Total demand for the variety of a firm in country i therefore is given by:

$$x^i(j) = M^i\alpha[p_i(j)\mu]^{1/(\alpha-1)}$$

Derivation II:

Inserting (1.3) in (1.4) following condition arises:

$$\pi = p_N(j)^{\alpha/(\alpha-1)}\mu^{1/(\alpha-1)}\alpha M^N + p_S(j)^{\alpha/(\alpha-1)}\mu^{1/(\alpha-1)}\alpha M^S - p_N(j)^{1/(\alpha-1)}\mu^{1/(\alpha-1)}\alpha M^N\frac{c_N}{\theta}$$

$$-p_S(j)^{1/(\alpha-1)}\mu^{1/(\alpha-1)}\alpha M^S\frac{c_S}{\theta}-k$$

(1.4')

$$\overline{\overline{X}}=\mu^{1/(\alpha-1)}\alpha$$

According:

$$\frac{\partial\pi}{\partial p}=\frac{\alpha}{(\alpha-1)}p_N(j)^{1/(\alpha-1)}M^N\overline{\overline{X}}+\frac{\alpha}{(\alpha-1)}p_S(j)^{1/(\alpha-1)}M^S\overline{\overline{X}}-\frac{1}{(\alpha-1)}p_N(j)^{1/(\alpha-1)}p_N(j)^{-1}M^N\overline{\overline{X}}\frac{c_N}{\theta}$$

$$-\frac{1}{(\alpha-1)}p_S(j)^{1/(\alpha-1)}p_S(j)^{-1}M^S\overline{\overline{X}}\frac{c_S}{\theta}=0$$

Solving this for p_N and p_S:

$p_N(j)_{opt}=\frac{1}{\alpha}\frac{c_N}{\theta}$, $p_S(j)_{opt}=\frac{1}{\alpha}\frac{c_S}{\theta}$

Derivation III:

By inserting $p_\ell(j)_{opt}$ in $\pi=\sum p_\ell(j)^{\alpha/(\alpha-1)}M^\ell\overline{\overline{X}}-\sum M^\ell\overline{\overline{X}}p_\ell(j)^{1/(\alpha-1)}\frac{c_\ell}{\theta}-k$ following profit condition for each firm derives:

$$\pi^*=M\overline{\overline{X}}\left(\frac{c}{\theta}\right)^{-\alpha/(1-\alpha)}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)}-\frac{1}{\alpha}^{-1/(1-\alpha)}\right)-k$$

or

$$\pi^*=M^N\overline{\overline{X}}\left(\frac{c_N}{\theta}\right)^{-\alpha/(1-\alpha)}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)}-\frac{1}{\alpha}^{-1/(1-\alpha)}\right)+M^S\overline{\overline{X}}\left(\frac{c_S}{\theta}\right)^{-\alpha/(1-\alpha)}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)}-\frac{1}{\alpha}^{-1/(1-\alpha)}\right)-k$$

Whereas $\Theta=\theta^{\alpha/(1-\alpha)}$, dC= $c^{\alpha/(1-\alpha)}$ and $\overline{\overline{X}}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)}-\frac{1}{\alpha}^{-1/(1-\alpha)}\right)=\mu^{1/(\alpha-1)}\alpha\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)}-\frac{1}{\alpha}^{-1/(1-\alpha)}\right)$

$\overline{\overline{X}}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)}-\frac{1}{\alpha}^{-1/(1-\alpha)}\right)$ is a country neutral size. Furthermore,

$M^N\overline{\overline{X}}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)}-\frac{1}{\alpha}^{-1/(1-\alpha)}\right)=\overline{X^N}$ and $M^S\overline{\overline{X}}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)}-\frac{1}{\alpha}^{-1/(1-\alpha)}\right)=\overline{X^S}$, where $\overline{X^S}<\overline{X^N}$ because the market share of the South is smaller than of the North.

For this reason the profit function is:

$$\pi^*_{a,b}=\frac{\overline{X^N}\Theta}{dC(j,r)}+\frac{\overline{X^S}\Theta}{dC(j,r)}-k$$

IV: All seven possible profit functions with transport costs for final goods

$$\pi_{N,N}=\frac{\overline{X^N}\Theta}{C(1,1)}+\frac{\overline{X^S}\Theta}{dC(1,1)}$$

$$\pi_{N,NS} = \frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{C(1,w)} - f$$

$$\pi_{N,S} = \frac{\overline{X^N}\Theta}{dC(1,w)} + \frac{\overline{X^S}\Theta}{C(1,w)} - f$$

$$\pi_{S,N} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{dC(w,1)} - g$$

$$\pi_{S,NS} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g$$

$$\pi_{S,S} = \frac{\overline{X^N}\Theta}{dC(w,w)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g$$

$\pi_{NS,NS} = \frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g$, where $\pi_{NS,NS}$ can only be an optimal strategy if transport costs for intermediate goods exist. This does not occur in this analysis. For this reason, $\pi_{S,NS}$ always dominates $\pi_{NS,NS}$ here.

Derivation V:

For that this set of integration strategies is optimal, following is necessary:

$\pi_{N,NS} \succ \pi_{N,S}$

$\pi_{S,NS} \succ \pi_{S,S}$

$\pi_{S,NS} \succ \pi_{NS,NS}$

This must be the case because each of these profit function pairs contains the same fixed costs and only differ by the components of per-unit variable costs and transport costs.

$$\pi_{N,NS} = \frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{C(1,w)} - f \succ \frac{\overline{X^N}\Theta}{d_H C(1,w)} + \frac{\overline{X^S}\Theta}{C(1,w)} - f = \pi_{N,S}$$

$$\pi_{S,NS} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g \succ \frac{\overline{X^N}\Theta}{d_H C(w,w)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g = \pi_{S,S}$$

$$\pi_{S,NS} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g \succ \frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g = \pi_{NS,NS}$$

If $\pi_{S,NS} \succ \pi_{S,S}$ also $\pi_{S,NS} \succ \pi_{NS,NS}$ always holds because $C(w,1) < C(1,1)$.

If this is true it can also be followed from the equations that:

$C(1,1) < d_H\, C(1,w)$ (iv)

$C(w,1) < d_H\, C(w,w)$ (v)

holds.

Transformation delivers:

$$\frac{C(1,1)}{C(1,w)} < d_H \text{ and } \frac{C(w,1)}{C(w,w)} < d_H$$

This proves that this set of optimal integration strategies only is optimal, if high transport costs exist.

Derivation VI:

To calculate this $\pi_{N,N}$ is equated with $\pi_{S,NS}$. Then $\pi_{N,NS}$ and $\pi_{N,N}$ are compared at this location and for N,NS to be an optimal strategy it is necessary that: $\pi_{N,NS} > \pi_{N,N}$.

$$\pi_{N,N} = \pi_{S,NS}$$

$$\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_H C(1,1)} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g$$

$$\Theta(N,N;S,NS) = \frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)}$$

This is the x-axis coordinate. At this point $\pi_{N,NS}$ has to be greater than $\pi_{N,N}$.

For this reason, the x-axis coordinate of $\pi_{N,N}$ is required:

$$y_{N,N} = \left(\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_H C(1,1)}\right)\frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)}$$

y-axis coordinate of $\pi_{N,NS}$:

$$y_{N,NS} = \left(\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(1,w)}\right)\frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)} - f$$

It is necessary that:

$$y_{N,NS} \geq y_{N,N}$$

$$\left(\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(1,w)}\right)\frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)} - f \geq$$

$$\left(\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_H C(1,1)}\right)\frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)}$$

$$\left(\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(1,w)}\right)\cdot\frac{\left(1+\frac{g}{f}\right)}{\overline{X^N}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^S}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}-1\geq$$

$$\left(\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_H C(1,1)}\right)\cdot\frac{\left(1+\frac{g}{f}\right)}{\overline{X^N}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^S}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}$$

$$1+\frac{g}{f}\geq\frac{\overline{X^N}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^S}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(1,w)}-\frac{\overline{X^N}}{C(1,1)}-\frac{\overline{X^S}}{d_H C(1,1)}\right)}$$

$$\frac{g}{f}\geq\frac{\overline{X^N}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^S}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^S}}{C(1,w)}-\frac{\overline{X^S}}{d_H C(1,1)}\right)}-1$$

$$\frac{g}{f}\left(\frac{\overline{X^S}}{C(1,w)}-\frac{\overline{X^S}}{d_H C(1,1)}\right)\geq\left(\frac{\overline{X^N}}{C(w,1)}-\frac{\overline{X^N}}{C(1,1)}\right)+\left(\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^S}}{d_H C(1,1)}\right)-\frac{\overline{X^S}}{C(1,w)}+\frac{\overline{X^S}}{d_H C(1,1)}$$

$$\frac{g}{f}\geq\frac{\frac{\overline{X^N}}{C(w,1)}-\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^S}}{C(1,w)}}{\left(\frac{\overline{X^S}}{C(1,w)}-\frac{\overline{X^S}}{d_H C(1,1)}\right)}=\gamma_H$$

<u>Derivation VII:</u>

$$\pi_{N,N}=\pi_{S,NS}$$

$$\frac{\overline{X^N}\Theta}{C(1,1)}+\frac{\overline{X^S}\Theta}{d_H C(1,1)}=\frac{\overline{X^N}\Theta}{C(w,1)}+\frac{\overline{X^S}\Theta}{C(w,w)}-f-g$$

$$\Theta(N,N;S,NS)=\frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^S}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}$$

This is the x-axis coordinate. At this point $\pi_{S,N}$ has to be greater than $\pi_{N,N}$.

For this reason, the y-axis coordinate of $\pi_{N,N}$ is required:

$$y_{N,N}=\left(\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_H C(1,1)}\right)\frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^S}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}$$

y-axis coordinate of $\pi_{S,N}$:

$$y_{S,N} = \left(\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} \right) \frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)} \right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)} \right)} - g$$

It is necessary that:

$y_{S,N} \geq y_{N,N}$

$$\left(\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} \right) \frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)} \right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)} \right)} - g \geq$$

$$\left(\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_H C(1,1)} \right) \frac{(f+g)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)} \right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)} \right)}$$

$$\left(\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} \right) \cdot \frac{\left(\frac{f}{g} + 1 \right)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)} \right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)} \right)} - 1 \geq$$

$$\left(\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_H C(1,1)} \right) \cdot \frac{\left(\frac{f}{g} + 1 \right)}{\overline{X^N}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)} \right) + \overline{X^S}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)} \right)}$$

$$1 + \frac{f}{g} \geq \frac{\left(\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} \right) + \left(\frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)} \right)}{\left(\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} \right) - \left(\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_H C(1,1)} \right)}$$

$$\frac{f}{g} \geq \frac{\left(\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} \right) + \left(\frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)} \right)}{\left(\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} \right) - \left(\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_H C(1,1)} \right)} - 1$$

$$\frac{f}{g}\left(\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} - \frac{\overline{X^N}}{C(1,1)} - \frac{\overline{X^S}}{d_H C(1,1)} \right) \geq$$

$$\left(\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} \right) + \left(\frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)} \right) - \left(\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} - \frac{\overline{X^N}}{C(1,1)} - \frac{\overline{X^S}}{d_H C(1,1)} \right)$$

$$\frac{f}{g} \geq \frac{\frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(w,1)}}{\left(\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} - \frac{\overline{X^N}}{C(1,1)} - \frac{\overline{X^S}}{d_H C(1,1)}\right)}$$

$$\frac{g}{f} \leq \frac{\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(w,1)} - \frac{\overline{X^N}}{C(1,1)} - \frac{\overline{X^S}}{d_H C(1,1)}}{\frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(w,1)}} = \gamma_L$$

Derivation VIII:

$$\pi_{N,N} = \pi_{N,NS}$$

$$\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_H C(1,1)} = \frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{C(1,w)} - f$$

$$\Theta \cdot \left(\frac{\overline{X^N}}{C(1,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_H C(1,1)} - \frac{\overline{X^S}}{C(1,w)}\right) = -f$$

$$\Theta(N,N;N,NS) = \frac{f}{\overline{X^S}\left[\frac{1}{C(1,w)} - \frac{1}{d_H C(1,1)}\right]}$$

$$\pi_{N,N} = \pi_{S,NS}$$

$$\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_H C(1,1)} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g$$

$$\Theta \cdot \left(\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}\right) = f + g$$

$$\Theta(N,N;S,NS) = \frac{f+g}{\overline{X^N}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^S}\left[\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right]}$$

$$\pi_{N,N} = \pi_{S,N}$$

$$\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_H C(1,1)} = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{d_H C(w,1)} - g$$

$$\Theta \cdot \left(\frac{\overline{X^N}}{C(1,1)} - \frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_H C(1,1)} - \frac{\overline{X^S}}{d_H C(w,1)}\right) = -g$$

$$\Theta(N,N;S,N) = \frac{g}{\overline{X^N}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^S}\left[\frac{1}{d_H C(w,1)} - \frac{1}{d_H C(1,1)}\right]}$$

$$\pi_{N,NS} = \pi_{S,NS}$$

$$\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{C(1,w)} - f = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g$$

$$\Theta \cdot \left(\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{C(1,w)} \right) = g$$

$$\Theta(N,NS;S,NS) = \frac{g}{\overline{X^N}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^S}\left[\frac{1}{C(w,w)} - \frac{1}{C(1,w)}\right]}$$

$$\pi_{S,N} = \pi_{S,NS}$$

$$\frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{d_H C(w,1)} - g = \frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{C(w,w)} - f - g$$

$$\Theta \cdot \left(\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(w,1)} \right) = f$$

$$\Theta(S,N;S,NS) = \frac{f}{\overline{X^S}\left[\frac{1}{C(w,w)} - \frac{1}{d_H C(w,1)}\right]}$$

<u>Derivation IX:</u>

$$U_i = x_0 + X \qquad X = \frac{1}{\mu\alpha^\alpha}\left[\int_0^{\Theta_{max}} x_i(j)^\alpha dj\right]$$

$$L = x_0 + \frac{1}{\mu\alpha^\alpha}\left[\int_0^{\Theta_{max}} (x_i(j) + \beta\varsigma(j))^\alpha dj\right] + \lambda\left[m_i - x_0 - \int_0^{\Theta_{max}} p_i(j)(x_i(j) + \beta\varsigma(j))dj\right]$$

$$\frac{\partial L}{\partial x_0} = 1 - \lambda = 0 \quad \Rightarrow \lambda = 1$$

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^\alpha}\left[\int_0^{\Theta_{max}} (x_i(j) + \beta\varsigma(j))^{(\alpha-1)}\varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

If $\beta = 0$:

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^\alpha}\left[\int_0^{\Theta_{max}} x_i(j)^{(\alpha-1)}\varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

$$\Rightarrow \int_0^{\Theta_{max}} \left[\frac{\alpha}{\mu\alpha^\alpha} x_i(j)^{(\alpha-1)} - p_i(j)\right]\varsigma(j)dj = 0$$

$$\Rightarrow \left[\frac{\alpha}{\mu\alpha^\alpha} x_i(j)^{(\alpha-1)} - p_i(j)\right] = 0$$

$$\Rightarrow x_i(j) = \alpha[p_i(j)\mu]^{1/(\alpha-1)}$$

$$\frac{\partial L}{\partial \lambda} = m_i - x_0 - \int_0^{\Theta_{max}} p_i(j)(x_i(j) + \beta\varsigma(j))dj = 0 \quad \Rightarrow x_0 = m_i - \int_0^{\Theta_{max}} p_i(j)(x_i(j) + \beta\varsigma(j))dj$$

$$\Rightarrow x_0 = m_i - \int_0^{\Theta_{max}} p_i(j)\alpha[p_i(j)\mu]^{1/(\alpha-1)} dj$$

$$V_i = m_i - \int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)} \alpha[\mu]^{1/(\alpha-1)} dj + \frac{1}{\mu\alpha^{\alpha}} \int_0^{\Theta_{max}} [p_i(j)\mu]^{\alpha/(\alpha-1)} \alpha^{\alpha} dj$$

$$V_i = m_i + (1-\alpha)\mu^{1/(\alpha-1)} \int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)} dj$$

Derivation X:

To show the set of optimal integration strategies, depending on the size of d, profit functions independent of t_i have to be looked at. For that this set of integration strategies is optimal from the point of view of firms, following conditions are necessary:

$\pi_{N,S} \succ \pi_{N,NS}$,

$\pi_{S,S} \succ \pi_{S,NS}$,

$\pi_{S,S} \succ \pi_{NS,NS}$,

The inequalities above must hold because these strategies are compared directly.
As a result, a further set of inequalities surfaces in our analysis:

$d_L C(1,w) < C(1,1)$, as $\pi_{N,S} \succ \pi_{N,NS}$. (i)

$d_L C(w,w) < C(w,1)$, as $\pi_{S,S} \succ \pi_{S,NS}$. (ii)

$d_L C(w,w) < C(1,1)$, as $\pi_{S,S} \succ \pi_{NS,NS}$. (iii)

Whereas (iii) always holds if (ii) is true because C(1,1)>C(w,1).
Transformation delivers:

$$\frac{C(1,1)}{C(1,w)} > d_L \text{ and } \frac{C(w,1)}{C(w,w)} > d_L$$

This proves that this set of integration strategies only is optimal, if low transport costs exist.

Derivation XI:

$$\pi_{N,N} = \pi_{N,S}$$

$$\left[\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_L C(1,1)}\right](1-t_N) = \left[\frac{\overline{X^N}\Theta}{d_L C(1,w)} + \frac{\overline{X^S}\Theta}{C(1,w)}\right](1-t_S) - f$$

$$\Theta(N,N;N,S) = \frac{f}{\left[\frac{\overline{X^N}}{d_L C(1,w)} + \frac{\overline{X^S}}{C(1,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$\pi_{N,N} = \pi_{S,N}$$

$$\left[\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_L C(1,1)}\right](1-t_N) = \left[\frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{d_L C(w,1)}\right](1-t_N) - g$$

$$\Theta(N,N;S,N) = \frac{g}{\left[\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_L C(w,1)} - \frac{\overline{X^N}}{C(1,1)} - \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$\pi_{N,N} = \pi_{S,S}$$

$$\left[\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_L C(1,1)}\right](1-t_N) = \left[\frac{\overline{X^N}\Theta}{d_L C(w,w)} + \frac{\overline{X^S}\Theta}{C(w,w)}\right](1-t_S) - f - g$$

$$\Theta(N,N;S,S) = \frac{f+g}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$\pi_{N,S} = \pi_{S,S}$$

$$\left[\frac{\overline{X^N}\Theta}{d_L C(1,w)} + \frac{\overline{X^S}\Theta}{C(1,w)}\right](1-t_S) - f = \left[\frac{\overline{X^N}\Theta}{d_L C(w,w)} + \frac{\overline{X^S}\Theta}{C(w,w)}\right](1-t_S) - f - g$$

$$\Theta(N,S;S,S) = \frac{g}{\left[\frac{\overline{X^N}}{d_L C(w,w)} - \frac{\overline{X^N}}{d_L C(1,w)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{C(1,w)}\right](1-t_S)}$$

$$\pi_{S,N} = \pi_{S,S}$$

$$\left[\frac{\overline{X^N}\Theta}{C(w,1)} + \frac{\overline{X^S}\Theta}{d_L C(w,1)}\right](1-t_N) - g = \left[\frac{\overline{X^N}\Theta}{d_L C(w,w)} + \frac{\overline{X^S}\Theta}{C(w,w)}\right](1-t_S) - f - g$$

$$\Theta(S,N;S,S) = \frac{f}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)}$$

<u>Derivation XII:</u>

because $\Theta = \theta^{\alpha/(1-\alpha)}$ and $dC = c^{\alpha/(1-\alpha)}$:

$$\pi = \left[p_N(j)^{\alpha/(\alpha-1)} M^N \overline{\overline{X}} + p_S(j)^{\alpha/(\alpha-1)} M^S \overline{\overline{X}} - p_N(j)^{1/(\alpha-1)} M^N \overline{\overline{X}} \frac{\Theta}{dC_N} - p_S(j)^{1/(\alpha-1)} M^S \overline{\overline{X}} \frac{\Theta}{dC_S}\right][1-t_i] - k$$

$$\overline{\overline{X}} = \mu^{1/(\alpha-1)}\alpha$$

According,

$$\frac{\partial\pi}{\partial p_N} = \frac{\alpha}{(\alpha-1)} p_N(j)^{1/(\alpha-1)} M^N \overline{\overline{X}}(1-t_i) - \frac{1}{(\alpha-1)} p_N(j)^{1/(\alpha-1)} p_N(j)^{-1} M^N \overline{\overline{X}} \left(\frac{\Theta}{dC_N}\right)^{(\alpha-1)/\alpha} (1-t_i) = 0$$

$$\frac{\partial\pi}{\partial p_S}=\frac{\alpha}{(\alpha-1)}p_S(j)^{1/(\alpha-1)}M^S\overline{\overline{X}}(1-t_i)-\frac{1}{(\alpha-1)}p_S(j)^{1/(\alpha-1)}p_S(j)^{-1}M^S\overline{\overline{X}}\left(\frac{\Theta}{dC_S}\right)^{(\alpha-1)/\alpha}(1-t_i)=0$$

Solving this for p:

$p_N(j)_{opt}=\frac{1}{\alpha}\left(\frac{dC_N}{\Theta}\right)^{(\alpha-1)/-\alpha}$ and $p_S(j)_{opt}=\frac{1}{\alpha}\left(\frac{dC_S}{\Theta}\right)^{(\alpha-1)/-\alpha}$ if transport costs and taxes exist.

<u>Derivation XIII:</u>

To calculate this, $\pi_{N,N}$ is equated with $\pi_{S,S}$. Then $\pi_{N,S}$ and $\pi_{N,N}$ are compared at this location and for N,S to be an optimal strategy, it is necessary that: $\pi_{N,S}>\pi_{N,N}$.

$\pi_{N,N} = \pi_{S,S}$

$$\left[\frac{\overline{X^N}\Theta}{C(1,1)}+\frac{\overline{X^S}\Theta}{d_L C(1,1)}\right](1-t_N)=\left[\frac{\overline{X^N}\Theta}{d_L C(w,w)}+\frac{\overline{X^S}\Theta}{C(w,w)}\right](1-t_S)-f-g$$

$$\Theta(N,N;S,S)=\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

This is the x-axis coordinate. At this point $\pi_{N,S}$ must be greater than $\pi_{N,N}$.

For this reason, the y-axis coordinate of $\pi_{N,N}$ is required:

$$y_{N,N}=\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

y-axis coordinate of $\pi_{N,S}$:

$$y_{N,S}=\left[\frac{\overline{X^N}}{d_L C(1,w)}+\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}-f$$

It is necessary that:

$y_{N,S}\geq y_{N,N}$

$$\left[\frac{\overline{X^N}}{d_L C(1,w)}+\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}-f\ \geq$$

$$\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$\left[\frac{\overline{X^N}}{d_L C(1,w)}+\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)\frac{\left(1+\frac{g}{f}\right)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}-1\geq$$

$$\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)\cdot\frac{\left(1+\frac{g}{f}\right)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$1+\frac{g}{f}\geq\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(1,w)}+\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$\frac{g}{f}\geq\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(1,w)}+\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}-1$$

$$\frac{g}{f}\left(\left[\frac{\overline{X^N}}{d_L C(1,w)}+\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)\right)\geq$$

$$\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)-\left[\frac{\overline{X^N}}{d_L C(1,w)}+\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)$$
$$+\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)$$

$$\frac{g}{f}\geq\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^N}}{d_L C(1,w)}-\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{d_L C(1,w)}+\frac{\overline{X^S}}{C(1,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}=\gamma_{H2}$$

<u>Derivation XIV:</u>

To calculate this $\pi_{N,N}$ is equated with $\pi_{S,S}$. Then $\pi_{S,N}$ and $\pi_{N,N}$ are compared at this location and for S,N to be an optimal strategy, it is necessary that: $\pi_{S,N} > \pi_{N,N}$.

$\pi_{N,N} = \pi_{S,S}$

$$\left[\frac{\overline{X^N}\Theta}{C(1,1)} + \frac{\overline{X^S}\Theta}{d_L C(1,1)}\right](1-t_N) = \left[\frac{\overline{X^N}\Theta}{d_L C(w,w)} + \frac{\overline{X^S}\Theta}{C(w,w)}\right](1-t_S) - f - g$$

$$\Theta(N,N;S,S) = \frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

This is the x-axis coordinate. At this point $\pi_{S,N}$ must be greater than $\pi_{N,N}$.

For this reason, the y-axis coordinate of $\pi_{N,N}$ is required:

$$y_{N,N} = \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

y-axis coordinate of $\pi_{S,N}$:

$$y_{S,N} = \left[\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)} - g$$

It is necessary that:

$y_{S,N} \geq y_{N,N}$

$$\left[\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)} - g \geq$$

$$\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)\frac{(f+g)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$\left[\frac{\overline{X^N}}{C(w,1)} + \frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)\frac{\left(1+\frac{f}{g}\right)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)} - 1 \geq$$

$$\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)\cdot\frac{\left(1+\frac{f}{g}\right)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$1+\frac{f}{g}\geq\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{C(w,1)}+\frac{\overline{X^S}}{d_L C(w,1)}-\frac{\overline{X^N}}{C(1,1)}-\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$\frac{f}{g}\geq\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{C(w,1)}+\frac{\overline{X^S}}{d_L C(w,1)}-\frac{\overline{X^N}}{C(1,1)}-\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}-1$$

$$\frac{f}{g}\left(\left[\frac{\overline{X^N}}{C(w,1)}+\frac{\overline{X^S}}{d_L C(w,1)}-\frac{\overline{X^N}}{C(1,1)}-\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)\right)\geq$$

$$\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)-\left[\frac{\overline{X^N}}{C(w,1)}+\frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)$$
$$+\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)$$

$$\frac{f}{g}\geq\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(w,1)}+\frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{C(w,1)}+\frac{\overline{X^S}}{d_L C(w,1)}-\frac{\overline{X^N}}{C(1,1)}-\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}$$

$$\frac{g}{f}\leq\frac{\left[\frac{\overline{X^N}}{C(w,1)}+\frac{\overline{X^S}}{d_L C(w,1)}-\frac{\overline{X^N}}{C(1,1)}-\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)-\left[\frac{\overline{X^N}}{C(w,1)}+\frac{\overline{X^S}}{d_L C(w,1)}\right](1-t_N)}=\gamma_{L2}$$

<u>Derivation XV:</u>

The fixed costs relation is medium high:

Utility of the representative household in S with taxation:

$$V_S new = m_S+(1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(N,N;S,S)} p_S(j)^{\alpha/(\alpha-1)}dj+\int_{\Theta(N,N;S,S)}^{\Theta_{max}} p_S(j)^{\alpha/(\alpha-1)}dj\right]$$

$$= m_S + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \cdot$$

$$\left[\frac{1}{2C(w,w)} + \left[\frac{1}{2d_L C(1,1)} - \frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}\right)^2\right]$$

Following it is defined:

$$A = \left(\frac{f+g}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}\right)^2$$

This results in:

$$\frac{1}{A} = (1-t_S)^2\left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]}{(f+g)}\right)^2 - (1-t_S)2\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{(f+g)^2}$$

$$+\left(\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{(f+g)}\right)^2$$

Then:

$$V_S new \frac{1}{A} = m_S \frac{1}{A} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \frac{1}{A}\frac{1}{2C(w,w)}$$

$$+(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2d_L C(1,1)} - \frac{1}{2C(w,w)}\right]$$

Utility of the representative household in S without taxation:

$$V_S old = m_S + (1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(N,N;S,NS)} p_S(j)^{\alpha/(\alpha-1)} dj + \int_{\Theta(N,N;S,NS)}^{\Theta_{max}} p_S(j)^{\alpha/(\alpha-1)} dj\right]$$

$$= m_S + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \cdot$$

$$\left[\frac{1}{2C(w,w)} + \left[\frac{1}{2d_H C(1,1)} - \frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]$$

Then:

$$V_S old \frac{1}{A} = m_S \frac{1}{A} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \frac{1}{A}$$

$$\left[\frac{1}{2C(w,w)} + \left[\frac{1}{2d_H C(1,1)} - \frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]$$

For that $V_S new \frac{1}{A} = V_S old \frac{1}{A}$ holds true, following condition is necessary:

$$m_S \frac{1}{A} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \frac{1}{A}\frac{1}{2C(w,w)} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2d_L C(1,1)} - \frac{1}{2C(w,w)}\right] =$$

$$m_S \frac{1}{A} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \frac{1}{A}$$

$$\left[\frac{1}{2C(w,w)} + \left[\frac{1}{2d_H C(1,1)} - \frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]$$

This results in:

$$(1-t_S)^2\left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]}{(f+g)}\right)^2\left((1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \cdot\right.$$

$$\left.\left[\frac{1}{2C(w,w)} - \left[\frac{1}{2C(w,w)} + \left[\frac{1}{2d_H C(1,1)} - \frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]\right]\right)$$

$$-(1-t_S)2\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{(f+g)^2}\left((1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot\right.$$

$$\left.\left[\frac{1}{2C(w,w)}-\left[\frac{1}{2C(w,w)}+\left[\frac{1}{2d_H C(1,1)}-\frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)}-\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]\right]\right)$$

$$+\left(\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{(f+g)}\right)^2\left((1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot\right.$$

$$\left.\left[\frac{1}{2C(w,w)}-\left[\frac{1}{2C(w,w)}+\left[\frac{1}{2d_H C(1,1)}-\frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)}-\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]\right]\right)$$

$$+(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2d_L C(1,1)}-\frac{1}{2C(w,w)}\right]=0$$

Following, it is defined:

$$D=\left((1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot\right.$$

$$\left.\left[\frac{1}{2C(w,w)}-\left[\frac{1}{2C(w,w)}+\left[\frac{1}{2d_H C(1,1)}-\frac{1}{2C(w,w)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)}-\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]\right]\right)$$

Inserting D in $V_N new\frac{1}{A}=V_N old\frac{1}{A}$ and dividing by D and $\left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}{(f+g)}\right)^2$:

$$(1-t_S)^2-(1-t_S)2\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}+\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]^2(1-t_N)^2}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]^2}$$

$$+\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2d_L C(1,1)}-\frac{1}{2C(w,w)}\right]}{\left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}{(f+g)}\right)^2 D}=0$$

Solving for $(1-t_S)$:

$$\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}\pm\left[\left(\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}\right)^2-\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]^2(1-t_N)^2}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]^2}\right.$$

$$\left.-\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2d_L C(1,1)}-\frac{1}{2C(w,w)}\right]}{\left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}{(f+g)}\right)^2 D}\right]^{1/2}=(1-t_S)_{1/2}$$

Following, it is defined:

$$E=-\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2d_L C(1,1)}-\frac{1}{2C(w,w)}\right]}{\left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}{(f+g)}\right)^2 D}$$

This results in:

$$\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]} \pm [E]^{1/2} = (1-t_S)_{1/2}$$

<u>Derivation XVI:</u>

In any parameter configuration, E is positive:

2a.) $$\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]} > [E]^{1/2}:$$

$$(1-t_S)_1 = \frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]} + [E]^{1/2},$$

$$\text{if } 0 < \frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]} + [E]^{1/2} < 1 \Rightarrow 0<t_S<1$$

or:

$$(1-t_S)_2 = \frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]} - [E]^{1/2},$$

$$\text{if } 0 < \frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]} - [E]^{1/2} < 1 \Rightarrow 0<t_S<1$$

2b.) $$\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]} < [E]^{1/2}:$$

$$(1-t_S)_3 = \frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]} + [E]^{\frac{1}{2}},$$

$$\text{if } 0 < \frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]} + [E]^{\frac{1}{2}} < 1 \Rightarrow 0<t_S<1$$

or:

$$(1-t_S)_4 = \frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]} - [E]^{\frac{1}{2}},$$

but $\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]} - [E]^{\frac{1}{2}}$ is negative. This results in $t_S > 1$

$\Rightarrow$ no optimal $0<t_S<1$ exists

2c.) $\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]} = [E]^{\frac{1}{2}}$:

$$(1-t_S)_5 = 2\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]},$$

$$\text{if } 0< 2\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right]} <1 \Rightarrow 0<t_S<1$$

or:

$(1-t_S)_6 = 0$, but this results in $t_S = 1$

$\Rightarrow$ no optimal $0<t_S<1$ exists

Derivation XVII:

The fixed costs relation is medium high:

Utility of the representative household in N with taxation:

$$V_N new = m_N new + (1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(N,N;S,S)} p_N(j)^{\alpha/(\alpha-1)}dj + \int_{\Theta(N,N;S,S)}^{\Theta_{max}} p_N(j)^{\alpha/(\alpha-1)}dj\right]$$

$$= m_N new + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}.$$

$$\left[\frac{1}{2d_L C(w,w)} + \left[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)}\right]\left(\frac{f+g}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}\right)^2\right]$$

Following, it is defined:

$$A = \left(\frac{f+g}{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S) - \left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right](1-t_N)}\right)^2$$

This results in:

$$\frac{1}{A} = \left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{(f+g)}\right)^2 - (1-t_N)2\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]}{(f+g)^2}$$

$$+(1-t_N)^2\left(\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]}{(f+g)}\right)^2$$

Then:

$$V_N new \frac{1}{A} = m_N new \frac{1}{A} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\frac{1}{A}\frac{1}{2d_L C(w,w)}$$

$$+(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)}\right]$$

Utility of the representative household in N without taxation:

$$V_N old = m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(N,N;S,NS)} p_N(j)^{\alpha/(\alpha-1)} dj + \int_{\Theta(N,N;S,NS)}^{\Theta_{max}} p_N(j)^{\alpha/(\alpha-1)} dj\right]$$

$$= m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} .$$

$$\left[\frac{1}{2C(w,1)} + \left[\frac{1}{2C(1,1)} - \frac{1}{2C(w,1)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]$$

Then:

$$V_N old \frac{1}{A} = m_N old \frac{1}{A} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \frac{1}{A}$$

$$\left[\frac{1}{2C(w,1)} + \left[\frac{1}{2C(1,1)} - \frac{1}{2C(w,1)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]$$

For that $V_N new \frac{1}{A} = V_N old \frac{1}{A}$ holds true, following condition is necessary:

$$m_N new \frac{1}{A} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \frac{1}{A}\frac{1}{2d_L C(w,w)} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)}\right] =$$

$$m_N old \frac{1}{A} + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} \frac{1}{A}$$

$$\left[\frac{1}{2C(w,1)} + \left[\frac{1}{2C(1,1)} - \frac{1}{2C(w,1)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]$$

This results in:

$$(1-t_N)^2\left(\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]}{(f+g)}\right)^2\left(m_N new - m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)} .\right.$$

$$\Bigg[\frac{1}{2d_L C(w,w)} - \Bigg[\frac{1}{2C(w,1)} + \bigg[\frac{1}{2C(1,1)} - \frac{1}{2C(w,1)}\bigg]\Bigg(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\Bigg)^2\Bigg]\Bigg]\Bigg)$$

$$-(1-t_N)2\frac{\bigg[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\bigg](1-t_S)\bigg[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\bigg]}{(f+g)^2}\Bigg(m_N new - m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot$$

$$\Bigg[\frac{1}{2d_L C(w,w)} - \Bigg[\frac{1}{2C(w,1)} + \bigg[\frac{1}{2C(1,1)} - \frac{1}{2C(w,1)}\bigg]\Bigg(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\Bigg)^2\Bigg]\Bigg]\Bigg)$$

$$+\left(\frac{\bigg[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\bigg](1-t_S)}{(f+g)}\right)^2\Bigg(m_N new - m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot$$

$$\Bigg[\frac{1}{2d_L C(w,w)} - \Bigg[\frac{1}{2C(w,1)} + \bigg[\frac{1}{2C(1,1)} - \frac{1}{2C(w,1)}\bigg]\Bigg(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\Bigg)^2\Bigg]\Bigg]\Bigg)$$

$$+(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\bigg[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)}\bigg] = 0$$

Following, it is defined:

$$B = \Bigg(m_N new - m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot$$

$$\Bigg[\frac{1}{2d_L C(w,w)} - \Bigg[\frac{1}{2C(w,1)} + \bigg[\frac{1}{2C(1,1)} - \frac{1}{2C(w,1)}\bigg]\Bigg(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)} - \frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{C(w,w)} - \frac{\overline{X^S}}{d_H C(1,1)}}\Bigg)^2\Bigg]\Bigg]\Bigg)$$

Inserting B in $V_N new \frac{1}{A} = V_N old \frac{1}{A}$ and dividing by B and $\left(\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]}{(f+g)} \right)^2$:

$$(1-t_N)^2 - (1-t_N)2 \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)} \right](1-t_S)\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]^2}$$

$$+ \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)} \right]^2 (1-t_S)^2}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]^2} + \frac{(1-\alpha)\mu^{1/(\alpha-1)} \left(\frac{1}{\alpha} \right)^{\alpha/(\alpha-1)} \left[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)} \right]}{\left(\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]}{(f+g)} \right)^2 B} = 0$$

Solving for (1-t_N):

$$\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)} \right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]} \pm \left[\left(\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)} \right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]} \right)^2 - \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)} \right]^2 (1-t_S)^2}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]^2} \right.$$

$$\left. - \frac{(1-\alpha)\mu^{1/(\alpha-1)} \left(\frac{1}{\alpha} \right)^{\alpha/(\alpha-1)} \left[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)} \right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]^2}{(f+g)^2} B} \right]^{1/2} = (1-t_N)_{1/2}$$

Following, it is defined:

$$K = -\frac{(1-\alpha)\mu^{1/(\alpha-1)} \left(\frac{1}{\alpha} \right)^{\alpha/(\alpha-1)} \left[\frac{1}{2C(1,1)} - \frac{1}{2d_L C(w,w)} \right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)} \right]^2}{(f+g)^2} B}$$

This results in:

$$\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} \pm [K]^{1/2} = (1-t_N)_{1/2}$$

<u>Derivation XVIII:</u>

1.) if K is negative $\Rightarrow$ no optimal t_N exists

2.) if K is positive:

2a.) $\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} > [K]^{1/2}$ results in:

$$(1-t_N)_1 = \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} + [K]^{1/2},$$

if $0 < \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} + [K]^{1/2} < 1 \Rightarrow 0<t_N<1$

or:

$$(1-t_N)_2 = \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} - [K]^{1/2},$$

if $0 < \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]} - [K]^{1/2} < 1 \Rightarrow 0<t_N<1$

2b.) $$\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]} < [K]^{1/2}$$ results in:

$$(1-t_N)_3 = \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]} + [K]^{1/2},$$

if $$0 < \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]} + [K]^{1/2} < 1 \Rightarrow 0<t_N<1$$

or:

$$(1-t_N)_4 = \frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]} - [K]^{1/2},$$

but $$\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]} - [K]^{1/2}$$ is negative. This results in $t_N > 1$

$\Rightarrow$ no optimal $0<t_N<1$ exists

2c.) $$\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]} = [K]^{1/2}$$ results in:

$$(1-t_N)_5 = 2\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)} + \frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)} + \frac{\overline{X^S}}{d_L C(1,1)}\right]},$$

if $0<2\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right](1-t_S)}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]}<1 \Rightarrow 0<t_N<1$

or:

$(1-t_N)_6 = 0$, but this results in $t_N = 1$

$\Rightarrow$ no optimal $0<t_N<1$ exists

<u>Derivation XIX:</u>

Also $m_N$new depends on taxation. For this reason,

$$\frac{\partial(1-t_N)}{\partial(1-t_S)}=\frac{\left[\frac{\overline{X^N}}{d_L C(w,w)}+\frac{\overline{X^S}}{C(w,w)}\right]}{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]}\pm$$

$$\left(-\frac{1}{2}\left[-\frac{(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{2C(1,1)}-\frac{1}{2d_L C(w,w)}\right]}{\frac{\left[\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{d_L C(1,1)}\right]^2}{(f+g)^2}}\right]^{1/2}(B)^{-3/2}\cdot\left(\frac{\partial m_N new}{\partial(1-t_S)}+\frac{\partial m_N new}{\partial(1-t_N)}\frac{\partial(1-t_N)}{\partial(1-t_S)}\right)\right)$$

Where:

$$B=\left(m_N new - m_N old + (1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot\right.$$

$$\left.\left[\frac{1}{2d_L C(w,w)}-\left[\frac{1}{2C(w,1)}+\left[\frac{1}{2C(1,1)}-\frac{1}{2C(w,1)}\right]\left(\frac{f+g}{\frac{\overline{X^N}}{C(w,1)}-\frac{\overline{X^N}}{C(1,1)}+\frac{\overline{X^S}}{C(w,w)}-\frac{\overline{X^S}}{d_H C(1,1)}}\right)^2\right]\right]\right)$$

Chapter 2

Profit Taxation of Heterogeneous Firms with Lump-Sum Transfer

2.1 Introduction

In so-called "New Trade Theory" models firms produce differentiated goods under monopolistic competition and trade emerges independently of comparative advantages.[77] However, in the course of the always more proceeding international integration, trade, and foreign direct investments (FDIs) recent innovation to the literature derived.

In the prevailing opinion, multinational enterprises (MNEs) belong to the key players in an economically integrated world. Also policy makers want them to invest in their country because MNEs have dramatically gained importance in the past decades. For instance, between 1990 and 2001 the sails of foreign affiliates of MNEs grew a lot faster than the exports of goods.[78] It also has been estimated that MNEs then were responsible for 75% of commodity trade in the world.[79] The top-rate of FDI inflows was reached in 2000 with $1.4 trillion.[80] After the enormous growth, the FDIs of MNEs stabilized between 2001 and 2005.[81]

On the basis of this description, of the increasing importance of FDIs since the 1990s, the gain of the relevance of MNEs for the world economy is clearly made. Their modes of organization are quite diverse.[82] And mostly motives as savings of transport costs, savings of factor prices, or economies of scale come to the fore.[83] Even though factor endowments are difficult to measure, evidence for FDIs being influenced by factor cost differences can be found in latest studies; additionally, firm-level economies of scale influence the decision of an integration strategy of a firm.[84] In sectors in which firm-level economies of scale are important firms are less likely to serve foreign markets through exports than through subsidiaries.[85]

Not only more complex integration strategies are introduced into the theory. Also a very convenient but not at all realistic assumption, applied in most of the recent models, is abandoned: the assumption of identical firms. Instead, we introduce

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[77] As in Krugman (1979).
[78] As in UNCTAD (2002).
[79] As in Dunning (1993).
[80] As in UNCTAD (2004).
[81] As in Barba Navaretti and Venables (2006).
[82] Evidence here fore also is found in UNCTAD (1998) and Feinberg and Keane (2006).
[83] As in Markusen (2002).
[84] Evidence for the influence of factor cost differences can be found by Hanson et al. (2001) and Yeaple (2003) .
[85] Studies underpinning the motive of economies of scale are Brainard (1997) and Ekholm(1998).

heterogeneous firms and focus on the interaction of productivity, trade, and international integration.[86] Such a framework exhibits important features suggested by empirical evidence.[87]

Our analysis assumes monopolistic competition between firms in manufacturing, diverse integration strategies, and firm heterogeneity. A government levies taxes as a benevolent planner. From recent literature it is known that the economic structure and the nature of competition are essential for optimal policies.[88]

A single government is interested in maximizing its own national welfare. To benefit from activities of MNEs and from profits of other firms in their jurisdictions, governments levy corporate taxes. MNEs shift their profits across borders in response to corporate tax increases. Hence, an increasing national corporate tax rate induces a decline of multinational investments.[89] According to Hines (1999), an elasticity of FDIs, with respect to taxes, of minus 0.6 is a typical result.

Realizing the dramatically gained importance of MNE activities and its relevance for corporate taxation, this model outlines a possibility of efficient corporate tax policies for governments in a two country setting with monopolistic competition and heterogeneous firms.

The subsequent analysis is structured in the following way to deal with the outlined problems:

Section 2.2 first shows the composition of the model and then optimal integration strategies of firms in the differentiated sector are derived. These depend on the relative size of fixed costs, factor price differences, relative market shares, firm productivities, and transport costs.

We then introduce profit taxation where tax revenue is spent for a lump-sum transfer to the households in the jurisdictions. Again the reactions of firms are shown and optimal tax policy of both governments is portrayed. First, a scenario with profit taxation only and, afterwards, a scenario with profit taxation and depreciation possibilities, and their impacts are discussed.

Section 2.3 summarizes the results of the analysis and illustrates its impacts on the economic outcome.

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[86] Main theoretical papers are Bernard et al. (2003), Melitz (2003), Helpman, Melitz, and Yeaple (2004), Melitz and Ottaviano (2005) or Baldwin and Okubo (2006).
[87] As in e.g. Bernard and Jensen (2001) or Aw, Chung, and Roberts (2000).
[88] As in Dixit and Grossman (1987), Venables (1985) or Helpman and Flam(1986).
[89] Evidence therefore can be found in Devereux (2006), Hines and Rice (1994) or Clausing (2003).

2.2 Optimal profit taxation of heterogeneous firms with lump-sum transfer

2.2.1 Some general features of the model set-up

The following partial analysis describes the optimal integration strategies of heterogeneous firms based on the theoretical framework of Grossman, Helpman and Szeidl (2006) with particular emphasis on the role of profit taxation.

In this analysis, the optimal tax policy of governments is considered when tax revenue is spent as lump-sum transfer. A government's choice depends on the integration strategies chosen by the heterogeneous firms.

We set up a simple model with two countries: A and B. The former is developed, the latter less developed. Although factors are assumed to be immobile across national borders, goods are not. However, factor price equalization does not emerge due to the presence of transport costs. With regard to integration strategies, firms choose between two options: concentrating production in one country and serving consumers world-wide from there (exporting) or engaging in multi-plant production and serving consumers locally through domestic and foreign subsidiaries (multinational activity). In the parsimonious framework chosen, labor is the only factor used in production and for firm or plant set-up.

One industry produces a homogeneous good x_0; the other industry produces differentiated goods.

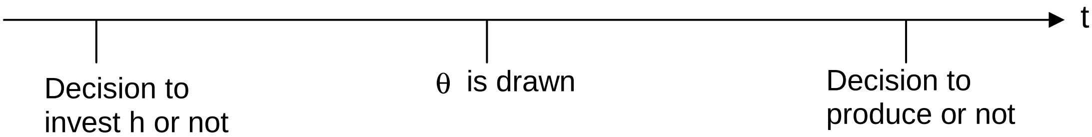
The homogeneous good is supplied under perfect competition. A is more productive in this sector than B. For this reason, there exists a gap between wages (w) in A and B. It is assumed that one unit of labor is needed to fabricate one of these goods in A. However, $\frac{1}{w} > 1$ units of labor are needed in B to produce one unit of the homogeneous good. We focus on parameter configurations to ensure that the homogeneous good is produced in both countries in equilibrium and traded across national borders. The price of the homogeneous good is chosen as the numéraire. Consequently, $w^A = 1 > w^B = w$ arises, where w^i is the wage rate in country i, $i \in \{A, B\}$, and transport costs for the homogeneous good exist.[90]

[90] As in Grossman, Helpman, and Szeidl (2006).

The differentiated good is supplied under monopolistic competition. Each firm acts as a monopolist in supplying its variety. The price elasticity of demand between varieties is $\varepsilon > 1$ so that firms charge a fixed mark-up over marginal costs. Due to monopolistic competition, the price will be lower than the monopoly price because, otherwise, the firms will loose an over proportional amount of demand for their varieties.

We assume that these firms are heterogeneous in productivity that they only can be founded in A, and that firm headquarters are not internationally mobile. For this reason, all headquarters are located in A (e.g., because of the unfavorable institutional environment in B) and are all owned by A.
To enter the differentiated industry, an amount of h units of A's labor, which are sunk costs, must be invested. These are firm set-up costs. With this investment, a firm in the heterogeneous sector gets to know its own potential productivity level (θ). Then, the firm can decide if it wants to enter the market. Firms in the differentiated sector can be diverse in their productivity so, if they decide to enter the market after investing h, they can make positive profits.[91] However, before investing h, all heterogeneous firms have the same expectations about their profits. For this reason, all heterogeneous firms are the same ex ante. If ex ante zero profits are expected, no more firms are willing to enter the differentiated sector. The productivity level drawn by a firm is a random variable (graphic 2.1).

Graphic 2.1



In addition, it is assumed that not only are production costs less in B than in A but also that its market for differentiated goods (M^B) is much smaller than the differentiated goods market in A (M^A).

2.2.2 The utility function of a representative household

All households have the same preferences and their utility function depends on a homogeneous good x_0 and the sub-utility of consumption of differentiated goods X.

[91] As in Helpman, Melitz, and Yeaple (2004).

Each household consumes goods of either sector and, in formal accounts, its utility function may be written as:

$$U_i = x_0 + X\,,\ \ i \in \{A, B\} \tag{2.1}$$

where $$X = \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{\alpha} dj\right] \qquad 0 < \alpha < 1,\ 0<\mu<1 \text{ and } \mu < \alpha \tag{2.2}$$

Consequently, household utility increases if more varieties of the differentiated product are available. These love for variety preferences exist for the consumption of differentiated goods.[92] The elasticity of substitution between two of these varieties is constant: $\frac{1}{(1-\alpha)}$. All varieties in the differentiated sector are non-perfect substitutes for one another, as α<1. But as α>0, they are somehow substitutable. μ is a constant with 0<μ<α<1 and reflects the preference for the differentiated industry over the homogeneous industry in the utility function of the representative household. X shows the sub-utility of consumption of the differentiated output, where $x^i(j)$ features the consumption in i of the j-th variety in this industry.[93]

Thus, the utility function of a representative household is linear in x_0 and non-linear in differentiated goods. This implies that the demand for differentiated products depends on prices of differentiated goods, but not on earnings.

2.2.3 The heterogeneous firms

As mentioned before, heterogeneous firms arise in the differentiated industry and locate their immobile headquarters in A. Irrespective of their integration strategies, these firms sell their products on each market.

In this analysis, the optimal integration strategies of these firms, which depend on firm productivity levels, are discussed. An integration strategy is defined by the choice of production location of intermediate and final goods. In the following sections the choice of an integration strategy is influenced not only by transport costs but also by taxation on profits.

To begin, a firm in the differentiated industry with productivity θ produces final goods according to the production function $\theta F(m,\ a)$. The amount of intermediate input

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[92] As in Krugman (1979) and Dixit and Stiglitz (1977).
[93] As in Grossman, Helpman, and Szeidl (2006).

used is denoted by m, and a is the level of final goods activity. Both are measured in units of labor input. F(m, a) is an increasing, concave function with constant returns to scale. Furthermore, the elasticity of substitution between m and a is not greater than 1. $c(p_m, p_a)$ describes the unit cost function, referring to F(m, a), where the price of input i at the location of final goods production is denoted by p_i, $i \in \{m, a\}$. Taking stock, $c(p_m, p_a)/\theta$ describes the per-unit variable costs of production of a firm with productivity θ at a particular location.[94]

Households only consume final goods.

A firm producing intermediate goods in B has to bear extra fixed costs of g for communication and supervision, because the headquarters of MNEs are located in A. Likewise, MNEs incur additional fixed costs of f if they produce final goods in B. These fixed costs are measured in labor units of the home country. Therefore, it is assumed that fixed costs do not exist in A.[95]

However, as already discussed, wages in B are lower than in A. It is assumed that production of one unit of the intermediate or final goods requires one unit of local labor at the place of production but that the intermediate goods have to be transported to the location of final production, if the latter are manufactured elsewhere. However, per-unit variable costs of manufacturing differentiated final or intermediate goods in B are lower than those of manufacturing these goods in A. Because $w^B = w < 1 = w^A$, B has a comparative advantage in manufacturing differentiated goods.

Table 2.1:[96]

Intermediate production m	Final good production a	Fixed costs	Per-unit variable costs
in A	in A	0	$c(1, 1) / \theta$
in A	in B	f	$c(1, w) / \theta$
in B	in A	g	$c(w, 1) / \theta$
in B	in B	f+g	$c(w, w) / \theta$

Table 2.1 shows that the optimality of integration strategies depends on per-unit variable costs $c(p_m, p_a)$ and the fixed costs of firms in the differentiated industry.

[94] As in Grossman, Helpman, and Szeidl (2006).
[95] As in Grossman, Helpman, and Szeidl (2006).
[96] As in Grossman, Helpman, and Szeidl (2006).

Furthermore, the total factor productivity of a firm is elemental for optimal integration strategies.

Additionally, these strategies also depend on market size, the level of transport costs, and taxes.

In the following, strategies depend on the location of intermediate and final goods production, where both can be produced in B as well as in A.

2.2.4 Iceberg transport costs

Now, iceberg transport costs (d) are introduced. This implies that an exporting firm has to ship more than one unit of the final goods so that one unit of the goods arrives at the location of foreign consumers. Transport costs for final goods are identical across countries and differentiated products, and they are proportional to the extent of shipments.[97]

In the following section, the size of transport costs is relatively high: ($d=d_H$).

2.2.5 Analysis with high transport costs and without taxation

Let us first describe the case in which transport costs for final goods are high and taxes are zero. By assumption, transport of intermediate goods is free.[98]

Compared to production in A, setting up foreign production plants in B induces additional fixed costs for a firm. However, its per-unit variable costs can be reduced when production activities are shifted to B.[99]

Subsequently, the variation in firm productivity levels θ in the differentiated industry will be observed more precisely.[100]

A firm will also never conduct activities in more than one plant per country. Such a strategy will unnecessarily incur additional costs.

To illustrate optimal integration strategies depending on the productivity level of a firm, we compare profits across alternative integration strategies. Consistent with the preferences depicted in (2.1) and (2.2), every manufacturing firm of this industry faces the following demand function in each country i, $i \in \{A, B\}$:[101]

$$x^i(j) = M^i \alpha [p_i(j)\mu]^{1/(\alpha-1)} \tag{2.3}$$

[97] As in Grossman, Helpman, and Szeidl (2006).
[98] As in Grossman, Helpman, and Szeidl (2006).
[99] As also in Yeaple (2003) and Helpman, Melitz, and Yeaple (2004).
[100] As in Grossman, Helpman, and Szeidl (2006).
[101] See derivation I in Appendix 2.4.

x^i (j) describes the total demand in one country for the differentiated good of a single firm. This demand depends on market size M^i, $i \in \{A,B\}$. Furthermore, it depends on the substitutability of differentiated products among each other, α, on μ, which reflects the preference for the differentiated industry over the homogeneous industry by the representative household, and on p_i (j), which is the effect of the price of the individual firm on x^i. Hence, demand from a single household for differentiated goods is independent of income.

Each firm, therefore, maximizes its profits accordingly:

$$\pi = p_A(j)x^A(j) + p_B(j)x^B(j) - x^A(j)\frac{c_A}{\theta} - x^B(j)\frac{c_B}{\theta} - k \tag{2.4}$$

Here $p_A(j)x^A(j) + p_B(j)x^B(j)$ denotes total sales, $(-x^A(j)\frac{c_A}{\theta} - x^B(j)\frac{c_B}{\theta})$reflects total costs in both countries and k are the fixed costs. $\frac{c_A}{\theta}$ and $\frac{c_B}{\theta}$ are per-unit variable costs in N and S, respectively.

This results in the identification of the optimal prices of a firm:[102]

$$p_A(j)_{opt} = \frac{1}{\alpha}\frac{c_A}{\theta}, \quad p_B(j)_{opt} = \frac{1}{\alpha}\frac{c_B}{\theta} \tag{2.5}$$

As shown here, the optimal price of a firm is independent of demand, respectively, on market size in A and B. Each market price is defined as $\frac{1}{\alpha}$ times the per-unit variable costs of a firm serving the specific market. Hence, prices entail a fixed markup over marginal costs.

In the following, we allow for transport costs and introduce terms that capture transport costs as well as variable (marginal) production costs.

Generally, profits may be formulated as follows:[103]

$$\pi^*_{a,b} = \frac{\overline{X^N}\Theta}{dC_{a,b}(j,r)} + \frac{\overline{X^S}\Theta}{dC_{a,b}(j,r)} - k_{a,b}\text{, with } a \in \{A,B\} \text{ and } b \in \{A,B\} \tag{2.6}$$

[102] See derivation II in Appendix 2.4.
[103] See derivation III in Appendix 2.4.

Furthermore, $\Theta = \theta^{\alpha/(1-\alpha)}$, $dC = c^{\alpha/(1-\alpha)}$, $\overline{\overline{X}} = (1-\alpha)\cdot\left(\frac{\alpha}{\mu}\right)^{1/(1-\alpha)}$, $M^A\overline{\overline{X}} = \overline{X^A}$, and $M^B\overline{\overline{X}} = \overline{X^B}$, where $\overline{X^B} < \overline{X^A}$ because the market share of B is smaller than of A.

Firm profits depend on its integration strategy, where a is the determinant of the location of intermediate goods production and b of final goods production. Hence, intermediate as well as final differentiated goods can be produced either in A or in B or in both countries. Depending on the location of production of a and b, different possible fixed costs ($k_{a,b}$) are taken into account in the profit function of a firm. If intermediate goods are produced in B, $k_{a,b}$ has size g; if final goods are produced in B, $k_{a,b}$ has size f; and if intermediate or final goods are produced in A, fixed costs are zero. Also per-unit variable costs $dC_{a,b}(j, r)$ depend on the locations of intermediate and final production, a and b. As denoted in table 2.1 j is the determinant of the dependency of total per-unit variable costs on per-unit variable costs for intermediate goods, measured in units of labor at the production location. Hence, j is $j \in \{1, w\}$; 1 occurs if intermediate goods are produced in A; and w<1 denotes these costs if they are produced in B. Additionally, r is the determinant of the dependency of total per-unit variable costs on per-unit variable costs for final goods, measured in units of labor at the production location. Hence, r is $r \in \{1, w\}$; 1 occurs if final goods are produced in A; and w<1 denotes for these costs if they are produced in B. Finally, also transport costs (d) are part of per-unit variable costs and depend on the location of final production. If final goods have to be shipped to serve a market, d >1 occurs; if final goods are produced at the location of consumption, d =1 (no transportation of final goods) is taken into account in the profit function of a firm.

Furthermore, high transport costs exist if:[104]

$$\frac{C(w,1)}{C(w,w)} < d_H \quad \text{or} \quad \frac{C(1,1)}{C(1,w)} < d_H$$

For this reason, the following possible profit functions arise for a firm, depending on its productivity level, in a two-country setting with high transport costs:

$$\pi_{A,A} = \frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)} \tag{2.I}$$

This strategy A,A with the profit function $\pi_{A,A}$ describes concentration of intermediate and final good production in the home country. A firm operates in the market in B by exporting the differentiated products. For this reason, supplying the market in B is

[104] See Grossman, Helpman, and Szeidl (2006).

more expensive. This strategy minimizes fixed costs but produces with relatively high per-unit variable costs C(1,1) because factor prices in A are higher than in B.

$$\pi_{A,AB} = \frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{C(1,w)} - f \tag{2.II}$$

Firms choosing this strategy supply the market in A by producing intermediate and final goods there. Intermediate goods from A are shipped to B, where final goods production takes place to serve consumers in B locally. In this case, MNE activity in final goods eliminates all trade in final goods. With this strategy, medium high fixed costs of f are incurred. On the other hand, the firm can save per-unit variable costs when supplying B compared to (2.I).

A strategy A,B with the profit function $\pi_{A,B}$ is no alternative to A,AB in the case with high transport costs.

$$\pi_{A,B} = \frac{\overline{X^A}\Theta}{d_H C(1,w)} + \frac{\overline{X^B}\Theta}{C(1,w)} - f \tag{2.II'}$$

Even though the fixed costs and the costs of supplying B are identical when selecting one of these two strategies, this strategy can be eliminated because of the costs of operating in the market in B. Supplying to A under strategy A,AB, a firm produces intermediate as well as final goods in A. Consequently, the only difference to strategy A,B is that the per-unit variable costs of supplying A are lower. This is due to the high transport costs occur to supply A's market when selecting A,B instead of A,AB. For this reason, this strategy never is reasonable if high transport costs exist.

$$\pi_{B,A} = \frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{d_H C(w,1)} - g \tag{2.III}$$

In this case, intermediate goods are produced in B and final goods in A. For this reason, this strategy also can be seen as "partial globalization".[105] Intra-firm trade exists. Transport costs arise when supplying B, because final goods are produced in A.

Similar to strategy A,AB, a firm in this case has to bear medium high fixed costs, here amounting to g, because intermediate goods are produced in B and final goods in A. However, adequate ranking of strategies A,AB and B,A cannot be determined without an exact identification of the level of the different fixed costs f and g and of the per-unit variable costs.

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[105] Grossman, Helpman, and Szeidl (2006).

$$\pi_{B,AB} = \frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{C(w,w)} - f - g \qquad (2.IV)$$

Firms choosing this strategy supply to B by producing intermediate and final goods there. To satisfy demand in A, these firms produce intermediate goods in B, ship them to A at zero transport costs, produce final goods in A, and sell them there. In this case, international trade in final goods does not occur. Strategy B,AB is associated with fixed costs of f and g. Hence, these firms save high per-unit variable costs, including trade costs. Because of the higher fixed costs associated with this strategy, B,AB only is reasonable for highly productive firms, that face a high demand.

Table 2.2 is a summary of the described profit functions.

Table 2.2:

Strategy a,b	**Meaning**	**Marginal costs of serving consumers in A**	**Marginal costs of serving consumers in B**	**Fixed costs $k_{a,b}$**
A,A	Intermediate good production in A; final good production in A	C(1,1)	d_HC(1,1)	0
A,B	Intermediate good production in A; final good production in B	d_HC(1,w)	C(1,w)	f
A,AB	Intermediate good production in A; final good production in A and B	C(1,1)	C(1,w)	f
B,A	Intermediate good production in B; final good production in A	C(w,1)	d_HC(w,1)	g
B,AB	Intermediate good production in B; final good production in A and B	C(w,1)	C(w,w)	f and g

Alternative strategies to B,AB are B,B and AB,AB. Their costs of supplying to B and the fixed costs of these strategies match those of $\pi_{B,AB}$, but the per-unit variable costs for supplying A are higher. In this scenario, with high transport costs, per-unit variable costs are lower with B,AB than with B,B or AB,AB; fixed costs are the same. Therefore, firms will never choose B,B or AB,AB.

Theoretically two further integration strategies, namely AB,A and AB,B, are possible. However, these strategies are never reasonable. A firm will only produce intermediate goods in both A and B (associated with extra fixed costs for intermediate production) if high transport costs for intermediate goods exist. If this is the case, it will only make sense to produce final products in both countries to save on transport costs.[106]

Hence (2.I), (2.II), (2.III) and (2.IV) are the only relevant strategies if transport costs are high.[107]

In this case, a pure problem between fixed costs and per-unit variable costs exists. Transportation of final goods to A is never optimal because of the size of d_H.

This can be seen from $\frac{C(w,1)}{C(w,w)} < d_H$.

The lowest per-unit variable costs to satisfy demand in each market, therefore, can be achieved with local production of final goods. Strategies that are chosen in this setting where final goods are not only produced locally are B,A and A,A. If g is very small, B,A is a possible optimal strategy although high transport costs exist. Also, A,A belongs to the set of optimal strategies. However, both of these strategies are chosen by more unproductive firms because they cannot afford high fixed costs.

A firm produces intermediate goods at only one location because their transportation is free.[108] A firm producing intermediate goods in A also produces final goods there to satisfy demand in A, because transportation of final goods from B is relatively costly. Therefore, it is not attractive for a firm.

This can be considered by $\frac{C(1,1)}{C(1,w)} < d_H$.

A firm producing intermediate goods in B has two possibilities. Either it only produces final goods in A, or it ships some of them to A to serve its demand and the intermediate goods for B stay in B so that final goods for every market are produced

[106] All seven possible strategies with transport costs for final goods are shown in IV in Appendix 2.4, where the size of transport costs is the determinant of the set of optimal strategies.

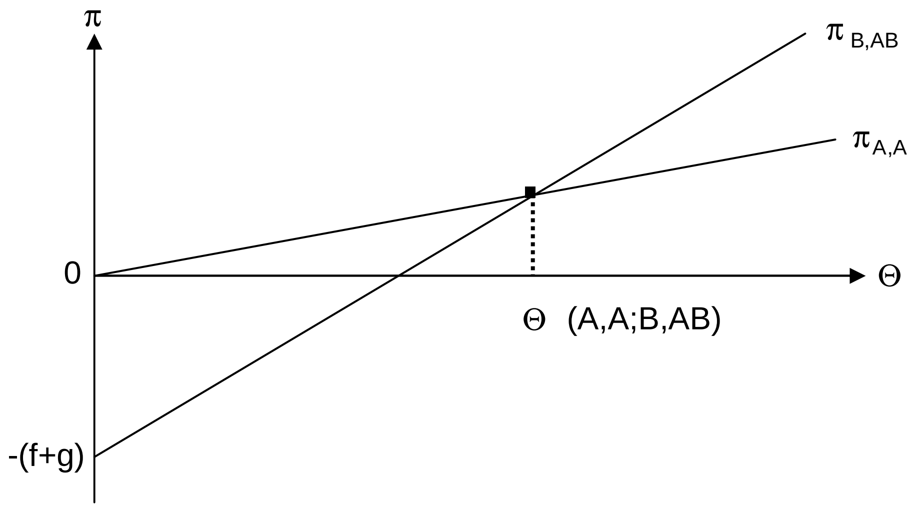
[107] If, and only if, high transport costs exist this set of optimal integration strategies is chosen. This can be seen in derivation V in Appendix 2.4.

[108] As in Grossman, Helpman, and Szeidl (2006).

locally. The optimal strategy for a firm depends on its productivity and fixed costs. Therefore, following integration strategies are possibly relevant: A,A; A,AB; B,A; B,AB.

Graphic 2.2 shows $\pi_{A,A}$ and $\pi_{B,AB}$ depending on productivity Θ.

<u>Graphic 2.2:</u>[109]



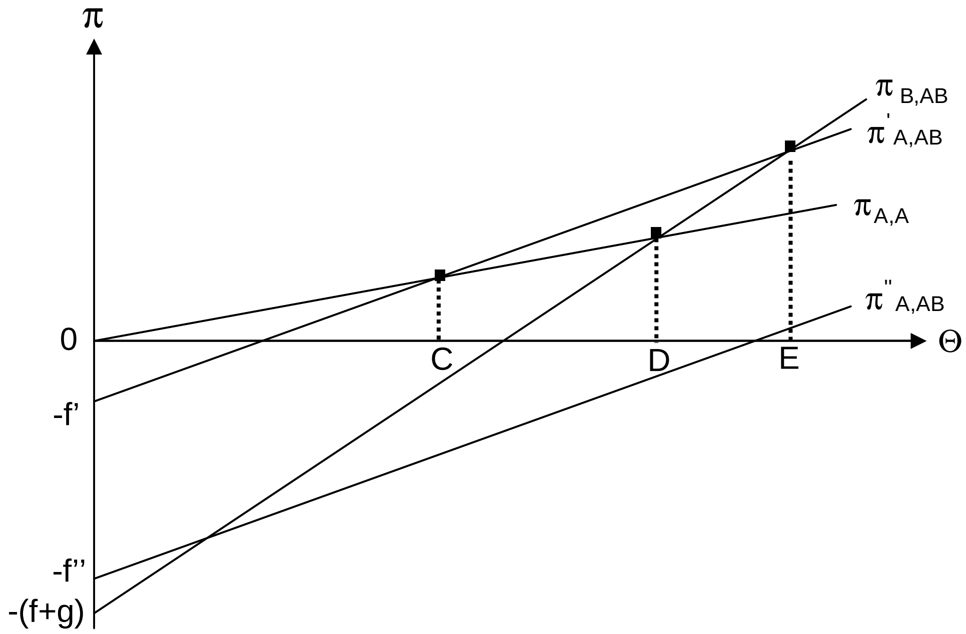
Firms will always choose the integration strategy with the highest attainable positive profit at a given level of Θ. $\pi_{B,AB}$ is associated with fixed costs f and g, while $\pi_{A,A}$ is associated with zero fixed costs. However, the variable production costs under A,A are higher than those under B,AB. Therefore, $\pi_{A,A}$ is higher than $\pi_{B,AB}$ if productivity is lower than a critical level Θ(A,A; B,AB) and is lower than $\pi_{B,AB}$ at $\Theta > \Theta$(A,A; B,AB). $\pi_{A,A}$ and $\pi_{B,AB}$ intercept at Θ(A,A; B,AB).

The profit function $\pi_{A,AB}$ now can be added to this analysis. $\pi_{A,AB}$ is associated with fixed costs f. The variable production costs under A,AB are higher than those under B,AB and lower than those under A,A. Graphic 2.3 shows alternative possibilities for this strategy. Therefore, $\pi_{A,A}$ is higher than $\pi'_{A,AB}$ if productivity is lower than a critical level C and is lower than $\pi'_{A,AB}$ at Θ>C. $\pi_{A,A}$ and $\pi'_{A,AB}$ intercept at C. $\pi_{B,AB}$ is lower than $\pi'_{A,AB}$ if productivity is lower than a critical level E, and is higher than $\pi'_{A,AB}$ at Θ>E. $\pi_{B,AB}$ and $\pi'_{A,AB}$ intercept at E. Another possibility for the profit

[109] Own construction on the basis of Grossman, Helpman, and Szeidl (2006).

function corresponding to strategy A,AB is $\pi''_{A,AB}$. In this case, $\pi''_{A,AB}$ is lower than $\pi_{A,A}$ and $\pi_{B,AB}$. Only $\pi_{A,A}$ and $\pi_{B,AB}$ then intercept at D in the graphic.

Graphic 2.3:[110]



C = $\Theta(A,A;A,AB)$; D = $\Theta(A,A;B,AB)$; E = $\Theta(A,AB;B,AB)$

For A,AB to be an optimal strategy, it is necessary that the intersection of $\pi_{A,AB}$ and $\pi_{B,AB}$ lies above the intersection of $\pi_{A,A}$ and $\pi_{B,AB}$, at $\Theta(A,A;B,AB)$, resulting in[111]

$$\frac{g}{f} \geq \frac{\dfrac{\overline{X^A}}{C(w,1)} - \dfrac{\overline{X^A}}{C(1,1)} + \dfrac{\overline{X^B}}{C(w,w)} - \dfrac{\overline{X^B}}{C(1,w)}}{\left(\dfrac{\overline{X^B}}{C(1,w)} - \dfrac{\overline{X^B}}{d_H C(1,1)}\right)} = \gamma_H . \tag{2.7}$$

This condition has to hold so that A,AB is an optimal strategy for a firm. As shown in graphic 2.3, low productivity firms locate all production activities at home; high productivity firms produce intermediate goods only in B and final goods in A and B;

[110] Own construction on the basis of Grossman, Helpman, and Szeidl (2006).
[111] See derivation VI in Appendix 2.4.

and, if $\pi_{A,AB}$ runs like $\pi'_{A,AB}$, firms with intermediate productivity levels produce intermediate goods in A and final goods in A and B.

Just as $\pi_{A,AB}$ can be added to the analysis in graphic 2.2, this is also possible with $\pi_{B,A}$. $\pi_{B,A}$ is associated with fixed costs g. The variable production costs under B,A are higher than those under B,AB and lower than those under A,A.

For B,A to become an optimal strategy, it is necessary that the intersection of $\pi_{B,A}$ and $\pi_{B,AB}$ lies above the intersection of $\pi_{A,A}$ and $\pi_{B,AB}$. Using the same approach as in the previous analysis for $\pi_{A,AB}$, the following condition must hold for B,A to become an optimal strategy:[112]

$$\frac{g}{f} \leq \frac{\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}}{\frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{d_H C(w,1)}} = \gamma_L \tag{2.8}$$

If (2.8) holds, firms with low productivity levels locate all production activities at home, highly productive firms produce intermediate goods in B and final goods in A and B, and firms with intermediate levels of productivity manufacture intermediate goods in B and final goods in A.

From (2.7) and (2.8), it can be seen that, if $\gamma_L < \frac{g}{f} < \gamma_H$ is true, only two optimal strategies exist: Either all firms only produce in A, or intermediate goods are produced in B and final goods are produced in both locations. The assumption that the elasticity of substitution between intermediate and final goods production is not greater than 1 ensures that $\gamma_L < \gamma_H$ holds.[113]

For $\pi_{A,AB}$ or $\pi_{B,A}$ to be a dominate integration strategy, either $\frac{g}{f} \leq \gamma_L$ or $\frac{g}{f} \geq \gamma_H$ must hold true. Because this is not possible at the same time, only one of the strategies, B,A or A,AB, can be optimal, depending on the size of the fixed costs relation. In graphic 2.3 $\pi'_{A,AB}$ is a possible optimal strategy for a firm, depending on its

112 See derivation VII in Appendix 2.4.

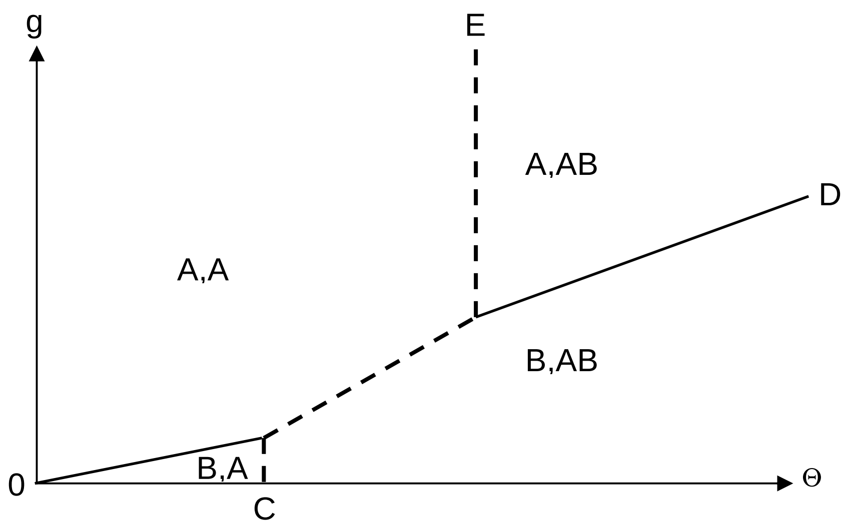
113 $\gamma_L < \gamma_H$ is considered if, and only if, $\frac{1}{C(w,w)} + \frac{1}{d_H C(1,1)} \succ \frac{1}{d_H C(w,1)} + \frac{1}{C(1,w)}$.

productivity. This means that $\frac{g}{f} \geq \gamma_H$ must be true. Then, the fixed costs for a final goods producing plant in B are relatively lower than the fixed costs for an intermediate goods producing plant there.

In case B,A, not A,AB, is optimal, $\frac{g}{f} \leq \gamma_L$ holds. This means that the fixed costs for a final goods producing plant in B are relatively higher than the fixed costs for an intermediate goods producing plant in B. Accordingly, whether A,AB or B,A is optimal depends on the fixed costs.[114]

For this reason, another graphical description (graphic 2.4) shows all areas of optimal strategies in one diagram.

Graphic 2.4:[115]



$C = \Theta(B,A;B,AB)$; $D = \Theta(A,AB;B,AB)$; $E = \Theta(A,A;A,AB)$

Graphic 2.4 shows combinations of fixed costs g for intermediate goods and Θ that generate different strategies of integration. In this connection, the level of fixed costs for final goods f is held constant. If f changes, the bold, broken lines will change.[116]

In the section A,A, all activities of a firm are located in A; in section B,A, intermediate goods are produced in B and final goods in A. Section A,AB shows firms that

[114] As in Grossman, Helpman, and Szeidl (2006).
[115] Own construction on the basis of Grossman, Helpman, and Szeidl (2006).
[116] As in Grossman, Helpman, and Szeidl (2006).

manufacture intermediate goods in A and final goods in A and B. Finally, if the productivity of a firm lies in region B,AB, intermediate goods producing activities are shifted to B; and final goods are produced in both countries.[117]

Hence, if, depending on the productivity level of a firm, strategies A,A; A,AB or B,AB are reasonable, fixed costs g are high relative to the given value of f. If, depending on the productivity level of a firm, strategies A,A; B,A or B,AB are reasonable, fixed costs g are small relative to the given value of f. If, depending on the productivity level of a firm, strategies A,A or B,AB are only reasonable, the fixed costs relation between g and f is medium high.

The five graphical analogues to the analytical cut-off levels separating the optimal integration strategies in graphic 2.4 result from the following:

The cut-offs are calculated by equating the profits of one strategy with those of another strategy and solving for Θ. Four different possibly optimal π exist: $\pi_{A,A}$, $\pi_{A,AB}$, $\pi_{B,A}$, and $\pi_{B,AB}$; and five different cut-off levels arise. The sixth theoretically possible comparison is $\pi_{A,AB}$ with $\pi_{B,A}$. However, as already discussed, these two strategies cannot be equated because they are never optimal at the same time if only firm productivities differ because they arise when different fixed costs relations exist.

Hence, the different cut-off levels are given by[118]

$$\Theta(A,A;A,AB) = \frac{f}{\overline{X^B}\left[\frac{1}{C(1,w)} - \frac{1}{d_H C(1,1)}\right]}. \tag{2.a}$$

This cut-off level between sections A,A and A,AB is independent of g. For this reason, it is represented by a vertical line in graphic 2.4.

From graphic 2.3 it is known that A,AB is the optimal strategy for firms with intermediate levels of productivity, if $\frac{g}{f} \geq \gamma_H$ holds. If Θ is smaller than Θ (A,A;A,AB), A,A is optimal. If Θ is greater, then A,AB is the optimal strategy. Firms with the exact productivity of Θ (A,A;A,AB) are just indifferent between the production of all goods at home and the production of intermediate goods in A and of final goods in A and B because their profits are the same in both cases.

[117] As in Grossman, Helpman, and Szeidl (2006).
[118] See derivation VIII in Appendix 2.4.

$$\Theta(A,A;B,A)=\frac{g}{\overline{X^A}\left[\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right]+\overline{X^B}\left[\frac{1}{d_H C(w,1)}-\frac{1}{d_H C(1,1)}\right]} \tag{2.b}$$

This cut-off level between sections A,A and B,A depends on g and is represented by a line through the origin. At levels of Θ that exceed Θ(A,A;B,A), B,A is optimal; for lower levels, A,A is the optimal strategy.

$$\Theta(A,A;B,AB)=\frac{f+g}{\overline{X^A}\left[\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right]+\overline{X^B}\left[\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right]} \tag{2.c}$$

This cut-off level between sections A,A and B,AB depends on g and starts from a negative intercept. Because of the per-unit variable costs, it is steeper than Θ(A,A;B,A). At levels of Θ that exceed Θ(A,A;B,AB), B,AB is optimal; for lower levels, A,A is optimal.

$$\Theta(A,AB;B,AB)=\frac{g}{\overline{X^A}\left[\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right]+\overline{X^B}\left[\frac{1}{C(w,w)}-\frac{1}{C(1,w)}\right]} \tag{2.d}$$

This cut-off level between sections A,AB and B,AB again depends on g and is represented by a line through the origin. Because of the per-unit variable costs, it is steeper than Θ(A,A;B,A). At levels of Θ that exceed Θ(A,AB;B,AB), B,AB is optimal; for lower levels, A,AB is the better strategy for a firm. The higher fixed costs g are, the higher firm productivity must be for intermediate goods production in B to be profitable.

$$\Theta(B,A;B,AB)=\frac{f}{\overline{X^B}\left[\frac{1}{C(w,w)}-\frac{1}{d_H C(w,1)}\right]} \tag{2.e}$$

This cut-off level between sections B,A and B,AB is independent of g. For this reason, it is represented by a vertical line in graphic 2.4. If the level of Θ is lower than Θ(B,A;B,AB), then B,A is optimal. If the level of Θ exceeds Θ(B,A;B,AB), then B,AB is the optimal strategy for a firm.

Because of the high transport costs, firms choose this strategy (B,AB) to produce final goods locally. Hence, in final goods production, these are horizontal firms.[119] These highly productive firms shift most production activities to B, where per-unit costs are lower, to generate the highest possible reduction of variable per-unit

[119] As in Markusen and Venables (1998).

costs.[120] Due to high transport costs, final goods for the market in A are produced in A to maximize firm profits. The fraction of firms choosing this strategy depends on the productivity of the firms. It increases if g falls and then becomes independent of g.
MNE activities for final goods production only arise to the right of the bold, broken line in graphic 2.4. The smaller g, the greater this fraction of firms will be.
If g is very high, the fraction of firms producing final goods in A and B is independent of g; whereas the fraction of them choosing strategy A,AB or B,AB depends on the size of g. The fraction of firms choosing strategy B,A increases if g is small and firm productivity is > 0. In the graphical analogue to the cut-off level $\Theta(B,A;B,AB)$ in graphic 2.4, this fraction becomes independent of g.[121]
If firms have an intermediate productivity level Θ, namely that $\Theta(B,A;B,AB) < \Theta < \Theta(A,A;A,AB)$, then the fixed costs for a production plant in B for final goods are only borne if the fixed costs for intermediate goods producing plants g are small. Accordingly, these firms either shift intermediate production activities to B and produce final goods in both countries, due to high transport costs; or they produce intermediate and final goods only in A, if $\gamma_L < \frac{g}{f} < \gamma_H$ holds.[122] For positive values of given fixed costs for intermediate goods g, the most unproductive firms locate all production activities in A and export their final goods to deliver the market in B, whereas transport costs are high.
Consequently, a reduction of fixed costs, as well as a reduction of barriers to trade, or transport costs, is influential in determining optimal integration strategies for firms and encourages their economic outcome.

2.2.6 Analysis with high transport costs, profit taxation and lump-sum transfer

In the following, governments can set profit taxes in the first stage but cannot rescind their offers by assumption. Firms must decide upon their optimal integration strategies, whereas the governments take this into account when setting tax rates. Governments choose tax rates t_i, $i \in \{A,B\}$, to tax firm profits, and pass tax revenue on to the households in their jurisdictions. Therefore, the governments take the utility of the representative household in their jurisdictions into account when selecting optimal tax rates t_i.

[120] As in Grossman, Helpman, and Szeidl (2006).
[121] As in Grossman, Helpman, and Szeidl (2006).
[122] As in Yeaple (2003).

Transport costs reduce firm profits. On the one hand, the set of optimal integration strategies is influenced by these transport costs; on the other hand, transport costs also influence the run of the graphical analogues to the cut off levels shown in graphic 2.4. Profit taxes influence the run of these graphical analogues, which indicate the profitability of alternative modes of firm integration. Strategies producing final goods in A, as well as in B, only become optimal because of d. This argument of local production is independent of taxes.

2.2.6.1 The problem of the governments

In this chapter, the cases analyzed are those, in which the governments of both countries, A and B, can levy taxes t_A and t_B, which are taken into account in the profit functions of the firms. In this setting, taxes are paid on firm profits either in A or in B. The location of tax payment depends on the location of final goods production of a firm. Intermediate goods production is not taxed. Therefore, in this setting, double taxation is not the problem of the analysis.[123]

Furthermore, by assumption, households do not know the underlying tax basis for provision of the lump-sum transfer so that the composition of consumption of differentiated goods is not distorted. Additionally, by assumption, the highest possible productivity level $\Theta_{max}=1$ always is part of the integration strategy, with most of its total production in B. We assume a uniform distribution function of firms over productivity levels in this analysis.

The price for the homogeneous product is $p_0=1$, and prices for differentiated products are shown by $p_i(j)$, where p is the price for variety j in country i, $i \in \{A;B\}$.

As already shown in section 2.2.2, the utility of a representative household in country i, $i \in \{A;B\}$, is given by:

$$U_i = x_0 + X \tag{2.1}$$

where $$X = \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{\alpha}dj\right] \qquad 0<\alpha<1,\ 0<\mu<1 \text{ and } \mu<\alpha \tag{2.2}$$

This can also be shown by:[124]

$$V_i = m_i + (1-\alpha)\cdot\mu^{1/(\alpha-1)}\int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)}dj \tag{2.9}$$

[123] As in Egger et al. (2006a).
[124] See derivation IX in Appendix 2.4.

The utility of a representative household increases in m_i and declines in $p_i(j)$.

For a government to decide to pass on a lump-sum transfer to the households in its jurisdiction and, therefore, select $t_i>0$, the utility of the representative household with lump-sum transfer may not be smaller than the previously shown utility in 2.9 (i.e., $V' \geq V$). However, tax revenue of a government depends on the strategies chosen by the firms. For this reason, we must first look at the profit functions of the firms, depending on tax rates, to set up the corresponding utility function with lump-sum transfer.

To show welfare implications, optimal integration strategies with taxation are examined in the following sub-section.

2.2.6.2 Integration strategies with profit taxation

Assume now that optimal integration strategies depend on t_i as well, where $i \in \{A, B\}$. The set of optimal integration strategies stays the same as the one without taxation. However, the corresponding profit functions now also depend on t_i. The profit functions depend on firm productivity, market sizes, per-unit variable costs, fixed costs, transport costs, and the degrees of taxation:

$$\pi_{A,A} = \frac{\overline{X^A}\Theta}{C(1,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{d_H C(1,1)}(1-t_A) \qquad (2.I')$$

If a firm chooses strategy A,A, all its taxes on profits are paid in A because all final goods are produced there. t_A reduces profits of a firm. The degree of the reduction depends on the tax rate selected by A. The higher the degree of taxation, the flatter the slope of $\pi_{A,A}$.

Another profit function is:

$$\pi_{A,AB} = \frac{\overline{X^A}\Theta}{C(1,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{C(1,w)}(1-t_B) - f(1-\delta t_B) \qquad (2.II'')$$

If a firm chooses strategy A,AB, taxes on profits are paid in A and in B because final goods are produced in both locations to supply the local markets of final production. t_i also reduces firm profits; the degree of this reduction depends on the tax rate chosen by both governments. Furthermore, fixed costs f are incurred in B. In this case, δ affects the depreciation possibilities on the part of t_B, referring to the fixed costs f. In further analysis, depreciation is analyzed either with $\delta=1$ or $\delta=0$ so that either taxation referring to the fixed costs is depreciated totally or not at all.

This results in,

$$\pi_{A,AB} = \frac{\overline{X^A}\Theta}{C(1,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{C(1,w)}(1-t_B) - f(1-t_B)$$

or

$$\pi_{A,AB} = \frac{\overline{X^A}\Theta}{C(1,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{C(1,w)}(1-t_B) - f\ .$$

In a graphical description, such as graphic 2.3, $\pi_{A,AB}$ is flatter. If depreciation is possible, the intercept is less negative than in the analysis without taxation.

A further profit function is:

$$\pi_{B,A} = \frac{\overline{X^A}\Theta}{C(w,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{d_H C(w,1)}(1-t_A) - g \qquad (2.\text{III}')$$

Again, if a firm chooses strategy B,A, all its taxes on profits are paid in A because all final goods are produced there. t_A again reduces firm profits. The degree of this reduction depends on the tax rate chosen by A. The higher the degree of taxation, the flatter the slope of $\pi_{B,A}$. Furthermore, g are fixed costs abroad. They are not considered if a firm is taxed in A, and depreciation possibilities do not occur because t_B is irrelevant.

A further profit function is:

$$\pi_{B,AB} = \frac{\overline{X^A}\Theta}{C(w,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{C(w,w)}(1-t_B) - g - f(1-\delta t_B) \qquad (2.\text{IV}')$$

If a firm chooses strategy B,AB, taxes on profits are paid in A and B because final goods are produced in both locations to supply the local final production markets. t_i also reduces firm profits. The degree of this reduction depends on the tax rate chosen by both governments. Furthermore, fixed costs f and g are incurred in B with strategy B,AB. In this case, δ affects the depreciation possibilities on the part of t_B, referring to the fixed costs f, which are associated with production plants for final goods in B. In further analysis, depreciation is analyzed either with $\delta=1$ or $\delta=0$ so that either taxation referring to fixed costs f is depreciated totally or not at all.

This results in,

$$\pi_{B,AB} = \frac{\overline{X^A}\Theta}{C(w,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{C(w,w)}(1-t_B) - g - f(1-t_B)$$

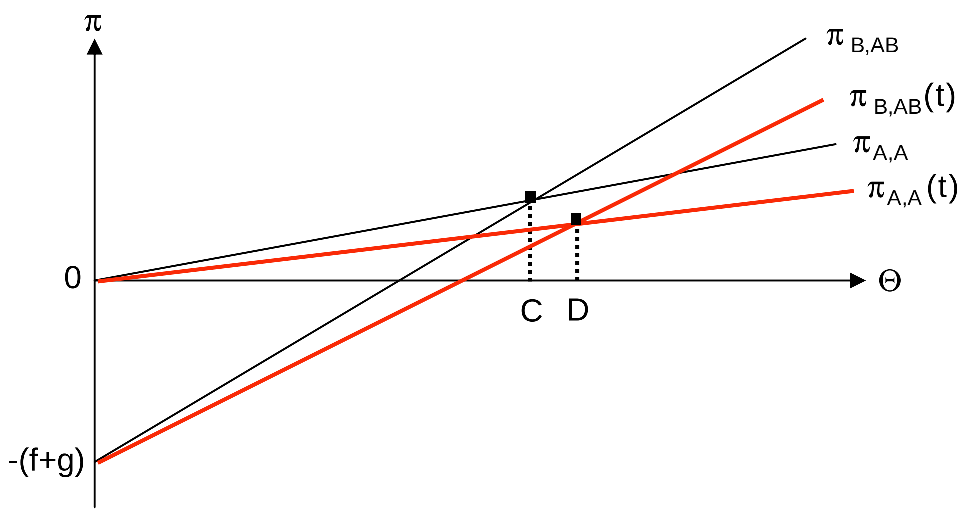
or

$$\pi_{B,AB} = \frac{\overline{X^A}\Theta}{C(w,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{C(w,w)}(1-t_B) - (f+g).$$

In a graphical description, such as graphic 2.2, $\pi_{B,AB}$ is flatter. If depreciation is possible, the intercept is less negative than in the analysis without taxation.

From the formal description of the profit functions, it can be seen that they are all flatter than in the previous analysis with high transport costs. Therefore, if profit functions additionally depend on taxation, graphic 2.2 is changed in the following way if $\delta=0$ (graphic 2.5):

Graphic 2.5:

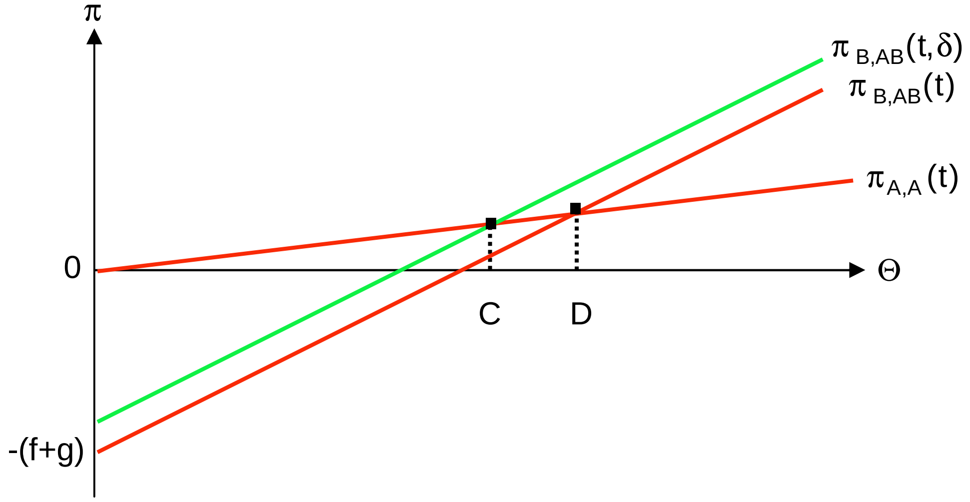


C= $\Theta(A,A;B,AB)$ without taxation

D= $\Theta(A,A;B,AB)$ with taxation

If depreciation is possible instead, the intercept of profit functions $\pi_{B,AB}$ and $\pi_{A,AB}$ is less negative than before. Therefore, if profit functions depend on taxation and additionally on depreciation with δ=1, the profit functions with taxation in graphic 2.5 are changed in the following way (graphic 2.6):

Graphic 2.6:

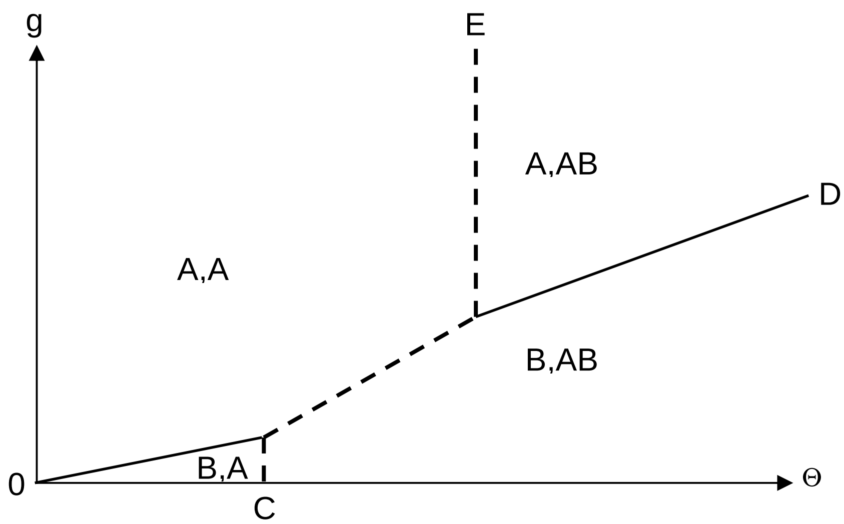


C= $\Theta(A, A; B, AB)$ with taxation and $\delta = 1$

D= $\Theta(A, A; B, AB)$ with taxation and $\delta = 0$

In graphic 2.4 in section 2.2.5, with high transport costs and without taxation, the cut-off levels between two strategies are shown. For this graphical analysis (graphic 2.7) δ=0 is assumed and the level of fixed costs for final goods f is held constant.[125]

Graphic 2.7:



C = $\Theta(B, A; B, AB)$; D = $\Theta(A, AB; B, AB)$; E = $\Theta(A, A; A, AB)$

[125] See derivation X in Appendix 2.4.

Compared to graphic 2.4, the graphical analogues to the cut-off levels with $\delta=1$ cannot be shown because the fixed costs f are held constant but $\delta=1$ influences the size of f.

The following explains the change of the graphical analogues to the cut-off levels as shown in graphic 2.7 with $\delta=0$ and with taxation in comparison to graphic 2.4:

$$\Theta(A,A;A,AB)=\frac{f(1-\delta t_B)}{\overline{X^B}\left[\frac{1}{C(1,w)}(1-t_B)-\frac{1}{d_H C(1,1)}(1-t_A)\right]} \tag{2.a´}$$

$\Theta(A,A;A,AB)$ is independent of g. For this reason, it is represented by a vertical line in the graphical analysis.

In comparison to the analysis without taxation in graphic 2.4, the line representing this cut-off level shifts inward the higher the tax rate selected by the government in A is; and the higher the tax rate selected by the government in B is, the more the line representing this cut-off level shifts back outward.

$$\Theta(A,A;B,A)=\frac{g}{\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{d_H C(w,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right](1-t_A)} \tag{2.b´}$$

In comparison to the analysis without taxation in graphic 2.4, the line representing this cut-off level is flatter the higher the tax rate selected by the government in A is.

$$\Theta(A,A;B,AB)=\frac{g+f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)(1-t_A)+\frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]} \tag{2.c´}$$

In comparison to the analysis without taxation in graphic 2.4, the line representing this cut-off level is flatter the higher the tax rates selected by the governments in A and B are.

$$\Theta(A,AB;B,AB)=\frac{g}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}\right)(1-t_A)+\left(\frac{\overline{X^B}}{C(w,w)}-\frac{\overline{X^B}}{C(1,w)}\right)(1-t_B)\right]} \tag{2.d´}$$

Because of the per-unit variable costs, this cut-off level is steeper than Θ(A,A;B,A). In comparison to the analysis without taxation in graphic 2.4, the line representing this cut-off level is flatter the higher the tax rates selected by the governments in A and B are.

$$\Theta(B,A;B,AB) = \frac{f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^B}}{d_H C(w,1)}\right)(1-t_A) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]} \qquad (2.e')$$

$\Theta(B,A;B,AB)$ is independent of g. For this reason, it is represented by a vertical line in the graphical analysis.

In comparison to the analysis without taxation in graphic 2.4, the line representing this cut-off level shifts inward the higher the tax rates selected by the governments in A and B are.

By combining all five graphical analogues to the aforementioned cut-off levels, the representation of optimal firm integration strategies as shown in graphic 2.7 is obtained.

However, the following question must be answered:

Which tax rates are selected by governments in A and B if they can anticipate the reaction of firms and if social welfare in their jurisdictions cannot decline because of their decisions to tax profits?

2.2.6.3 Optimal tax policy

Government decisions depend on the exogenous variables, such as transport costs, market size, per-unit variable costs, fixed costs, and firm productivities (which result in a set of optimal integration strategies), and the firm reactions according to the tax rates chosen.

First, it must be considered that prices of a single firm do not change in response to taxes. These are only influenced by transport costs. For this reason, it is clear that[126]

$$p_A(j)_{opt} = \frac{1}{\alpha}\left(\frac{dC_A}{\Theta}\right)^{(\alpha-1)/-\alpha} \text{ and } p_B(j)_{opt} = \frac{1}{\alpha}\left(\frac{dC_B}{\Theta}\right)^{(\alpha-1)/-\alpha}.$$

Transport costs are passed on to households; taxes must be paid by the firms. Consequently, prices in A and B only differ if transport costs exist.

For this reason, firm profits do not change because of a change in prices in this analysis. Firm profits, including taxation, only change if levied taxes influence firms to select other strategies as optimal. If this is true, the tax revenue of the governments

[126] See derivation XI in Appendix 2.4.

also changes. Because optimal integration strategies depend on d, tax revenue depends on it, too. Furthermore, taxes on profits are levied at the location of final goods production. If a strategy of final goods production in A and B is reasonable, not all profits of a firm are taxed by a single government. However, governments maximize the utility of the representative household in their jurisdictions.
Hence, household utility with lump-sum transfer in general is given by:[127]

$$V'_i = m_i + t_i \frac{\int_0^{\Theta_{max}} \pi_i(j)dj}{M^i} + (1-\alpha)\mu^{1/(\alpha-1)} \int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)} dj \qquad (2.10)$$

Thus, V'_i is influenced by the size of α, μ, M^i, m_i, the cut-off levels, and t_i on profits. The government choice of t_i, therefore, influences the location of cut-off levels. For this reason, $\int_0^{\Theta_{max}} \pi_i(j)dj$ and $\int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)} dj$ are influenced by profit taxation.

The following aspects are considered by governments when setting optimal tax rates:

1. In general, a lump-sum transfer is additional income for households in that country.
2. Prices in the differentiated sector depend on the chosen strategies of firms, and the mass of firms selecting an integration strategy depends on t_i. An impact on utility of all households arises if firms select other strategies from the set of optimal integration strategies as optimal because of taxation. Therefore, if firms in the differentiated sector select strategies other than those in the analysis without taxes, their single prices and, therefore, their outputs are influenced. This also influences the outputs of those firms that do not select other strategies.
3. If firms in the differentiated sector select strategies other than those in the analysis without taxes, this does not lower the working income of the households in the original production location because they can work in the homogeneous sector.
4. The degree of taxation does not influence the mass of firms entering the market because of profit taxation. Firms that decide to enter the market at least make zero profits; this is not changed if governments tax firm profits in the described way.

[127] See derivation XII in Appendix 2.4.

5. When selecting t_I>0, the tax rate selected by one government depends on the tax rate of the other.

Only if the positive impacts of taxation outweigh the negative ones will a government selects t_i>0.

This results in different optimal tax rates, depending on the Country A or B maximizing the representative household utility in its jurisdiction.

Considering Country A, all firms in the differentiated sector are headquartered in A and, by assumption, also belong to households in A. For this reason, profit taxation in A with a lump-sum transfer to the households there does not induce higher income for them. Furthermore, if taxation in A is introduced, firms with productivity near a cut-off level may no longer find it reasonable, for example, to select B,AB but A,A instead because the fixed costs of B,AB now are too high. The final goods from these firms, then, are more expensive for households in A and B than they are without taxation. This impact on prices the taxation of the government in A imposes always is negative for households in A if d is high. How many firms increase their prices in A depends on the distribution of firms over Θ. Higher prices reduce the output of these firms because demand for their differentiated goods declines. Hence, the output of cheaper products from other firms in the differentiated sector increases due to demand. This weakens the negative impact of the higher prices.

Therefore, profit taxation to finance a lump-sum transfer in A does not have a positive impact on utility of the representative household in A. For this reason, the optimal tax rate selected by the government in A is zero. This decision is independent of the tax rate selected by the government in B.

Considering Country B:

If the government in B levies profit taxes, and t_A=0 is selected, more firms produce in A than do so without taxation if depreciation of taxation on the fixed costs is not introduced, too. How many firms select different strategies from the set of optimal integration strategies as optimal because of the taxation depends on the distribution of firms over Θ. This has a negative impact on households in B because prices for the goods of these firms increase there. However, because of taxation, the demand for the varieties from these firms declines; and the output of firms with lower prices increases so that this negative impact is weakened, depending on the degree of α.

Furthermore, households in B achieve additional income because of the lump-sum transfer. This, in turn, obviously lowers the income of households in A; and the government in A can do nothing about it. For $t_B>0$ to be selected by the government, positive impacts of taxation in B (e.g., the lump-sum transfer) must outweigh negative ones (i.e., higher prices for goods from firms selecting other integration strategies). Depending on the exact parameter configurations, either depreciation of taxation on the fixed costs $(\delta = 1)$ or no depreciation $(\delta = 0)$ may be the more reasonable strategy for the government in B. For this reason, both possibilities must be examined.

The optimal tax rate from the perspective of this government is $\frac{\partial V'_B}{\partial t_B} = 0$.

This is shown in the case of a medium high fixed costs relation.

In other words, if $\gamma_{L2} < \frac{g}{f} < \gamma_{H2}$ holds true, only strategies A,A or B,AB are optimal. Because taxation is introduced into the model, the range of parameters for those a medium high fixed costs relation holds true in this part of the analysis with taxation, has changed in comparison to the analysis without taxation.

Now, only if the fixed costs relation is given by[128]

$$\gamma_{L2} = \frac{\left[\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right]}{\left[\frac{\overline{X^B}}{C(w,w)}(1-t_B) - \frac{\overline{X^B}}{d_H C(w,1)}\right]}(1-\delta t_B) < \frac{g}{f} \tag{2.11}$$

and

$$\frac{g}{f} < \frac{\left[\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{C(w,w)}(1-t_B) - \frac{\overline{X^B}}{C(1,w)}(1-t_B)\right]}{\left(\frac{\overline{X^B}}{C(1,w)}(1-t_B) - \frac{\overline{X^B}}{d_H C(1,1)}\right)}(1-\delta t_B) = \gamma_{H2} \tag{2.12}$$

Are A,A and B,AB the only optimal strategies in this setting.

The representative household utility with lump-sum transfer in B then is given by:

[128] See derivations XIII and XIV in Appendix 2.4.

$$V'_B = m_B + \frac{t_B}{M^B}\left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}} \pi_B(j)dj\right] \tag{2.10'}$$

$$+(1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(A,A;B,AB)} p_B(j)^{\alpha/(\alpha-1)}dj + \int_{\Theta(A,A;B,AB)}^{\Theta_{max}} p_B(j)^{\alpha/(\alpha-1)}dj\right]$$

Given this situation the government in B selects the following tax rates as optimal:

<u>(a) Without depreciation</u> $(\delta = 0)$:[129]

First, tax revenue in B in this setting must be examined:

$$t_B\left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}} \pi_B(j)dj\right], \text{ whereas } \pi_B = \left[\frac{\overline{X^B}\Theta}{C(w,w)}\right]$$

This results in a per capita lump-sum transfer of:

$$\frac{t_B}{M^B}\left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}} \frac{\overline{X^B}\Theta}{C(w,w)}dj\right] \tag{2.13}$$

Solving the utility function of the representative household for $\frac{\partial V'_B}{\partial t_B} = 0$, the following condition is achieved:

$$t_B{}^3 - 3\left[\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)} + \frac{\overline{X^B}}{C(w,w)}\right]\cdot\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-1} t_B{}^2 \tag{2.14}$$

$$-\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-2} 2\left(\frac{3}{2}(g+f)^2 - 2\left[\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)} + \frac{\overline{X^B}}{C(w,w)}\right]^2\right)\cdot t_B$$

$$-\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-3}\left[\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)} + \frac{\overline{X^B}}{C(w,w)}\right]^3$$

$$-\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-3}\left(-(g+f)^2\left[\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)} + \frac{\overline{X^B}}{C(w,w)}\right]\right)$$

$$-\left(\frac{1}{M^B}\left(\frac{\overline{X^B}}{C(w,w)}\right)^3\frac{1}{2}\right)^{-1}(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{d_H C(1,1)} - \frac{1}{C(w,w)}\right]\cdot(f+g)^2 = 0$$

[129] See derivation XV in Appendix 2.4.

This can be defined as $t_B^3+a\ t_B^2+b\ t_B+c=0$. Accordingly, three general equations for optimal tax rates can be derived.[130] Inserting the exogenously given parameters, we can determine whether an optimal tax rate with $0<t_B<1$ exists. In solving the equations for t_B not only real but also complex tax rates can occur.

Whether $0< t_B<1$ is reasonable or not depends on the distribution of firms over Θ because the negative impact of t_B on prices of firms with productivity levels near cut-off levels has to be outweighed. Households in B get additional income because of the lump-sum transfer. However, additional income only is spent for the homogeneous goods. If $0<t_B<1$ really is selected by the government in B, this results in maximizing the utility of the representative household in B. At the same time, the income of households in A declines and their utility also is influenced by the negative impact of t_B on prices of differentiated goods.

Because optimal tax rates are difficult to see from general equations, possible numerical solutions are shown for tax rates in B with high transport costs and a medium high fixed costs relation without depreciation possibilities and selection of a uniform distribution of the firms:[131]

(a1) With exogenous parameter configurations given by

$\overline{X^A}=100,\quad \overline{X^B}=50,\quad C(1,1)=6,\quad C(w,1)=4,\quad C(w,w)=2,\quad d_H=5,$

$g=9,\quad f=9,\quad M^B=83,\quad \alpha=0.75,\quad \mu=0.6$, the following tax rates arise:

$$t_{B1}=0.0142255 \tag{2.15}$$

$$t_{B2}=1.89289+1.10711\ i$$

$$t_{B3}=1.89289-1.10711\ i$$

It is obvious that t_{B2} and t_{B3} are complex solutions. Only t_{B1} delivers a real optimal tax rate, and $0<t_{B1}<1$ holds true. In this scenario, a tax rate of 1.4% is selected by the government in B to be optimal.

Prices for differentiated goods from firms now selecting strategy A,A instead of B,AB without taxation obviously increase. Therefore, their output declines. Due to α, differentiated products are better substitutes for one another in this case than those following in (a2). Therefore, the output of firms supplying the market with lower prices increases; and the negative impact of higher prices for goods supplied by the firms

[130] See derivation XVI in Appendix 2.4.
[131] See derivation XVII in Appendix 2.4.

selecting A,A instead of B,AB previously may be weakened. Additionally, the representative household in B obtains a lump-sum transfer from the achieved tax revenue.

(a2) With exogenous parameter configurations given by

$\overline{X^A} = 100, \quad \overline{X^B} = 50, \quad C(1,1) = 6, \quad C(w,1) = 4, \quad C(w,w) = 2, \quad d_H = 5,$

$g = 9, \quad f = 9, \quad M^B = 131, \quad \alpha = 0.7, \quad \mu = 0.65$, the following tax rates arise:

t_{B4}=-0.0031552 (2.16)

t_{B5}=1.90158 + 1.12186 i

t_{B6}=1.90158 – 1.12186 i

It is obvious that t_{B5} and t_{B6} again are complex solutions. Only t_{B4} delivers a real optimal tax rate, but 0<t_{B1}<1 does not hold true. With this parameter configuration without depreciation possibilities, a tax rate of zero is selected by the government in B to be optimal because the negative impact of taxation on prices cannot be outweighed.

For this reason, it may also be reasonable to allow depreciation on the part of taxation, referring to the fixed costs for final goods occurring in B, from the perspective of the government in B.

<u>(b) With depreciation</u> $(\delta = 1)$:[132]

First, tax revenue in B in this setting must be examined:

$t_B \left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}} \pi_B(j)\,dj \right]$, where $\pi_B = \left[\frac{\overline{X^B}\Theta}{C(w,w)} - f \right]$

This delivers a per capita lump-sum transfer of:

$$\frac{t_B}{M^B} \left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}} \left(\frac{\overline{X^B}\Theta}{C(w,w)} - f \right) dj \right] \tag{2.17}$$

Solving for $\frac{\partial V'_B}{\partial t_B} = 0$, a condition t_B^3+a t_B^2+b t_B+c=0 can be achieved. Again, three general equations for optimal tax rates can be derived in which not only real but also complex tax rates can occur.[133] Inserting the exogenously given parameters, we can determine whether an optimal tax rate with 0<t_B<1 exists.

[132] See derivation XVIII in Appendix 2.4.
[133] See derivation XIX in Appendix 2.4.

In this case, if 0< t_B<1 is selected by the government in B, more firms can select B,AB than without taxation and depreciation possibilities, depending on the distribution of firms over Θ. This implies that more varieties of differentiated goods are purchasable for lower prices. If the government in B selects 0<t_B<1 with depreciation possibilities, the additional utility of the representative household in B must be high enough that the representative household utility in B increases in comparison to the analysis without taxation. The total impact of introducing depreciation possibilities, therefore, obviously depends on the mass of firms selecting B,AB instead of A,A.

Furthermore, if the government in B selects 0<t_B<1 with depreciation possibilities, this also influences the utility of the representative household in A. On the one hand, profits of firms owned by households in A but producing final goods in B decline because of taxation in B. On the other hand, because of the depreciation possibilities, prices for final goods of firms with productivity near the cut-off levels for the representative household in A decline, too. The government in A still selects an optimal tax rate of t_A=0 because it cannot positively influence the impact of t_B on the utility of the representative household in A by profit taxing policies in A.

Again, optimal tax rates are difficult to see from general equations. Therefore, possible numerical solutions are shown for tax rates in B with high transport costs and a medium high fixed costs relation with depreciation possibilities and selection of a uniform distribution of the firms:[134]

(b1) With exogenous parameter configurations given by

$\overline{X^A} = 100, \quad \overline{X^B} = 50, \quad C(1,1) = 6, \quad C(w,1) = 4, \quad C(w,w) = 2, \quad d_H = 5,$

$g = 9, \quad f = 9, \quad M^B = 83, \quad \alpha = 0.75, \quad \mu = 0.6$, the following tax rates arise:

t_{B7}=0.48007 (2.18)

t_{B8}=0.245466 + 2.18785 i

t_{B9}=0.245466 – 2.18785 i

These are the corresponding tax rates to scenario (a1) without depreciation possibilities. It is obvious that t_{B8} and t_{B9} are complex solutions. Only t_{B7} delivers a real optimal tax rate and 0<t_{B1}<1 holds true. In this scenario, a tax rate of 48% is selected by the government in B to be optimal, where without depreciation possibilities 1.4% is selected. Inserting 48% in (2.10') with a per capita lump-sum

[134] See derivation XX in Appendix 2.4.

transfer defined by (2.17) and inserting 1.4% in (2.10') with a per capita lump-sum transfer defined by (2.13), the government in B can determine the representative household utility from either taxation strategy. The scenario that results in higher utility, then, is selected by the government in B.

(b2) With exogenous parameter configurations given by

$\overline{X}^A = 100, \quad \overline{X}^B = 50, \quad C(1,1) = 6, \quad C(w,1) = 4, \quad C(w,w) = 2, \quad d_H = 5,$

$g = 9, \quad f = 9, \quad M^B = 131, \quad \alpha = 0.7, \quad \mu = 0.65$, the following tax rates arise:

t_{B10}=0.482567 (2.19)

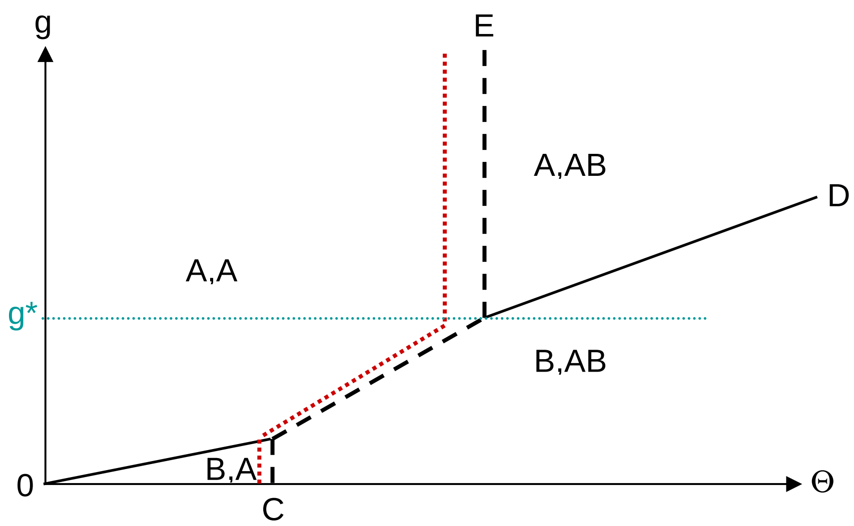
t_{B11}=0.244217 + 2.18981 i

t_{B12}=0.244217 – 2.18981 i

These are the corresponding tax rates to scenario (a2) without depreciation possibilities. It is obvious that t_{B11} and t_{B12} are complex solutions. Only t_{B10} delivers a real optimal tax rate, and $0<t_{B1}<1$ holds true. In this scenario, a tax rate of 48.26% is selected by the government in B to be optimal, where without depreciation possibilities, the government in B does not select taxation as optimal. For this reason, if this parameter configuration holds true, the government in B may select profit taxation with depreciation of taxation on fixed costs, choosing a tax rate of 48.26%.

Graphic 2.8 shows a comparison of the impact of the cases, with and without depreciation possibilities, on the optimal choice of firm strategies.

<u>Graphic 2.8:</u>



C = $\Theta(B,A;B,AB)$; D = $\Theta(A,AB;B,AB)$; E = $\Theta(A,A;A,AB)$

This graphic refers to a constant level of fixed costs for final goods f if taxation without depreciation is selected and to another constant level of f if taxation with depreciation is selected. The only difference between the two graphical descriptions is that the graphical analogues to the cut-off levels differ because of the selected δ. As $\Theta(A,A;B,A)$ and $\Theta(A,AB;B,AB)$ are independent of δ, the slope of their graphical analogues in graphic 2.8 does not change whether depreciation is possible or not. The other cut-off levels depend on f and, therefore, on δ. For this reason, as can be seen from graphic 2.8, if the fixed costs relation is medium high, strategy B,AB already is more reasonable for firms with lower productivity levels with depreciation possibilities than without depreciation of taxation. In scenario (b), f is smaller than in scenario (a), because of the selected δ. If the fixed costs relation is high, strategy A,AB instead of A,A will become reasonable for some firms with lower productivity level because of depreciation possibilities. If the fixed costs relation is low, some firms will select B,AB instead of B,A. The final goods produced by these firms, then, will be cheaper for consumers. Therefore, their utility from differentiated good consumption will increase.

Furthermore, the set of optimal integration strategies referring to a constant level of g may change because of depreciation possibilities. This can be seen from g* in graphic 2.8. In the case of g* in a setting without depreciation possibilities, A,A and B,AB are the optimal strategies, depending on the productivity level of a firm. With depreciation possibilities and a fixed costs level of g*, the optimal choice of a strategy is A,A, A,AB, or B,AB, depending on firm productivity levels. Therefore, the optimal set of integration strategies referring to a given fixed costs relation changes endogenously because of δ. For this reason, (2.11) and (2.12) have been derived previously to ensure that a situation with A,A and B,AB as optimal integration strategies is illustrated in both scenarios (a) and (b) when deriving the optimal profit tax rates.

By inserting the derived tax rates from the equations with and without depreciation possibilities in the respective utility function of the representative household, the government in B decides if depreciation is reasonable or not.

To summarize, if high transport costs exist, firms always supply to consumers in A locally. This cannot be influenced by welfare-optimizing taxation. If in this setting, B levies high taxes on profits, even fewer firms will produce final goods locally for the market in B. This implies much higher prices for differentiated goods supplied from these firms to the market in B. This has a negative impact on the representative household utility in B, which is not in the interest of a benevolent planner in B. This utility loss must be compensated through the lump-sum transfer and higher consumption of cheaper varieties. Therefore, the possibility of compensation depends on the exact value of α. If this is not possible, taxation without depreciation possibilities in B is not reasonable.

If depreciation is possible, positive impacts on the single prices of firms with Θ near cut-off levels can be achieved in B by introducing t_B. Therefore, depending on the exact values of the parameters and the distribution of firms over Θ, taxation with or without depreciation may be a reasonable instrument for a benevolent planner in B.

Furthermore, taxation in B results in a negative impact on the utility of households in A because firm profits are part of their income. Because of possibly lower single prices for differentiated goods in A, t_B in the scenario with depreciation possibilities also may have a positive impact on households in A. Regardless, the government in B does not take the impact of t_B on utility in A into account when selecting t_B; and taxation in A never is optimal if the government in A acts as a benevolent planner in providing a lump-sum transfer.

Furthermore, taxation with lump-sum transfer to the households in this setting does not influence the economic outcome as much as high transport costs do. Taxes, as well as depreciation possibilities, only somewhat influence the run of the cut-off levels between strategies of a given set; whereas the exogenously given, high transport costs restrict the set of optimal integration strategies.

In this analysis, this set of optimal integration strategies from the perspective of both governments and firms cannot be deviated because of the introduction of t_i, due to high transport costs.

2.2.7 Insight of heterogeneity

In our model, depending on exact parameter configurations, the government in B unilaterally can deviate from zero taxation to induce positive impacts on welfare in its jurisdiction. This influence on welfare is characterized by the following implications:

The higher the taxes on profits in B, the fewer final goods firms produce locally for the market in B. This implies much higher prices for differentiated goods supplied from these firms for the market in B. This negative impact on the representative household utility in B must be compensated through the lump-sum transfer and higher consumption of cheaper varieties. However, the possibility of compensation depends on the exact value of α. Therefore, depending on the exact values of the parameters, taxation may be a reasonable instrument for a benevolent planner in B.
However, exact parameter configurations, in particular the value of α, are not the only determinants. The role of firm heterogeneity and its effects on implications of taxation on welfare is especially outstanding. In our analysis, a uniform distribution of firms over Θ is assumed. As derived in section 2.2.6.3 (a) welfare maximization with this distribution function can result in optimal tax rates $t_B>0$ or $t_B=0$, depending on the other parameter configurations. The specification of an alternative distribution function, therefore, may induce differing results (e.g., if a distribution function is assumed where only a marginal mass of firms has a productivity level Θ near a cut-off level). In this scenario, fewer firms will be induced not to produce final goods locally for the market in B than in our analysis with a uniform distribution function when selecting t_B. These goods will be much more expensive for households in B. Concluding profit taxation will still depend on the other parameter configurations, but the negative impact of taxation will be weakened, assuming this distribution function in contrast to our analysis with a uniform distribution function.

Hence, the results in our analysis are mainly constituted from the exact specification of the distribution of firms over productivity and, therefore, due to heterogeneity.

2.3 Conclusion

In this analysis a trade-off between fixed costs and high per-unit variable costs is identified. Firms can choose between different integration strategies. Their headquarters are located in A, and they serve markets in A and B with differentiated products. Every single firm must produce intermediate and final goods for itself, although they can choose A, B, or both places as production locations. As a result, different integration strategies can be identified. Their optimality depends on the relative size of fixed costs for MNE activities, the size of transport costs for final goods, the fraction of demand in each market, per-unit variable costs, the productivity of a single firm, and the degree of profit taxation in both governments, respective to depreciation possibilities.

First, the case with high transport costs is analyzed, excluding taxes and depreciation possibilities. Transport of intermediate goods is free by assumption.
Firms with low productivity select strategies to minimize fixed costs; firms with high productivity minimize per-unit variable costs to supply both markets in consideration of transport costs. With high transport costs for final goods, some firms (depending on their productivity) may find it optimal to produce intermediate goods in one country and final goods in both countries locally.
The impact of high transport costs for final goods on the economic outcomes becomes apparent. The higher transport costs are, the more firms prefer local production. Transport costs affect the per-unit variable costs.

Then, cases in which transport costs stay high but governments levy additional profit taxes on firms in the differentiated sector for final goods production are analyzed. Governments pass tax revenue to the households in their jurisdictions as lump-sum transfers. Firms react, choosing strategies from the optimal set other than the ones used without taxation, although their own productivity levels stay the same. This is due to tax rates being considered in the profit functions of firms. Governments take firm reactions on profit taxation into account. Due to high transport costs, the set of optimal integration strategies stays the same as the set used in the case without taxation.
Governments select profit taxes in ways to maximize the representative household utility in their jurisdictions because they are benevolent planners. Otherwise, optimal tax rates are zero. Levying taxes has several impacts on the utility of households in both countries, influencing both income and the prices paid for differentiated goods.
A government tax rate $0<t_i<1$ is defined endogenously in this model. As profit taxation with a lump-sum transfer in A always induces a utility loss for the representative household in A, that government selects $t_A=0$ as optimal. This is also taken into account by the government in B, reflected in its selection of t_B.
From the perspective of a benevolent planner parameter configurations exist, for those taxation in B is reasonable. In this case, either the representative household

utility is higher due to profit taxation alone or to profit taxation with depreciation possibilities. In the first scenario, the utility of the representative household in B increases because of the lump-sum transfer but declines because of higher prices for differentiated goods from firms that select other strategies than those used without taxation. This negative impact is weakened due to demand and depends on the exact size of α because, if prices on goods from single firms increase, the demand for their products declines. Therefore, demand for other differentiated goods increases. Hence, the output of other firms producing differentiated goods increases as $0<\alpha$. For taxation in B to be set $0<t_B<1$, the positive impact of the additional income must outweigh the weakened but still negative impact of higher prices for some differentiated goods. However, the government in B can also select the second scenario: taxation with depreciation possibilities. Depending on which scenario delivers higher utility for the representative household in B with $0<t_B<1$, the government in B selects the corresponding scenario. In the case with depreciation possibilities, depending on the distribution of firms over productivity, prices for differentiated goods also can decline. This has an additional positive impact on households in A in contrast to the first scenario. Because firms belong to households in A, the lump-sum transfer in B has a negative impact on the representative household utility in A because it is financed at their expense. Although any activity of the government in A will be negative for its households, in this analysis, $t_A=0$ is selected. Furthermore B does not take the utility of the representative household in A into account when selecting t_B and δ. Depending on exact parameter configurations, $0<t_B<1$ can result in even higher utility for all households in both jurisdictions.

Hence, this analysis is an economical explanation of optimal tax policies of governments when integration strategies chosen by firms are endogenous, having comparative advantages on the one hand and elements of the “New Trade Theory”[135] on the other.
Using the derivates for optimal tax rates in this analysis, zero taxation may also be the best choice of governments acting as benevolent planners, depending on exact parameter configurations. In these cases, zero taxation is optimal from the welfare perspective of both governments independently. Therefore, a further result of this

[135] The first approach in this direction was derived by Krugman (1979).

analysis is an explanation of zero taxation as being optimal, independent of a race-to-the-bottom scenario, because of tax competition, as shown in other literature.[136]

[136] Compare to Davies and Eckel (2007).

2.4 Appendix

Derivation I:

$$U_i = x_0 + X \text{ , } i \in \{A,B\}$$

$$X = \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{\alpha} dj\right]$$

$$L = x_0 + \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} (x^i(j)+\beta\varsigma(j))^{\alpha} dj\right] + \lambda\left[m_i - x_0 - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj\right]$$

m=earnings

$$\frac{\partial L}{\partial x_0} = 1-\lambda = 0 \quad \Rightarrow \lambda = 1$$

$$\frac{\partial L}{\partial \lambda} = m_i - x_0 - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj = 0 \quad \Rightarrow x_0 = m_i - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj$$

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} (x^i(j)+\beta\varsigma(j))^{(\alpha-1)}\varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

If $\beta = 0$:

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{(\alpha-1)}\varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

$$\Rightarrow \int_0^{\Theta_{max}}\left[\frac{\alpha}{\mu\alpha^{\alpha}} x^i(j)^{(\alpha-1)} - p_i(j)\right]\varsigma(j)dj = 0$$

$$\Rightarrow \left[\frac{\alpha}{\mu\alpha^{\alpha}} x^i(j)^{(\alpha-1)} - p_i(j)\right] = 0$$

$$\Rightarrow x^i(j) = \alpha[p_i(j)\mu]^{1/(\alpha-1)}$$

This $x^i(j)$ is the demand of one household for the variety of a firm in country i.

Total demand for a firm variety in country i therefore is given by:

$$x^i(j) = M^i\alpha[p_i(j)\mu]^{1/(\alpha-1)}$$

Derivation II:

Inserting (2.3) in (2.4) following condition arises:

$$\pi = p_A(j)^{\alpha/(\alpha-1)}\mu^{1/(\alpha-1)}\alpha M^A + p_B(j)^{\alpha/(\alpha-1)}\mu^{1/(\alpha-1)}\alpha M^B - p_A(j)^{1/(\alpha-1)}\mu^{1/(\alpha-1)}\alpha M^A \frac{c_A}{\theta}$$

$$- p_B(j)^{1/(\alpha-1)}\mu^{1/(\alpha-1)}\alpha M^B \frac{c_B}{\theta} - k \qquad (2.4')$$

$$\overline{\overline{X}} = \mu^{1/(\alpha-1)}\alpha$$

According,

$$\frac{\partial\pi}{\partial p_i} = \frac{\alpha}{(\alpha-1)} p_i(j)^{1/(\alpha-1)} M^i \overline{\overline{X}} - \frac{1}{(\alpha-1)} p_i(j)^{1/(\alpha-1)} p_i(j)^{-1} M^i \overline{\overline{X}} \frac{c_i}{\theta} = 0$$

Solving this for p_A and p_B:

$p_A(j)_{opt} = \frac{1}{\alpha}\frac{c_A}{\theta}$, $p_B(j)_{opt} = \frac{1}{\alpha}\frac{c_B}{\theta}$

Derivation III:

By inserting $p_i(j)_{opt}$ in $\pi = \sum p_i(j)^{\alpha/(\alpha-1)} M^i \overline{\overline{X}} - \sum M^i \overline{\overline{X}} p_i(j)^{1/(\alpha-1)} \frac{c_i}{\theta} - k$ following profit condition for each firm derives:

$$\pi^* = M\overline{\overline{X}}\left(\frac{c_i}{\theta}\right)^{-\alpha/(1-\alpha)} \left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)} - \frac{1}{\alpha}^{-1/(1-\alpha)}\right) - k$$

or

$$\pi^* = M^A\overline{\overline{X}}\left(\frac{c_A}{\theta}\right)^{-\alpha/(1-\alpha)} \left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)} - \frac{1}{\alpha}^{-1/(1-\alpha)}\right) + M^B\overline{\overline{X}}\left(\frac{c_B}{\theta}\right)^{-\alpha/(1-\alpha)} \left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)} - \frac{1}{\alpha}^{-1/(1-\alpha)}\right) - k$$

Whereas $\Theta = \theta^{\alpha/(1-\alpha)}$, $dC = c^{\alpha/(1-\alpha)}$ and $\overline{\overline{X}}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)} - \frac{1}{\alpha}^{-1/(1-\alpha)}\right) = \mu^{1/(\alpha-1)}\alpha\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)} - \frac{1}{\alpha}^{-1/(1-\alpha)}\right)$

$\overline{\overline{X}}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)} - \frac{1}{\alpha}^{-1/(1-\alpha)}\right)$ is a country neutral size. Furthermore,

$M^A\overline{\overline{X}}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)} - \frac{1}{\alpha}^{-1/(1-\alpha)}\right) = \overline{X^A}$ and $M^B\overline{\overline{X}}\left(\frac{1}{\alpha}^{-\alpha/(1-\alpha)} - \frac{1}{\alpha}^{-1/(1-\alpha)}\right) = \overline{X^B}$, where $\overline{X^B} < \overline{X^A}$ because the market share in B is smaller than in A.

For this reason the profit function is:

$$\pi^*_{a,b} = \frac{\overline{X^A}\Theta}{dC(j,r)} + \frac{\overline{X^B}\Theta}{dC(j,r)} - k$$

IV: All seven possible profit functions with transport costs for final goods

$$\pi_{A,A} = \frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{dC(1,1)}$$

$$\pi_{A,AB} = \frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{C(1,w)} - f$$

$$\pi_{A,B} = \frac{\overline{X^A}\Theta}{dC(1,w)} + \frac{\overline{X^B}\Theta}{C(1,w)} - f$$

$$\pi_{B,A} = \frac{\overline{X^A\Theta}}{C(w,1)} + \frac{\overline{X^B\Theta}}{dC(w,1)} - g$$

$$\pi_{B,AB} = \frac{\overline{X^A\Theta}}{C(w,1)} + \frac{\overline{X^B\Theta}}{C(w,w)} - f - g$$

$$\pi_{B,B} = \frac{\overline{X^A\Theta}}{dC(w,w)} + \frac{\overline{X^B\Theta}}{C(w,w)} - f - g$$

$\pi_{AB,AB} = \frac{\overline{X^A\Theta}}{C(1,1)} + \frac{\overline{X^B\Theta}}{C(w,w)} - f - g$, where $\pi_{AB,AB}$ can only be an optimal strategy if transport costs for intermediate goods exist. This does not occur in this analysis. For this reason, $\pi_{B,AB}$ always dominates $\pi_{AB,AB}$ here.

<u>Derivation V:</u>

For that this set of integration strategies is optimal, following is necessary:

$\pi_{A,AB} \succ \pi_{A,B}$

$\pi_{B,AB} \succ \pi_{B,B}$

$\pi_{B,AB} \succ \pi_{AB,AB}$

This must be the case because each of these profit function pairs contains the same fixed costs and only differ by the components of per-unit variable costs and transport costs.

$$\pi_{A,AB} = \frac{\overline{X^A\Theta}}{C(1,1)} + \frac{\overline{X^B\Theta}}{C(1,w)} - f \succ \frac{\overline{X^A\Theta}}{d_H C(1,w)} + \frac{\overline{X^B\Theta}}{C(1,w)} - f = \pi_{A,B}$$

$$\pi_{B,AB} = \frac{\overline{X^A\Theta}}{C(w,1)} + \frac{\overline{X^B\Theta}}{C(w,w)} - f - g \succ \frac{\overline{X^A\Theta}}{d_H C(w,w)} + \frac{\overline{X^B\Theta}}{C(w,w)} - f - g = \pi_{B,B}$$

$$\pi_{B,AB} = \frac{\overline{X^A\Theta}}{C(w,1)} + \frac{\overline{X^B\Theta}}{C(w,w)} - f - g \succ \frac{\overline{X^A\Theta}}{C(1,1)} + \frac{\overline{X^B\Theta}}{C(w,w)} - f - g = \pi_{AB,AB}$$

If $\pi_{B,AB} \succ \pi_{B,B}$ also $\pi_{B,AB} \succ \pi_{AB,AB}$ always holds because C(w,1) < C(1,1).

If this is true, it can also be followed from the equations that

$C(1,1) < d_H\, C(1,w)$ (i)

$C(w,1) < d_H\, C(w,w)$ (ii)

holds.

Transformation results in:

$\frac{C(1,1)}{C(1,w)} < d_H$ and $\frac{C(w,1)}{C(w,w)} < d_H$

This proves that this set of optimal integration strategies only is optimal, if high transport costs exist.

Derivation VI:

To calculate this $\pi_{A,A}$ is equated with $\pi_{B,AB}$. Then $\pi_{A,AB}$ and $\pi_{A,A}$ are compared at this location and for A,AB to be an optimal strategy it is necessary that: $\pi_{A,AB} > \pi_{A,A}$.

$\pi_{A,A} = \pi_{B,AB}$

$$\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)} = \frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{C(w,w)} - f - g$$

$$\Theta(A,A;B,AB) = \frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)}$$

This is the x-axis coordinate. At this point $\pi_{A,AB}$ must be greater than $\pi_{A,A}$.

For this reason, the y-axis coordinate of $\pi_{A,A}$ is required:

$$y_{A,A} = \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right)\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)}$$

y-axis coordinate of $\pi_{A,AB}$:

$$y_{A,AB} = \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{C(1,w)}\right)\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)} - f$$

It is necessary that:

$y_{A,AB} \geq y_{A,A}$

$$\left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{C(1,w)}\right)\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)} - f \geq$$

$$\left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right)\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)}$$

$$\left(\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{C(1,w)}\right)\cdot\frac{\left(1+\frac{g}{f}\right)}{\overline{X^A}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^B}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}-1\geq$$

$$\left(\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{d_H C(1,1)}\right)\cdot\frac{\left(1+\frac{g}{f}\right)}{\overline{X^A}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^B}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}$$

$$1+\frac{g}{f}\ \geq\ \frac{\overline{X^A}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^B}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{C(1,w)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)}$$

$$\frac{g}{f}\ \geq\ \frac{\overline{X^A}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^B}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^B}}{C(1,w)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)}-1$$

$$\frac{g}{f}\left(\frac{\overline{X^B}}{C(1,w)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)\ \geq\ \left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}\right)+\left(\frac{\overline{X^B}}{C(w,w)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)-\frac{\overline{X^B}}{C(1,w)}+\frac{\overline{X^B}}{d_H C(1,1)}$$

$$\frac{g}{f}\geq\ \frac{\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{C(w,w)}-\frac{\overline{X^B}}{C(1,w)}}{\left(\frac{\overline{X^B}}{C(1,w)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)}=\gamma_H$$

<u>Derivation VII:</u>

$$\pi_{A,A}\ =\ \pi_{B,AB}$$

$$\frac{\overline{X^A}\Theta}{C(1,1)}+\frac{\overline{X^B}\Theta}{d_H C(1,1)}=\frac{\overline{X^A}\Theta}{C(w,1)}+\frac{\overline{X^B}\Theta}{C(w,w)}-f-g$$

$$\Theta(A,A;B,AB)=\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^B}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}$$

This is the x-axis coordinate. At this point $\pi_{B,A}$ must be greater than $\pi_{A,A}$.

For this reason, the y-axis coordinate of $\pi_{A,A}$ is required:

$$y_{A,A}\ =\left(\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{d_H C(1,1)}\right)\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^B}\left(\frac{1}{C(w,w)}-\frac{1}{d_H C(1,1)}\right)}$$

y-axis coordinate of $\pi_{B,A}$:

$$y_{B,A} = \left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right)\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)} - g$$

It is necessary that:

$$y_{B,A} \geq y_{A,A}$$

$$\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right)\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)} - g \geq$$

$$\left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right)\frac{(f+g)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)}$$

$$\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right)\cdot\frac{\left(\frac{f}{g}+1\right)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)} - 1 \geq$$

$$\left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right)\cdot\frac{\left(\frac{f}{g}+1\right)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right)}$$

$$1+\frac{f}{g} \geq \frac{\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)}\right) + \left(\frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right) - \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right)}$$

$$\frac{f}{g} \geq \frac{\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)}\right) + \left(\frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right) - \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right)} - 1$$

$$\frac{f}{g}\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) \geq$$

$$\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)}\right) + \left(\frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) - \left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right)$$

$$\frac{f}{g} \geq \frac{\frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{d_H C(w,1)}}{\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right)}$$

$$\frac{g}{f} \leq \frac{\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}}{\frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{d_H C(w,1)}} = \gamma_L$$

Derivation VIII:

$$\pi_{A,A} = \pi_{A,AB}$$

$$\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)} = \frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{C(1,w)} - f$$

$$\Theta \cdot \left(\frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)} - \frac{\overline{X^B}}{C(1,w)}\right) = -f$$

$$\Theta(A,A;A,AB) = \frac{f}{\overline{X^B}\left[\frac{1}{C(1,w)} - \frac{1}{d_H C(1,1)}\right]}$$

$$\pi_{A,A} = \pi_{B,A}$$

$$\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)} = \frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{d_H C(w,1)} - g$$

$$\Theta \cdot \left(\frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(1,1)} - \frac{\overline{X^B}}{d_H C(w,1)}\right) = -g$$

$$\Theta(A,A;B,A) = \frac{g}{\overline{X^A}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^B}\left[\frac{1}{d_H C(w,1)} - \frac{1}{d_H C(1,1)}\right]}$$

$$\pi_{A,A} = \pi_{B,AB}$$

$$\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)} = \frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{C(w,w)} - f - g$$

$$\Theta \cdot \left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) = f + g$$

$$\Theta(A,A;B,AB) = \frac{f+g}{\overline{X^A}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^B}\left[\frac{1}{C(w,w)} - \frac{1}{d_H C(1,1)}\right]}$$

$$\pi_{A,AB} = \pi_{B,AB}$$

$$\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{C(1,w)} - f = \frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{C(w,w)} - f - g$$

$$\Theta \cdot \left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{C(1,w)} \right) = g$$

$$\Theta(A, AB; B, AB) = \frac{g}{\overline{X^A}\left[\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right] + \overline{X^B}\left[\frac{1}{C(w,w)} - \frac{1}{C(1,w)}\right]}$$

$$\pi_{B,A} = \pi_{B,AB}$$

$$\frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{d_H C(w,1)} - g = \frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{C(w,w)} - f - g$$

$$\Theta \cdot \left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{C(w,w)} - \frac{\overline{X^B}}{d_H C(w,1)} \right) = f$$

$$\Theta(B, A; B, AB) = \frac{f}{\overline{X^B}\left[\frac{1}{C(w,w)} - \frac{1}{d_H C(w,1)}\right]}$$

<u>Derivation IX:</u>

$$U_i = x_0 + X \qquad\qquad X = \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{\alpha} dj\right]$$

$$L = x_0 + \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} (x^i(j) + \beta\varsigma(j))^{\alpha} dj\right] + \lambda\left[m_i - x_0 - \int_0^{\Theta_{max}} p_i(j)(x^i(j) + \beta\varsigma(j))dj\right]$$

$$\frac{\partial L}{\partial x_0} = 1 - \lambda = 0 \qquad \Rightarrow \lambda = 1$$

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} (x^i(j) + \beta\varsigma(j))^{(\alpha-1)} \varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

If $\beta = 0$:

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{(\alpha-1)} \varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

$$\Rightarrow \int_0^{\Theta_{max}} \left[\frac{\alpha}{\mu\alpha^{\alpha}} x^i(j)^{(\alpha-1)} - p_i(j)\right]\varsigma(j)dj = 0$$

$$\Rightarrow \left[\frac{\alpha}{\mu\alpha^{\alpha}} x^i(j)^{(\alpha-1)} - p_i(j)\right] = 0$$

$$\Rightarrow x^i(j) = \alpha[p_i(j)\mu]^{1/(\alpha-1)}$$

$$\frac{\partial L}{\partial \lambda} = m_i - x_0 - \int_0^{\Theta_{max}} p_i(j)(x^i(j) + \beta\varsigma(j))dj = 0 \quad \Rightarrow x_0 = m_i - \int_0^{\Theta_{max}} p_i(j)(x^i(j) + \beta\varsigma(j))dj$$

$$\Rightarrow x_0 = m_i - \int_0^{\Theta_{max}} p_i(j)\alpha[p_i(j)\mu]^{1/(\alpha-1)} dj$$

$$V_i = m_i - \int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)} \alpha[\mu]^{1/(\alpha-1)} dj + \frac{1}{\mu\alpha^\alpha} \int_0^{\Theta_{max}} [p_i(j)\mu]^{\alpha/(\alpha-1)} \alpha^\alpha dj$$

$$V_i = m_i + (1-\alpha)\mu^{1/(\alpha-1)} \int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)} dj$$

Derivation X:

Cut-off levels with profit taxation:

$$\pi_{A,A} = \pi_{A,AB}$$

$$\left[\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)}\right](1-t_A) = \frac{\overline{X^A}\Theta}{C(1,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{C(1,w)}(1-t_B) - f(1-\delta t_B)$$

$$\Theta \cdot \left(\frac{\overline{X^B}}{d_H C(1,1)}(1-t_A) - \frac{\overline{X^B}}{C(1,w)}(1-t_B)\right) = -f(1-\delta t_B)$$

$$\Theta(A,A;A,AB) = \frac{f(1-\delta t_B)}{\overline{X^B}\left[\frac{1}{C(1,w)}(1-t_B) - \frac{1}{d_H C(1,1)}(1-t_A)\right]}$$

$$\pi_{A,A} = \pi_{B,A}$$

$$\left[\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)}\right](1-t_A) = \left[\frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{d_H C(w,1)}\right](1-t_A) - g$$

$$\Theta \cdot \left(\frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(1,1)} - \frac{\overline{X^B}}{d_H C(w,1)}\right)(1-t_A) = -g$$

$$\Theta(A,A;B,A) = \frac{g}{\left[\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(w,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right](1-t_A)}$$

$$\pi_{A,A} = \pi_{B,AB}$$

$$\left[\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)}\right](1-t_A) = \frac{\overline{X^A}\Theta}{C(w,1)}(1-t_A) + \frac{\overline{X^B}\Theta}{C(w,w)}(1-t_B) - g - f(1-\delta t_B)$$

$$\Theta \cdot \left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right)(1-t_A) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right] = g + f(1-\delta t_B)$$

$$\Theta(A,A;B,AB)=\frac{g+f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)(1-t_A)+\frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

$$\pi_{A,AB}=\pi_{B,AB}$$

$$\frac{\overline{X^A}\Theta}{C(1,1)}(1-t_A)+\frac{\overline{X^B}\Theta}{C(1,w)}(1-t_B)-f(1-\delta t_B)=\frac{\overline{X^A}\Theta}{C(w,1)}(1-t_A)+\frac{\overline{X^B}\Theta}{C(w,w)}(1-t_B)-g-f(1-\delta t_B)$$

$$\Theta\cdot\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}\right)(1-t_A)+\left(\frac{\overline{X^B}}{C(w,w)}-\frac{\overline{X^B}}{C(1,w)}\right)(1-t_B)\right]=g$$

$$\Theta(A,AB;B,AB)=\frac{g}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}\right)(1-t_A)+\left(\frac{\overline{X^B}}{C(w,w)}-\frac{\overline{X^B}}{C(1,w)}\right)(1-t_B)\right]}$$

$$\pi_{B,A}=\pi_{B,AB}$$

$$\left[\frac{\overline{X^A}\Theta}{C(w,1)}+\frac{\overline{X^B}\Theta}{d_H C(w,1)}\right](1-t_A)-g=\frac{\overline{X^A}\Theta}{C(w,1)}(1-t_A)+\frac{\overline{X^B}\Theta}{C(w,w)}(1-t_B)-g-f(1-\delta t_B)$$

$$\Theta\cdot\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^B}}{d_H C(w,1)}\right)(1-t_A)+\frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]=f(1-\delta t_B)$$

$$\Theta(B,A;B,AB)=\frac{f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^B}}{d_H C(w,1)}\right)(1-t_A)+\frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

<u>Derivation XI:</u>

Because $\Theta=\theta^{\alpha/(1-\alpha)}$ and $dC=c^{\alpha/(1-\alpha)}$:

$$\pi=\left[p_A(j)^{\alpha/(\alpha-1)}M^A\overline{\overline{X}}+p_B(j)^{\alpha/(\alpha-1)}M^B\overline{\overline{X}}-p_A(j)^{1/(\alpha-1)}M^A\overline{\overline{X}}\frac{\Theta}{dC_A}-p_B(j)^{1/(\alpha-1)}M^B\overline{\overline{X}}\frac{\Theta}{dC_B}\right][1-t_i]-k$$

$$\overline{\overline{X}}=\mu^{1/(\alpha-1)}\alpha$$

According,

$$\frac{\partial\pi}{\partial p_A}=\frac{\alpha}{(\alpha-1)}p_A(j)^{1/(\alpha-1)}M^A\overline{\overline{X}}(1-t_i)-\frac{1}{(\alpha-1)}p_A(j)^{1/(\alpha-1)}p_A(j)^{-1}M^A\overline{\overline{X}}\left(\frac{\Theta}{dC_A}\right)^{(\alpha-1)/\alpha}(1-t_i)=0$$

$$\frac{\partial\pi}{\partial p_B}=\frac{\alpha}{(\alpha-1)}p_B(j)^{1/(\alpha-1)}M^B\overline{\overline{X}}(1-t_i)-\frac{1}{(\alpha-1)}p_B(j)^{1/(\alpha-1)}p_B(j)^{-1}M^B\overline{\overline{X}}\left(\frac{\Theta}{dC_B}\right)^{(\alpha-1)/\alpha}(1-t_i)=0$$

Solving this for p:

$p_A(j)_{opt}=\frac{1}{\alpha}\left(\frac{dC_A}{\Theta}\right)^{(\alpha-1)/-\alpha}$ and $p_B(j)_{opt}=\frac{1}{\alpha}\left(\frac{dC_B}{\Theta}\right)^{(\alpha-1)/-\alpha}$ if transport costs and taxes exist.

Derivation XII:

$$U_i = x_0 + X\ ,\ i \in \{A,B\}$$

$$X = \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{\alpha} dj\right]$$

$$L = x_0 + \frac{1}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} (x^i(j)+\beta\varsigma(j))^{\alpha} dj\right] + \lambda\left[m_i + t_i \frac{\int_0^{\Theta_{max}} \pi_i(j)dj}{M^i} - x_0 - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj\right]$$

$$\frac{\partial L}{\partial x_0} = 1 - \lambda = 0 \quad \Rightarrow \lambda = 1$$

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} (x^i(j)+\beta\varsigma(j))^{(\alpha-1)} \varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

If $\beta = 0$:

$$\frac{\partial L}{\partial \beta} = \frac{\alpha}{\mu\alpha^{\alpha}}\left[\int_0^{\Theta_{max}} x^i(j)^{(\alpha-1)} \varsigma(j)dj\right] - \int_0^{\Theta_{max}} p_i(j)\varsigma(j)dj = 0$$

$$\Rightarrow \int_0^{\Theta_{max}} \left[\frac{\alpha}{\mu\alpha^{\alpha}} x^i(j)^{(\alpha-1)} - p_i(j)\right]\varsigma(j)dj = 0$$

$$\Rightarrow \left[\frac{\alpha}{\mu\alpha^{\alpha}} x^i(j)^{(\alpha-1)} - p_i(j)\right] = 0$$

$$\Rightarrow x^i(j) = \alpha[p_i(j)\mu]^{1/(\alpha-1)}$$

$$\frac{\partial L}{\partial \lambda} = m_i + t_i \frac{\int_0^{\Theta_{max}} \pi_i(j)dj}{M^i} - x_0 - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj = 0$$

$$\Rightarrow x_0 = m_i + t_i \frac{\int_0^{\Theta_{max}} \pi_i(j)dj}{M^i} - \int_0^{\Theta_{max}} p_i(j)(x^i(j)+\beta\varsigma(j))dj$$

$$\Rightarrow x_0 = m_i + t_i \frac{\int_0^{\Theta_{max}} \pi_i(j)dj}{M^i} - \int_0^{\Theta_{max}} p_i(j)\alpha[p_i(j)\mu]^{1/(\alpha-1)} dj$$

$$V'_i = m_i + t_i \frac{\int_0^{\Theta_{max}} \pi_i(j)dj}{M^i} + (1-\alpha)\mu^{1/(\alpha-1)} \int_0^{\Theta_{max}} p_i(j)^{\alpha/(\alpha-1)} dj$$

<u>Derivation XIII:</u>

To calculate this $\pi_{A,A}$ is equated with $\pi_{B,AB}$. Then $\pi_{A,AB}$ and $\pi_{A,A}$ are compared at this location and for A,AB to be an optimal strategy it is necessary that: $\pi_{A,AB} > \pi_{A,A}$.

$\pi_{A,A} = \pi_{B,AB}$

$$\frac{\overline{X^A}\Theta}{C(1,1)} + \frac{\overline{X^B}\Theta}{d_H C(1,1)} = \frac{\overline{X^A}\Theta}{C(w,1)} + \frac{\overline{X^B}\Theta}{C(w,w)}(1-t_B) - f(1-\delta t_B) - g$$

$$\Theta(A,A;B,AB) = \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

This is the x-axis coordinate. At this point $\pi_{A,AB}$ must be greater than $\pi_{A,A}$.

For this reason, the y-axis coordinate of $\pi_{A,A}$ is required:

$$y_{A,A} = \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right) \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

y-axis coordinate of $\pi_{A,AB}$:

$$y_{A,AB} = \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{C(1,w)}(1-t_B)\right) \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]} - f(1-\delta t_B)$$

It is necessary that:

$y_{A,AB} \geq y_{A,A}$

$$\left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{C(1,w)}(1-t_B)\right) \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]} - f(1-\delta t_B) \geq$$

$$\left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right) \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

$$\left(\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{C(1,w)}(1-t_B)\right)\cdot\frac{\left(1+\frac{g}{f(1-\delta t_B)}\right)}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)+\frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}-1\geq$$

$$\left(\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{d_H C(1,1)}\right)\cdot\frac{\left(1+\frac{g}{f(1-\delta t_B)}\right)}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)+\frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

$$\frac{g}{f}\geq\left[\frac{\overline{X^A}\left(\frac{1}{C(w,1)}-\frac{1}{C(1,1)}\right)+\overline{X^B}\left(\frac{1}{C(w,w)}(1-t_B)-\frac{1}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{C(1,w)}(1-t_B)-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)}-1\right](1-\delta t_B)$$

$$\frac{g}{f}\left(\frac{\overline{X^B}}{C(1,w)}(1-t_B)-\frac{\overline{X^B}}{d_H C(1,1)}\right)\geq$$

$$\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}\right)+\left(\frac{\overline{X^B}}{C(w,w)}(1-t_B)-\frac{\overline{X^B}}{d_H C(1,1)}\right)-\frac{\overline{X^B}}{C(1,w)}(1-t_B)+\frac{\overline{X^B}}{d_H C(1,1)}\right](1-\delta t_B)$$

$$\frac{g}{f}\geq\frac{\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}+\frac{\overline{X^B}}{C(w,w)}(1-t_B)-\frac{\overline{X^B}}{C(1,w)}(1-t_B)\right]}{\left(\frac{\overline{X^B}}{C(1,w)}(1-t_B)-\frac{\overline{X^B}}{d_H C(1,1)}\right)}(1-\delta t_B)=\gamma_{H2}$$

<u>Derivation XIV:</u>

$$\pi_{A,A}=\pi_{B,AB}$$

$$\frac{\overline{X^A}\Theta}{C(1,1)}+\frac{\overline{X^B}\Theta}{d_H C(1,1)}=\frac{\overline{X^A}\Theta}{C(w,1)}+\frac{\overline{X^B}\Theta}{C(w,w)}(1-t_B)-f(1-\delta t_B)-g$$

$$\Theta(A,A;B,AB)=\frac{g+f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)+\frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

This is the x-axis coordinate. At this point $\pi_{B,A}$ must be greater than $\pi_{A,A}$.

For this reason, the y-axis coordinate of $\pi_{A,A}$ is required:

$$y_{A,A} = \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right) \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

y-axis coordinate of $\pi_{B,A}$:

$$y_{B,A} = \left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right) \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]} - g$$

It is necessary that:

$y_{B,A} \geq y_{A,A}$

$$\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right) \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]} - g \geq$$

$$\left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right) \frac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$$

$$\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right) \cdot \frac{\left(\frac{f(1-\delta t_B)}{g} + 1\right)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)}(1-t_B) - \frac{1}{d_H C(1,1)}\right)} - 1 \geq$$

$$\left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right) \cdot \frac{\left(\frac{f(1-\delta t_B)}{g} + 1\right)}{\overline{X^A}\left(\frac{1}{C(w,1)} - \frac{1}{C(1,1)}\right) + \overline{X^B}\left(\frac{1}{C(w,w)}(1-t_B) - \frac{1}{d_H C(1,1)}\right)}$$

$$1 + \frac{f(1-\delta t_B)}{g} \geq \frac{\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)}\right) + \left(\frac{\overline{X^B}}{C(w,w)}(1-t_B) - \frac{\overline{X^B}}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right) - \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right)}$$

$$\frac{f(1-\delta t_B)}{g} \geq \frac{\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)}\right) + \left(\frac{\overline{X^B}}{C(w,w)}(1-t_B) - \frac{\overline{X^B}}{d_H C(1,1)}\right)}{\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)}\right) - \left(\frac{\overline{X^A}}{C(1,1)} + \frac{\overline{X^B}}{d_H C(1,1)}\right)} - 1$$

$$\frac{f(1-\delta t_B)}{g}\left(\frac{\overline{X^A}}{C(w,1)} + \frac{\overline{X^B}}{d_H C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) \geq$$

$$\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}\right)+\left(\frac{\overline{X^B}}{C(w,w)}(1-t_B)-\frac{\overline{X^B}}{d_H C(1,1)}\right)\text{-}\left(\frac{\overline{X^A}}{C(w,1)}+\frac{\overline{X^B}}{d_H C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)$$

$$\frac{f}{g}\geq\frac{\left[\frac{\overline{X^B}}{C(w,w)}(1-t_B)-\frac{\overline{X^B}}{d_H C(w,1)}\right]}{\left(\frac{\overline{X^A}}{C(w,1)}+\frac{\overline{X^B}}{d_H C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)(1-\delta t_B)}$$

$$\frac{g}{f}\leq\frac{\left[\frac{\overline{X^A}}{C(w,1)}+\frac{\overline{X^B}}{d_H C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right]}{\left[\frac{\overline{X^B}}{C(w,w)}(1-t_B)-\frac{\overline{X^B}}{d_H C(w,1)}\right]}(1-\delta t_B)=\gamma_{L2}$$

<u>Derivation XV:</u>

$$V'_B = m_B+\frac{t_B}{M^B}\left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}}\pi_B(j)dj\right]$$

$$+(1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(A,A;B,AB)}p_B(j)^{\alpha/(\alpha-1)}dj+\int_{\Theta(A,A;B,AB)}^{\Theta_{max}}p_B(j)^{\alpha/(\alpha-1)}dj\right]$$

$$V'_B = m_B+\frac{t_B}{M^B}\left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}}\frac{\overline{X^B}\Theta(j)}{C(w,w)}dj\right]+(1-\alpha)\mu^{1/(\alpha-1)}$$

$$\left[\int_0^{\Theta(A,A;B,AB)}\left(\frac{1}{\alpha}\left(\frac{\Theta(j)}{d_H C(1,1)}\right)^{(\alpha-1)/\alpha}\right)^{\alpha/(\alpha-1)}dj+\int_{\Theta(A,A;B,AB)}^{\Theta_{max}}\left(\frac{1}{\alpha}\left(\frac{\Theta(j)}{C(w,w)}\right)^{(\alpha-1)/\alpha}\right)^{\alpha/(\alpha-1)}dj\right]$$

whereas without depreciation $\Theta(A,A;B,AB)=\dfrac{g+f}{\left[\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)+\frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$.

Solving for $\dfrac{\partial V'_B}{\partial t_B}=0$, following condition is achieved:

$$t_B^3-3\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]\cdot\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-1}t_B^2$$

$$-\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-2}2\left(\frac{3}{2}(g+f)^2-2\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]^2\right)\cdot t_B$$

$$-\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-3}\left(\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]^3-(g+f)^2\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]\right)$$

$$-\left(\frac{1}{M^B}\left(\frac{\overline{X^B}}{C(w,w)}\right)^3\frac{1}{2}\right)^{-1}(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{d_H C(1,1)}-\frac{1}{C(w,w)}\right]\cdot(f+g)^2=0$$

<u>Derivation XVI:</u>

$t_B^3+a\,t_B^2+b\,t_B+c=0$

$$a=a\left(\overline{X^A},\overline{X^B},C(1,1),C(w,1),C(w,w),d_H\right)=-3\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]\cdot\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-1}$$

$$b=b\left(\overline{X^A},\overline{X^B},C(1,1),C(w,1),C(w,w),d_H,g,f\right)=$$

$$-\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-2}2\left(\frac{3}{2}(g+f)^2-2\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]^2\right)$$

$$c=c\left(\overline{X^A},\overline{X^B},C(1,1),C(w,1),C(w,w),d_H,g,f,M^B,\alpha,\mu\right)=$$

$$-\left(\frac{1}{M^B}\left(\frac{\overline{X^B}}{C(w,w)}\right)^3\frac{1}{2}\right)^{-1}(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{d_H C(1,1)}-\frac{1}{C(w,w)}\right]\cdot(f+g)^2$$

$$-\left(\frac{\overline{X^B}}{C(w,w)}\right)^{-3}\left(\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]^3-(g+f)^2\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]\right)$$

The three general equations for the optimal tax rates are given by:

$$L1[a\_,b\_,c\_]=-\frac{a}{3}-\frac{2^{1/3}(-a^2+3b)}{3(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}}$$

$$+\frac{(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}}{32^{1/3}}$$

$$L2[a\_,b\_,c\_]=-\frac{a}{3}+\frac{(1+i\sqrt{3})\cdot(-a^2+3b)}{32^{2/3}(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}}$$

$$-\frac{1}{62^{1/3}}(1-i\sqrt{3})\cdot(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}$$

$$L3[a\_,b\_,c\_]= -\frac{a}{3} + \frac{(1-i\sqrt{3})\cdot(-a^2+3b)}{3 2^{2/3}(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}}$$
$$-\frac{1}{6 2^{1/3}}(1+i\sqrt{3})\cdot(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}$$

Derivation XVII:

For (a1): With exogenous parameter configurations given by

$\overline{X^A}=100,\quad \overline{X^B}=50,\quad C(1,1)=6,\quad C(w,1)=4,\quad C(w,w)=2,\quad d_H=5,$

$g=9,\quad f=9,\quad M^B=83,\quad \alpha=0.75,\quad \mu=0.6$

following tax rates arise, solving for L1[a_,b_,c_], L2[a_,b_,c_], L3[a_,b_,c_] from derivation XVI:

$L1[a(100;50;6;4;2;5),b(100;50;6;4;2;5;9;9),c(100;50;6;4;2;5;9;9;83;0.75;0.6)]=$

t_{B1}=0.014225

$L2[a(100;50;6;4;2;5),b(100;50;6;4;2;5;9;9),c(100;50;6;4;2;5;9;9;83;0.75;0.6)]=$

t_{B2}=1.89289 + 1.10711 i

$L3[a(100;50;6;4;2;5),b(100;50;6;4;2;5;9;9),c(100;50;6;4;2;5;9;9;83;0.75;0.6)]=$

t_{B3}=1.89289 – 1.10711 i

For (a2): With exogenous parameter configurations given by

$\overline{X^A}=100,\quad \overline{X^B}=50,\quad C(1,1)=6,\quad C(w,1)=4,\quad C(w,w)=2,\quad d_H=5,$

$g=9,\quad f=9,\quad M^B=131,\quad \alpha=0.7,\quad \mu=0.65$

following tax rates arise, solving for L1[a_,b_,c_], L2[a_,b_,c_], L3[a_,b_,c_] from derivation XVI:

$L1[a(100;50;6;4;2;5),b(100;50;6;4;2;5;9;9),c(100;50;6;4;2;5;9;9;131;0.7;0.65)]=$

t_{B4}=-0.0031552

$L2[a(100;50;6;4;2;5),b(100;50;6;4;2;5;9;9),c(100;50;6;4;2;5;9;9;131;0.7;0.65)]=$

t_{B5}=1.90158 + 1.12186 i

$L3[a(100;50;6;4;2;5),b(100;50;6;4;2;5;9;9),c(100;50;6;4;2;5;9;9;131;0.7;0.65)]=$

t_{B6}=1.90158 – 1.12186 i

Derivation XVIII:

$$V'_B = m_B + \frac{t_B}{M^B}\left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}} \pi_B(j)dj\right]$$

$$+(1-\alpha)\mu^{1/(\alpha-1)}\left[\int_0^{\Theta(A,A;B,AB)} p_B(j)^{\alpha/(\alpha-1)}dj + \int_{\Theta(A,A;B,AB)}^{\Theta_{max}} p_B(j)^{\alpha/(\alpha-1)}dj\right]$$

$$V'_B = m_B + \frac{t_B}{M^B}\left[\int_{\Theta(A,A;B,AB)}^{\Theta_{max}}\left[\frac{\overline{X^B}\Theta(j)}{C(w,w)} - f\right]dj\right] + (1-\alpha)\mu^{1/(\alpha-1)}$$

$$\left[\int_0^{\Theta(A,A;B,AB)}\left(\frac{1}{\alpha}\left(\frac{\Theta(j)}{d_H C(1,1)}\right)^{(\alpha-1)/\alpha}\right)^{\alpha/(\alpha-1)}dj + \int_{\Theta(A,A;B,AB)}^{\Theta_{max}}\left(\frac{1}{\alpha}\left(\frac{\Theta(j)}{C(w,w)}\right)^{(\alpha-1)/\alpha}\right)^{\alpha/(\alpha-1)}dj\right]$$

whereas with depreciation $\Theta(A,A;B,AB) = \dfrac{g + f(1-\delta t_B)}{\left[\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}(1-t_B)\right]}$.

Solving for $\frac{\partial V'_B}{\partial t_B} = 0$, following condition is achieved:

$$t_B{}^3 - \left(\frac{\overline{X^B}}{C(w,w)}\left[\frac{3}{2}f^2 + \left(f - \frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\right)^{-1}\left[\left(\frac{5}{2}f^2 + \left(f - \frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right)\cdot\right.$$

$$\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)} + \frac{\overline{X^B}}{C(w,w)}\right) + 2\left(\frac{\overline{X^B}}{C(w,w)}\right) + 2\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right)$$

$$\left. + \left(\frac{\overline{X^B}}{C(w,w)}\right)\left(gf + f^2\right)\right]\cdot t_B{}^2$$

$$+\left(\frac{1}{M^B}\left(\frac{\overline{X^B}}{C(w,w)}\right)^2\left[\frac{3}{2}f^2 + \left(f - \frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\right)^{-1}\cdot$$

$$\left[\frac{1}{M^B}\frac{\overline{X^B}}{C(w,w)}\left[\left[3f^2 + 3gf + 2\left(f - \frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\cdot\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)} + \frac{\overline{X^B}}{C(w,w)}\right)\right.\right.$$

$$-\frac{1}{2}\frac{\overline{X^B}}{C(w,w)}(g+f)^2 + \left(f - \frac{\overline{X^B}}{2C(w,w)}\right)\cdot\left[\left(\left(\frac{\overline{X^A}}{C(w,1)} - \frac{\overline{X^A}}{C(1,1)} - \frac{\overline{X^B}}{d_H C(1,1)}\right) + \frac{\overline{X^B}}{C(w,w)}\right)^2 + \right.$$

$$2\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)\cdot\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right)\Bigg]\Bigg]\Bigg]+\frac{1}{M^B}2f^2+$$

$$(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{d_H C(1,1)}-\frac{1}{C(w,w)}\right]\cdot\Bigg[f^2\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)-\frac{\overline{X^B}}{C(w,w)}gf\Bigg]\Bigg]\Bigg]\cdot t_B$$

$$-\left(\left(\frac{\overline{X^B}}{C(w,w)}\right)^2\left[\frac{3}{2}f^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\right)^{-1}\cdot\Bigg[\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right]$$

$$\left[\frac{1}{2}\frac{\overline{X^B}}{C(w,w)}(g+f)^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\cdot\left(\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right]+\frac{\overline{X^B}}{C(w,w)}\right)^2\right]+(f^2+fg)\Bigg]$$

$$+\left[\frac{1}{M^B}\left(\frac{\overline{X^B}}{C(w,w)}\right)^2\cdot\left[\frac{3}{2}f^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\right]^{-1}(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot$$

$$\left[\frac{1}{d_H C(1,1)}-\frac{1}{C(w,w)}\right]\cdot\left[(g+f)^2\left(\frac{\overline{X^B}}{C(w,w)}\right)-(f^2+gf)\cdot\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right)\right]=0$$

Derivation XIX:

$t_B^3+a\,t_B^2+b\,t_B+c=0$

$$a=a\left(\overline{X^A},\overline{X^B},C(1,1),C(w,1),C(w,w),d_H,g,f\right)=$$

$$-\left(\frac{\overline{X^B}}{C(w,w)}\left[\frac{3}{2}f^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\right)^{-1}\Bigg[\left(\frac{5}{2}f^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right)\cdot$$

$$\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right)+2\left(\frac{\overline{X^B}}{C(w,w)}\right)+2\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)$$

$$+\left(\frac{\overline{X^B}}{C(w,w)}\right)\left(gf+f^2\right)\Bigg]$$

$$b=b\left(\overline{X^A},\overline{X^B},C(1,1),C(w,1),C(w,w),d_H,g,f,M^B,\alpha,\mu\right)=$$

$$+\left(\frac{1}{M^B}\left(\frac{\overline{X^B}}{C(w,w)}\right)^2\left[\frac{3}{2}f^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\right)^{-1}\cdot$$

$$\Bigg[\frac{1}{M^B}\frac{\overline{X^B}}{C(w,w)}\Bigg[\Bigg[3f^2+3gf+2\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\Bigg]\cdot\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right)$$

$$-\frac{1}{2}\frac{\overline{X^B}}{C(w,w)}(g+f)^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\cdot\Bigg[\left(\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)+\frac{\overline{X^B}}{C(w,w)}\right)^2+$$

$$2\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)\cdot\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right)\Bigg]\Bigg]+\frac{1}{M^B}2f^2+$$

$$(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\left[\frac{1}{d_H C(1,1)}-\frac{1}{C(w,w)}\right]\cdot\Bigg[f^2\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right)-\frac{\overline{X^B}}{C(w,w)}gf\Bigg]\Bigg]$$

$$c=c\left(\overline{X^A},\overline{X^B},C(1,1),C(w,1),C(w,w),d_H,g,f,M^B,\alpha,\mu\right)=$$

$$-\left(\left(\frac{\overline{X^B}}{C(w,w)}\right)^2\left[\frac{3}{2}f^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\right)^{-1}\cdot\Bigg[\Bigg[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\Bigg]$$

$$\Bigg[\frac{1}{2}\frac{\overline{X^B}}{C(w,w)}(g+f)^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\cdot\left(\left[\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}\right]+\frac{\overline{X^B}}{C(w,w)}\right)^2\Bigg]+(f^2+fg)\Bigg]$$

$$+\left[\frac{1}{M^B}\left(\frac{\overline{X^B}}{C(w,w)}\right)^2\cdot\left[\frac{3}{2}f^2+\left(f-\frac{\overline{X^B}}{2C(w,w)}\right)\frac{\overline{X^B}}{C(w,w)}\right]\right]^{-1}(1-\alpha)\mu^{1/(\alpha-1)}\left(\frac{1}{\alpha}\right)^{\alpha/(\alpha-1)}\cdot$$

$$\left[\frac{1}{d_H C(1,1)}-\frac{1}{C(w,w)}\right]\cdot\Bigg[(g+f)^2\left(\frac{\overline{X^B}}{C(w,w)}\right)-(f^2+gf)\cdot\left(\frac{\overline{X^A}}{C(w,1)}-\frac{\overline{X^A}}{C(1,1)}-\frac{\overline{X^B}}{d_H C(1,1)}+\frac{\overline{X^B}}{C(w,w)}\right)\Bigg]$$

The three general equations for the optimal tax rates are given by:

$$L1[a\_,b\_,c\_]=-\frac{a}{3}-\frac{2^{1/3}(-a^2+3b)}{3(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}}$$

$$+\frac{(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}}{32^{1/3}}$$

$$L2[a\_,b\_,c\_]=-\frac{a}{3}+\frac{(1+i\sqrt{3})\cdot(-a^2+3b)}{32^{2/3}(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}}$$

$$-\frac{1}{62^{1/3}}(1-i\sqrt{3})\cdot(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}$$

$$L3[a\_,b\_,c\_]=-\frac{a}{3}+\frac{(1-i\sqrt{3})\cdot(-a^2+3b)}{3 2^{2/3}(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}}$$
$$-\frac{1}{6 2^{1/3}}(1+i\sqrt{3})\cdot(-2a^3+9ab-27c+3\sqrt{3}\sqrt{-a^2b^2+4b^3+4a^3c-18abc+27c^2})^{1/3}$$

Derivation XX:

For (b1): With exogenous parameter configurations given by

$\overline{X^A}=100,\quad \overline{X^B}=50,\quad C(1,1)=6,\quad C(w,1)=4,\quad C(w,w)=2,\quad d_H=5,$

$g=9,\quad f=9,\quad M^B=83,\quad \alpha=0.75,\quad \mu=0.6$

following tax rates arise, solving for L1[a_,b_,c_], L2[a_,b_,c_], L3[a_,b_,c_] from derivation XIX:

$L1[a(100;50;6;4;2;5;9;9), b(100;50;6;4;2;5;9;9;83;0.75;0.6), c(100;50;6;4;2;5;9;9;83;0.75;0.6)]$
$=t_{B7}=0.48007$

$L2[a(100;50;6;4;2;5;9;9), b(100;50;6;4;2;5;9;9;83;0.75;0.6), c(100;50;6;4;2;5;9;9;83;0.75;0.6)]$
$=t_{B8}=0.245466 + 2.18785\, i$

$L3[a(100;50;6;4;2;5;9;9), b(100;50;6;4;2;5;9;9;83;0.75;0.6), c(100;50;6;4;2;5;9;9;83;0.75;0.6)]$
$=t_{B9}=0.245466 - 2.18785\, i$

For (b2): With exogenous parameter configurations given by

$\overline{X^A}=100,\quad \overline{X^B}=50,\quad C(1,1)=6,\quad C(w,1)=4,\quad C(w,w)=2,\quad d_H=5,$

$g=9,\quad f=9,\quad M^B=131,\quad \alpha=0.7,\quad \mu=0.65$

following tax rates arise, solving for L1[a_,b_,c_], L2[a_,b_,c_], L3[a_,b_,c_] from derivation XIX:

$L1[a(100;50;6;4;2;5;9;9), b(100;50;6;4;2;5;9;9;131;0.7;0.65),$
$c(100;50;6;4;2;5;9;9;131;0.7;0.65)]=t_{B10}=0.482567$

$L2[a(100;50;6;4;2;5;9;9), b(100;50;6;4;2;5;9;9;131;0.7;0.65),$

$c(100;50;6;4;2;5;9;9;131;0.7;0.65)]=t_{B11}=0.244217 + 2.18981\, i$

$L3[a(100;50;6;4;2;5;9;9), b(100;50;6;4;2;5;9;9;131;0.7;0.65),$

$c(100;50;6;4;2;5;9;9;131;0.7;0.65)]=t_{B12}=0.244217 - 2.18981\, i$

Chapter 3

Best-Response Tax Rates on Profits of Multinational Firms – A Numerical Approach

3.1 Introduction

In recent innovation to trade literature, heterogeneity of firm-productivity has been incorporated into models of monopolistic competition with international trade and multinational firms. Initially, models of vertical or horizontal integration strategies of multinational firms were developed under the assumption of homogeneous productivities between all plants in a market.[137] Later, theoretical work was focused on the study of optimal integration strategies of such and even more complex firms in the presence of firm heterogeneity in terms of total factor productivity.[138] One key finding was that the optimal integration strategy for a firm depends on its productivity. In addition, given productivity differences across firms, coexistence of alternative modes of integration is based on the notion of firm heterogeneity.

Empirically, the activity of multinational enterprises is among the most dynamic economic activities (followed by international trade in goods and services).[139] For instance, the average annual growth rate of foreign affiliate sales was 8.4% during the period 1996-2000 and was 16.2% in 2006.[140] The focus of empirical analyses of integration strategies of multinational enterprises (MNEs) has been on whether purely vertical or horizontal strategies are prevalent in data on foreign direct investments (FDIs). As a result of such work, indirect evidence has favored horizontal MNE models more than vertical MNE models.[141]

Work on the role of profit taxes on FDIs has suggested that FDIs react sensitively to changes in tax rates.[142] The latter indicates that the debate on optimal taxation should be of key interest to policy makers. Not only policy makers but also researchers have pointed out the importance of corporate taxation in influencing location and production decisions of irms.[143] Empirical evidence in support of this has suggested the relevance of taxation to location and volume of FDIs (i.e., production decisions of MNEs). The various impacts include the impact of the corporate tax rate

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[137] As in Markusen (1984) and Helpman (1984).

[138] Compare with Helpman, Melitz, and Yeaple (2004).

[139] In the year 2006, global FDI inflows grew for the third consecutive year and reached the level of \$1.306 trillion, being slightly below the record level of \$1.411 trillion in 2000. As in UNCTAD (2008) and World Bank Institute (2007).

[140] In the same time, the gross product of foreign affiliates increased 7.3% p.a. in the years 1996-2000 and rose by 16.2% in 2006. Exports of foreign affiliates showed an increase of 3.3% p.a. in 1996-2000 and rose by 12.2% in 2006. As in UNCTAD (2008).

[141] As supported by Markusen and Maskus (2001) and Brainard (1993a).

[142] As in Grubert and Mutti (1991) and Blonigen and Davies (2004).

[143] See Hines (1999) or Gresik (2001) for a survey.

in the the parent country on inbound FDIs, the impact of the corporate tax rate in the host country on outbound FDIs, and the effects of parent and host country taxation in terms of different methods of double taxation relief.[144]

Research regarding statutory tax rates and their impact on FDIs is abundant, containing diverse distinctions between different methods of double taxation relief and the impact of statutory corporate tax rates on MNE activities.[145] In contrast, analyzing the impact of withholding tax rates on MNE activities, we have seen that they are independent of the method of double taxation relief. For example, if foreign-earned profits are subject to withholding taxes levied, increasing withholding tax rates reduce MNE activities in the host country.[146]

Although diverse implications of withholding tax rates are cogitable, these and the impacts of tax rates on MNE activities of heterogeneous firms have hardly been studied in theoretical work.

To focus on the topics of firm heterogeneity, the increasing importance of MNEs, and the impact of corporate taxation on MNE activities, we set up a model of heterogeneous firms that select their strategies from a menu of three options: domestic operations, exporting operations or horizontal MNE activities.[147] We assume that manufacturing firms supply varieties of differentiated goods under monopolistic competition.

In our model, social welfare-maximizing governments levy withholding taxes on profits of MNEs earned by subsidiaries producing in the jurisdiction of the particular government. Furthermore, the generated tax revenue is spent for a lump-sum transfer to the households there. These corporate tax rates affect the integration strategies of heterogeneous firms. Of course, the economic structure and the nature of competition are essential for this to be a welfare-maximizing policy.[148]

We also distinguish between the perspective of a social planner and a single government on maximization, because a single government only maximizes its own national welfare. An increase in withholding tax rates, nevertheless, induces a

[144] To see the impact on inbound FDIs, see Head, Ries, and Swenson (1999) for a survey; to see the impact on outbound FDIs, see Mutti and Grubert (2004) for a survey; and for the impact of parent and host country taxation, see Swenson (1994).
[145] We can distiguish between the credit, exemption, and deduction methods. See Egger et al. (2006b) for a survey.
[146] As in Egger et al. (2006b).
[147] In contrast to Davies and Eckel (2007) assuming mobile firms.
[148] As in Dixit and Grossman (1986), Venables (1985) or Helpman and Flam (1986).

decline of MNE investments in this jurisdiction.[149] This coherence is consistent with the findings of Hines (1999) or Devereux and Griffith (2003).[150] Governments are completely informed and consider the implications of taxation on the integration strategies of heterogeneous firms and the resulting impacts on the utility of the representative household in their own jurisdictions. A social planner considers welfare implications in both countries.

The remainder of this chapter is structured as follows: In section 3.2, the model and the derived optimal integration strategies of firms in the differentiated are outlined. These depend on the relative size of fixed costs for plant set-up, market sizes, country sizes, firm productivities, transport costs, and corporate taxation. After presenting welfare maximization and government objectives, we set up a numerical framework in section 3.2.5. In contrast to related theoretical work, we endogenously derive the mass of firms entering markets as well as the market size itself.[151] We study the results of this numerical analysis, with special emphasis on the role of country size. In section 3.2.6, we flesh out the main differences of this approach relative to recent theoretical work. Finally, in section 3.3, we point to the implications of our findings in terms of optimal taxation and economic outcome.

3.2 Best-response tax rates on profits of multinational firms: A numerical approach

3.2.1 The set-up of the model

The following partial analysis is a description of the optimal integration strategies of heterogeneous firms, with particular emphasis on the role of profit taxation. We focus on the optimal tax policy of governments providing a lump-sum transfer to households in their jurisdictions depending on the integration strategies chosen by heterogeneous firms.

First, we consider a simple model with two countries, A and B, in which only one factor, labor (L), is used for production and firm or plant set-up. L is assumed to be

[149] Evidence for this can be found in Devereux (2006) and in Hines and Rice (1994).
[150] Early empirical work finds negligible effects of tax policies on FDIs. See Brainard (1997) and Wheeler and Mody (1992) for a survey.
[151] In contrast, see Grossman, Helpman, and Szeidl (2006) or Davies, Egger, and Egger (2009).

mobile between sectors but immobile across national borders. Goods may be consumed from local or foreign producers. The latter results in goods trade, which invokes iceberg-type trade costs. With regard to integration strategies, firms choose between three options: locating in one country and serving only domestic consumers, concentrating production in one country and serving consumers world-wide from there (exporting), or engaging in multi-plant production and serving consumers locally through domestic and foreign subsidiaries (MNEs).

There are two industries. One of them produces a homogeneous good x_0; the other industry produces differentiated goods. The homogeneous good is supplied under perfect competition. For the sake of elegance, we assume that one unit of labor is needed to fabricate one unit of the homogeneous good. We focus on parameter configurations, which ensure diversification of production, so that the homogeneous good is produced in both countries in equilibrium and may be traded at zero costs across national borders.

Varieties of the differentiated good are supplied under monopolistic competition. Each firm in the differentiated sector acts as a monopolist in supplying its variety. However, varieties are substitutable at an elasticity of $\sigma > 1$, which also reflects the elasticity of demand. Consequently, firms in that sector charge a fixed mark-up over marginal costs.

To enter the differentiated industry, the amount of f_d units of labor, which are sunk costs, must be invested. These can be considered as firm set-up costs. With this investment, a firm in this heterogeneous sector discovers its own potential productivity level (θ). The productivity level drawn by a firm is a random variable.

3.2.2 Demand

We assume that the preferences of households are quasi-linear and that households are identical with respect to their preferences. In formal accounts, the utility function of the representative household is represented by:

$$U_j = x_0 + \frac{1}{\mu}\left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)^{\mu}, \; j \in \{A,B\} \tag{3.1}$$

The representative household in A and B benefits from consumption of the homogeneous good x_0, which is taken as the numéraire for convenience. Furthermore, each of the two countries hosts a second industry that produces differentiated goods under monopolistic competition. $x_j(i)$ is the consumption of output of the i-th firm, which is $i \in \{0,...,\theta_{max}\}$. The condition $0<\alpha<1$ being constant results in a constant elasticity of substitution (C.E.S.) of $\sigma = 1/(1-\alpha) > 1$ between any pair of differentiated goods. This expression reflects standard properties of love for variety preferences, where a broader supply of differentiated goods results in an increased utility. μ is a constant with $0<\mu<\alpha<1$ and reflects the preference for the differentiated industry over the homogeneous industry in the utility function of the representative household. At a certain level of differentiated products supplied in one country, an additional unit shows diminishing marginal utility. The consumption of differentiated products is represented by the expression $X = \left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di \right)$, the sub-utility of the differentiated sector.

Obviously, the utility function is linear in x_0 but non-linear in the differentiated varieties. This implies that the demand for differentiated products depends on prices of differentiated goods but not on earnings.

To derive demand of a single household for the variety $x_j(i)$ in country j, we consider the utility function in (3.1) and satisfy the standard side condition $m_j \geq p_0 \cdot x_0 + \int_0^{\theta_{max}} p_j(i) \cdot x_j(i)$. Labor income m is spent on the homogeneous good, where we set p_0 = 1, and on differentiated goods. This results in the demand of a single household for differentiated goods of[152]

$$x_j(i) = \frac{1}{\left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di \right)^{\frac{1-\mu}{1-\alpha}} p_j(i)^{\frac{1}{1-\alpha}}} \tag{3.2}$$

[152] See derivation I in Appendix 3.4.

or

$$p_j(i) = \frac{1}{\left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)^{1-\mu} x_j(i)^{1-\alpha}}, \tag{3.3}$$

respectively.

The demand of a single household in country j for differentiated goods of the i-th firm depends on the price firm i sets, on how any pair of differentiated goods can be substituted for another through α, on μ, and on the sub-utility of consumption $X = \left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)$. The impact of an increasing α is that products of the differentiated sector become closer substitutes for one another, which results in reduced market power of a single firm.

As can be seen from equations (3.2) and (3.3), the size of X is determined endogenously. For this reason, X can also be interpreted as the market size for differentiated goods and demands for specification. X depends on the strategic alignment of heterogeneous firms.

We distinguish between different scenarios.

In the first case, market size X consists of the market of domestic firms, foreign firms exporting their goods from abroad (henceforth referred to as exporters), and firms choosing horizontal MNE activity. Market size X in equilibrium is defined as

$$X_{d,ex,i} = \underbrace{\left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)}_{\text{domestic (d)}} + \underbrace{\left(\int_{\theta_{d/ex}}^{\theta_{ex/i}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)}_{\text{exporter (ex)}} + \underbrace{\left(\int_{\theta_{ex/i}}^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)}_{\text{MNE (i)}}. \tag{3.4}$$

Alternatively, in another scenario, the export strategy does not exist (i.e., is not profitable). Firms choose either supplying domestically or acting as MNEs. This scenario results in a market size of

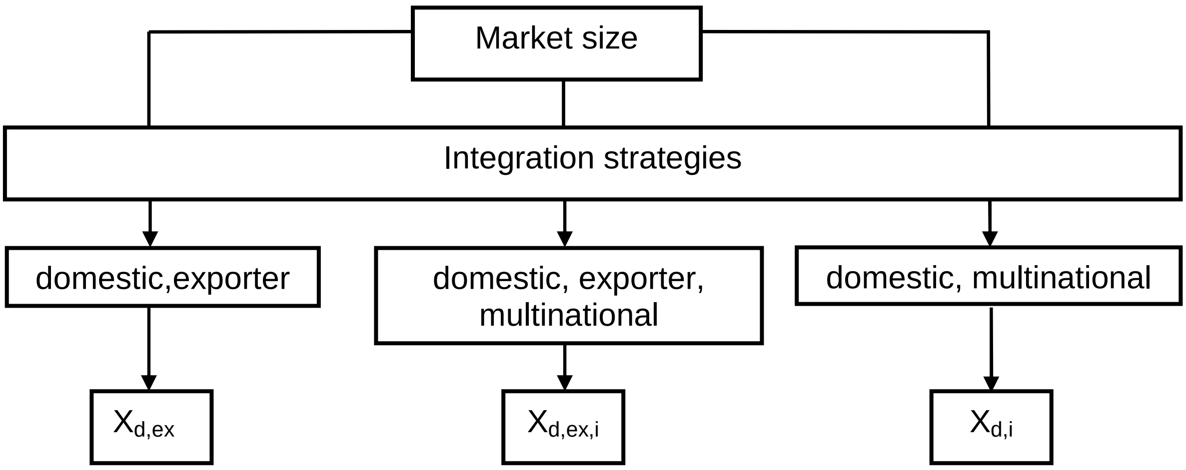
$$X_{d,i} = \underbrace{\left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)}_{\text{domestic}} + \underbrace{\left(\int_{\theta_{d/i}}^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)}_{\text{MNE}}. \tag{3.5}$$

Finally, MNE activity may be non-profitable so that market size consists of demand from domestic and exporting producers only. The specified market size in this case shows

$$X_{d,ex} = \underbrace{\left(\int_{0}^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di \right)}_{domestic} + \underbrace{\left(\int_{\theta_{d/ex}}^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di \right)}_{exporter}. \tag{3.6}$$

Graphic 3.1 shows market size under the alternative integration strategies of heterogeneous firms:

Graphic 3.1:



3.2.3 Production

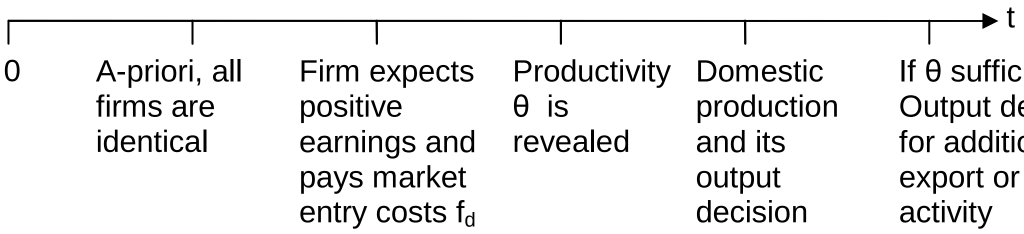
As mentioned before, we focus on equilibria with diversification of production so that each of the two countries, j={A,B}, hosts the two industries. The associated country size of A and B is reflected by s_A and s_B.

We assume that Countries A and B are endowed with a fixed amount of internationally immobile labor, L. Because the homogeneous good is freely tradable, is used as the numéraire, and one unit of L for one unit of output, there is international wage equalization at unitary wages (i.e., $w_j = 1$) as long as diversification of production prevails.

The differentiated goods available in a country j are provided by different sources. Consumers in j buy goods produced by national producers in j, imports from the other country, and goods from subsidiaries in j, where the origin of these firms is in the other country (MNEs). Hence, the mass of firms in the world equals the amount of differentiated goods potentially available.

Firms in the differentiated sector differ with respect to their productivity, but ex-ante all firms are identical. If they expect positive earnings from the production process, they pay sunk entry costs f_d upfront, which are measured in units of labor. As long as firms expect positive profits, they enter the market. It is assumed that the individual productivity levels of the firms in each country are independent draws from a cumulative productivity distribution function $F(\theta)$. The fee f_d allows the firms to independently draw their productivity from the distribution $F(\theta)$ with support over $(0, \theta_{max})$. With this procedure, firms located in the home country, even with very low productivity, will at least produce domestically in order to reduce the loss of f_d. The time line in graphic 3.2 shows the logical sequence from the moment prior to entry, where all firms are identical, to the moment where firms in the industry decide on their integration strategies and outputs.

<u>Graphic 3.2:</u>



Firms choose their integration strategies according to their productivity $\theta(i)$. In their domestic country, all firms start as domestic producers. If productivity is low, a firm will not enter the foreign market, neither through exports nor through foreign plant set-up. If productivity is high enough, a firm has the choice to serve foreign markets additionally via exports or foreign affiliate production (the latter being referred to as horizontal MNE activity). The choice between exporting and foreign plant set-up is driven by the proximity-concentration trade-off, characterized by the savings in trading costs for MNE activity relative to exports as reflected by iceberg transport costs t for cross-border trade of differentiated varieties.[153] The idea of iceberg transport costs is that to deliver of one unit of differentiated goods, the producer must ship $t \geq 1$ units to the distant point of sale. On the other hand, in foreign plant set-up the fixed costs f_i in terms of units of labor are higher than fixed costs for exporters f_{ex}

[153] See e.g. Horstmann and Markusen (1992), Brainard (1993b) or Markusen and Venables (2000) for a survey.

because production facilities must be duplicated.[154] For this reason $f_d<f_{ex}<f_i$ is assumed.

In addition to these fixed costs, firms pay variable costs, depending on their own productivity levels $\theta(i)$, on the integration strategies (i.e. exporters pay transport costs t>1), and on country size [i.e., $s_j x_j(i)t/\theta(i)$]. Hence, country size s_j reflects the total demand for variety i in j and t=1 for domestic producers and MNEs.
Given two firms with the same amount of output in one country, the firm with higher productivity $\theta(i)$ must bear lower variable costs, according to $s_j x_j(i)/\theta(i)$.

Furthermore, governments may choose positive profit tax rates subject to foreign MNEs to maximize welfare in their own jurisdiction. If tax revenue in j is positive, it is passed on to households in j as a lump-sum transfer. In this analysis, a government in j can levy taxes on profits earned by MNEs in j. These MNEs are headquartered in the other country, and only the profits earned from production in the plant in j can be taxed by the government in j (i.e., the location of tax payment is identical with an MNE's subsidiary location). Therefore, in this setting, double taxation is not the problem of the analysis.[155]
For this reason, γ_A denotes a withholding tax rate of the government in A on profits of an MNE plant in A, where the origin of this firm is in B. With $\gamma_A>0$, these firms consider γ_A an additional factor influencing profits. γ_B denotes a withholding tax rate of the government in B on profits of an MNE plant in B, where the origin of this firm is in A.
Because γ_j describes a withholding tax rate on profits earned by subsidiaries, taxation is not considered for domestic and exporting profits (i.e., γ_A and γ_B are relevant parameters considering profits of MNEs only).

Given the household demand in (3.2) and the price consumption curve in (3.3), it is straightforward to compute maximum attainable profits for a firm in j serving its domestic market:

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[154] As in Helpman, Melitz, and Yeaple (2004).
[155] As in Egger et al. (2006a).

$$\pi_j(i)_d = s_j p_j(i)_d x_j(i)_d - \frac{s_j x_j(i)_d}{\theta(i)} - f_d$$

$$= s_j \frac{1}{X^{(1-\mu)} x_j(i)_d^{(1-\alpha)}} x_j(i)_d - \frac{s_j x_j(i)_d}{\theta(i)} - f_d$$

The derivative with respect to $x_j(i)$ yields

$$\frac{\partial \pi_j(i)_d}{\partial x_j(i)_d} = s_j \alpha x_j(i)_d^{(\alpha-1)} \frac{1}{X^{(1-\mu)}} - \frac{s_j}{\theta(i)} = 0 .$$

This finally results in an expression for the profit maximizing output of a firm i in its domestic market j, $j \in \{A,B\}$,[156]

$$x_j(i)_d^* = \frac{(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}}, \tag{3.7}$$

associated with the optimal price[157]

$$p_j(i)_d^* = \frac{1}{\alpha\theta(i)} . \tag{3.8}$$

The optimal output of a firm in the domestic market depends on market size X.[158] According to (3.7), the optimal output level of a single firm is negatively correlated with X due to competitive conditions. Furthermore, the productivity level of a firm is positively correlated with its output.

In setting the price, firms follow standard mark-up pricing in which higher productivity is associated with smaller price. The mark-up is represented by the factor $\frac{1}{\alpha}$.

Accordingly, maximum attainable profits of a domestic firm in j are given by[159]

$$\pi_j(i)_d^* = \frac{s_j(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{1-\mu}{1-\alpha}}\theta(i)} \left(\frac{1}{\alpha} - 1\right) - f_d . \tag{3.9}$$

Analogously, we now can derive profits of firms with an export strategy. Profits of exporters from Country A are defined by

$$\pi_A(i)_{ex} = \underbrace{s_B p_B(i)_{ex} x_B(i)_{ex} - \frac{s_B x_B(i)_{ex} t}{\theta(i)} - f_{ex}}_{\text{engage in exports if} > 0} + \underbrace{s_A p_A(i)_d x_A(i)_d - \frac{s_A x_A(i)_d}{\theta(i)} - f_d}_{\text{domestic profits}} . \tag{3.10}$$

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[156] See derivation II in Appendix 3.4.
[157] See derivation II in Appendix 3.4.
[158] The market size X has to be specified according to $X_{d,ex}$, $X_{d,ex,i}$ or $X_{d,i}$.
[159] See derivation II in Appendix 3.4.

Profits of exporters from Country B are defined by

$$\pi_B(i)_{ex} = \underbrace{s_A p_A(i)_{ex} x_A(i)_{ex} - \frac{s_A x_A(i)_{ex} t}{\theta(i)} - f_{ex}}_{\text{engage in exports if} >0} + \underbrace{s_B p_B(i)_d x_B(i)_d - \frac{s_B x_B(i)_d}{\theta(i)} - f_d}_{\text{domestic profits}} . \tag{3.11}$$

An exporting firm has two sources of earnings. The company generates profits from domestic sales and export activity. The variable costs for exports depend on t. For a firm i from j, the expression results in optimal output in the other country (output for exporting),[160]

$$x_j(i)^*_{ex} = \frac{(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{1}{(1-\alpha)}}} \tag{3.12}$$

associated with the optimal price for exports,[161]

$$p_j(i)^*_{ex} = \frac{t}{\alpha\theta(i)} . \tag{3.13}$$

In addition to the previous analysis, we can see that the optimal output and price for exports depend on transport costs t in contrast to the optimal output and price when supplying domestic demand. Accordingly, maximum attainable profits of a firm i from A, exporting to B, are given by[162]

$$\pi_A(i)^*_{ex} = \frac{s_B(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{\alpha}{(1-\alpha)}} \theta(i)} \left(\frac{1}{\alpha} - 1\right) - f_{ex} + \pi_A(i)^*_d . \tag{3.14}$$

Analogously, this can be derived for a firm i from B exporting to A.

Now, it is straightforward to compute maximum attainable profits for firms engaged in multinational activities. As they produce goods for both markets locally, transport costs do not occur. Instead a firm i from Country A opens an affiliate in B and becomes a horizontal MNE.

To maximize social welfare, a government in j may choose to levy withholding taxes on profits of foreign MNEs earned by subsidiaries in its jurisdiction.
Profits of an MNE headquartered in Country A are defined by

160 See derivation III in Appendix 3.4.
161 See derivation III in Appendix 3.4.
162 See derivation III in Appendix 3.4.

$$\pi_A(i)_i = \underbrace{\left(s_B p_B(i)_i x_B(i)_i - \frac{s_B x_B(i)_i}{\theta(i)} \right)(1-\gamma_B) - f_i}_{\text{engage in MNE if } >0} + \pi_A(i)_d . \tag{3.15}$$

Profits of an MNE headquartered in Country B are defined by

$$\pi_B(i)_i = \underbrace{\left(s_A p_A(i)_i x_A(i)_i - \frac{s_A x_A(i)_i}{\theta(i)} \right)(1-\gamma_A) - f_i}_{\text{engage in MNE if } >0} + \pi_B(i)_d . \tag{3.16}$$

An MNE expects at least zero profits from running both domestic and foreign subsidiaries. Profit maximizing plant output is,[163]

$$x_j(i)_i^* = \frac{(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}} , \tag{3.17}$$

associated with optimal price[164]

$$p_j(i)_i^* = \frac{1}{\alpha}\frac{1}{\theta(i)} . \tag{3.18}$$

Accordingly, the maximum attainable profits of a multinational firm i headquartered in Country A are given by[165]

$$\pi_A(i)_i^* = \frac{s_B(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}(1-\gamma_B)}{X^{\frac{(1-\mu)}{(1-\alpha)}}\theta(i)}\left(\frac{1}{\alpha}-1\right) - f_i + \pi_A(i)_d^* . \tag{3.19}$$

Analogously, this can be derived for MNEs from B with subsidiaries in A.

Firms choose their integration strategies based on the knowledge of their productivity levels. This results in the cut-off levels being the determinants of minimum levels of productivity for a firm i to generate zero profits additionally when ex-ante selecting a strategy with more than domestic production. In general, more productive firms are more successful in all three strategies.

The least productive firms only serve the domestic market through domestic production. Because of their low productivity, their variable costs are too high. Therefore, the higher fixed costs to operate on an additional market cannot be covered.

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[163] See derivation IV in Appendix 3.4.
[164] See derivation IV in Appendix 3.4.
[165] See derivation IV in Appendix 3.4.

At this point, the cut-off levels must be analyzed.

At the first cut-off level productivity of a firm is such that additional profits of exporting exactly result in zero profits.

For a firm i from A and exporting to B, this is derived from

$$\pi_A(i)_{ex} = \underbrace{s_B p_B(i)^*_{ex} x_B(i)^*_{ex} - \frac{s_B x_B(i)^*_{ex} t}{\theta(i)} - f_{ex}}_{=D} + \underbrace{\pi_A(i)_d}_{\text{domestic profits}} .$$

Analogously, this holds true for a firm i from B exporting to A.

With $D \geq 0$, this applies for[166]

$$\theta_{d/ex} = \frac{f_{ex}^{\frac{(1-\alpha)}{\alpha}} t X^{\frac{(1-\mu)}{\alpha}}}{\alpha\left(s_j(1-\alpha)\right)^{\frac{(1-\alpha)}{\alpha}}} . \tag{3.20}$$

The market size X results endogenously according to $X_{d,ex,i}$. Furthermore, the cut-off productivity depends on the country size s_j. The larger the foreign country s_j, the smaller the productivity of a firm has to be for the export strategy to become reasonable. A firm with productivity $\theta_{d/ex}$ generates zero profits from exporting. Hence, this firm is indifferent in terms of only selling domestically or engaging in exports in addition to domestic sales. A firm with productivity just above this level is already earning positive profits from exporting and will definitely engage in exporting.

The critical productivity level in (3.20) is positively correlated with t, f_{ex} and market size X. Hence, the indifferent firm must be more productive to break even. In other words, a higher productivity yields lower variable costs of production. Furthermore, conditional on the existence of the export strategy, productivity levels exist that ensure that profits of exporters´ exceed profits of MNEs.

The next threshold, profits of an exporting firm equal profits of an MNE (i.e., $\pi(i)_{ex} = \pi(i)_i$).[167]

This applies to $$\theta_{ex/i} = \frac{(f_i - f_{ex})^{\frac{(1-\alpha)}{\alpha}} \cdot X^{\frac{(1-\mu)}{\alpha}}}{s_j^{\frac{(1-\alpha)}{\alpha}} \alpha(1-\alpha)^{\frac{(1-\alpha)}{\alpha}} \left((1-\gamma_j) - t^{\frac{-\alpha}{(1-\alpha)}}\right)^{\frac{(1-\alpha)}{\alpha}}} . \tag{3.21}$$

[166] See derivation V in Appendix 3.4.
[167] See derivation VI in Appendix 3.4.

Only firms with $\theta(i) > \theta_{ex/i}$ gain positive profits from serving foreign markets through building subsidiaries instead of exporting their goods.

$\theta_{ex/i}$ depends on the difference in fixed costs $(f_i - f_{ex}) > 0$ which can be interpreted as overhead and set-up costs of an MNE subsidiary. The higher the overhead costs $(f_i - f_{ex})$ for a foreign subsidiary are, the more productive the indifferent firm must be to engage in MNE activity (i.e., the cut-off level $\theta_{ex/i}$ takes over a higher value). The higher the transport costs t are, the more likely firms are to engage in the MNE integration strategy. Higher transport costs, therefore, result in a lower value of $\theta_{ex/i}$. The larger the foreign country s_j, the smaller the productivity of a firm must be for the export strategy to become reasonable.

Furthermore, only if $(1-\gamma_j) > t^{\frac{-\alpha}{(1-\alpha)}}$ holds does a real and unique solution exists. If the parameter configuration of the transport costs t, the tax rate γ and α does not satisfy this condition, MNE activities do not exist.

Alternatively, certain configurations of parameters may result in a situation in which domestic firms integrate directly as MNEs instead of choosing the export strategy. The following cut-off level is the relevant productivity threshold if $\theta_{d/i} < \theta_{d/ex}$. The associated cut-off level results from

$$\pi_A(i)_i = \underbrace{\left(s_B p_B(i)_i^* x_B(i)_i^* - \frac{s_B x_B(i)_i^*}{\theta(i)} \right)(1-\gamma_B) - f_i}_{=E} + \pi_A(i)_d ,$$

or

$$\pi_B(i)_i = \underbrace{\left(s_A p_A(i)_i^* x_A(i)_i^* - \frac{s_A x_A(i)_i^*}{\theta(i)} \right)(1-\gamma_A) - f_i}_{=E} + \pi_B(i)_d \text{ , with E>0, and shows}^{168}$$

$$\theta_{d/i} = \frac{f_i^{\frac{(1-\alpha)}{\alpha}} X^{\frac{(1-\mu)}{\alpha}}}{\alpha\left(s_j(1-\gamma_j)(1-\alpha)\right)^{\frac{(1-\alpha)}{\alpha}}} . \qquad (3.22)$$

The associated market size X in this scenario endogenously results in $X_{d,i}$. The larger the foreign country s_j, the smaller the productivity of a firm must be for the MNE strategy to become reasonable.

[168] See derivation VII in Appendix 3.4.

For $\theta_{d/i} < \theta_{d/ex}$ so that this cut-off level exists, the following condition must hold[169]

$$(1-\gamma_j) \geq \frac{f_i}{f_{ex} t^{\frac{\alpha}{(1-\alpha)}}} \tag{3.23}$$

3.2.4 Welfare maximization and the objective of the governments

In the following, governments can set profit taxes in a first stage and cannot rescind their offers by assumption. Then, firms decide upon their optimal integration strategies, whereas the governments take this into account when setting tax rates. A government chooses a withholding tax rate $0 < \gamma_j < 1$, $j \in \{A,B\}$, to capture profits of foreign MNEs earned in plants in j. Hence, MNE profits from production in j are taxed by the government in j. This tax revenue is passed on to the households within that jurisdiction. When selecting an optimal tax rate γ_j, the government in j maximizes the utility of the representative household in its country.

Furthermore, transport costs t reduce exporting firm profits and are given exogenously. Taxation reduces MNE profits, where tax rates are set endogenously by both governments. The set of optimal integration strategies is influenced by these transport costs and profit taxes, both of which have an impact on the mass of firms choosing the different optimal integrations strategies.

3.2.4.1 The objective of the governments

In this section, cases are analyzed in which the governments of both countries, A and B, can levy withholding taxes γ_A and γ_B, which are taken into account in the MNE profit functions. In this setting, taxes are paid on MNE profits either in A or in B. The location of tax payments depends on the production location of the firm.

Furthermore, by assumption, households do not know the underlying tax basis for provision of the lump-sum transfer so that the composition of consumption of differentiated goods is not distorted.

The price for the homogeneous product is p_0=1; and prices for differentiated products are shown by $p_j(i)$, where $p_j(i)$ is the price for variety i in country j.

As already shown, the utility of the representative household in country j, $j \in \{A;B\}$, is given by (3.1), which can also be shown by:

[169] See derivation VII in Appendix 3.4.

$$U_j = m_j - \int_0^{\theta_{max}} p_j(i)x_j(i)di + \frac{1}{\mu}\left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)^{\mu} \tag{3.24}$$

The utility of a representative household increases in m_j and declines in $p_j(i)$.

For a government to pass on a lump-sum transfer to the households in its jurisdiction j and, therefore, to select γ_j>0, the utility of the representative household with lump-sum transfer may not be smaller than the utility shown in (3.24), considering the implications of profit taxation in the other jurisdiction. Hence, government tax revenue depends on the strategies chosen by the firms. For this reason, the firm profit functions depending on tax rates must be examined to consider the associated utility function, including lump-sum transfer.

To show these welfare implications, optimal integration strategies with taxation are examined in the following sub-section.

3.2.4.2 Strategic alignment

According to alternative parameter configurations, strategic alignments of firms and their impact on welfare with γ_j>0 are examined in the following:

(a) For all integration strategies to coexist, these conditions must hold:

- $\theta_{d/ex} < \theta_{ex/i}$, which results in a relation between the fixed costs; transport costs t; and the tax rate γ_j:

$$(1-\gamma_j) < \frac{1}{t^{\frac{\alpha}{(1-\alpha)}}}\left(\frac{(f_i - f_{ex})}{f_{ex}} + 1\right) \tag{3.25}$$

- Furthermore, for the MNE strategy to exist $(1-\gamma_j) > t^{\frac{-\alpha}{(1-\alpha)}}$ must hold.[170] The resulting utility function of the representative household with lump-sum transfer is given by:

$$\begin{aligned} U_j = m_j &- \left(\int_0^{\theta_{max}} p_j(i)_d^* x_j(i)_d^* di + \int_{\theta_{d/ex}}^{\theta_{ex/i}} p_j(i)_{ex}^* x_j(i)_{ex}^* di + \int_{\theta_{ex/i}}^{\theta_{max}} p_j(i)_i^* x_j(i)_i^* di\right) \\ &+ \frac{1}{\mu}\left(\int_0^{\theta_{max}} \frac{1}{\alpha}(x_j(i)_d^*)^{\alpha} di + \int_{\theta_{d/ex}}^{\theta_{ex/i}} \frac{1}{\alpha}(x_j(i)_{ex}^*)^{\alpha} di + \int_{\theta_{ex/i}}^{\theta_{max}} \frac{1}{\alpha}(x_j(i)_i^*)^{\alpha} di\right)^{\mu} \\ &+ \frac{\gamma_j}{s_j}\int_{\theta_{ex/i}}^{\theta_{max}}\left(s_j p_j(i)_i^* x_j(i)_i^* - \frac{s_j x_j(i)_i^*}{\theta(i)}\right) di \end{aligned} \tag{3.26}$$

[170] See derivation VI in Appendix 3.4.

(b) Alternative parameter configurations can result in a situation in which only domestic firms and MNEs enter production. For this constellation to exist, the following conditions must hold:

- $\theta_{d/i} < \theta_{d/ex}$, which results in a relation between the fixed costs; transport costs t; and the tax rate γ_j:[171]

$$(1-\gamma_j) \geq \frac{f_i}{f_{ex} t^{\frac{\alpha}{(1-\alpha)}}}$$

- Furthermore, to ensure that the MNE strategy exists, it follows from $\theta_{d/i}$ that $(1-\gamma_j)(1-\alpha)s_j \neq 0$ must hold. Therefore, governments must select γ_j<1.

The resulting utility function of the representative household with lump-sum transfer is given by:

$$\begin{aligned} U_j = m_j &- \left(\int_0^{\theta_{max}} p_j(i)^*_d x_j(i)^*_d di + \int_{\theta_{d/i}}^{\theta_{max}} p_j(i)^*_i x_j(i)^*_i di \right) \\ &+ \frac{1}{\mu} \left(\int_0^{\theta_{max}} \frac{1}{\alpha} (x_j(i)^*_d)^{\alpha} di + \int_{\theta_{d/i}}^{\theta_{max}} \frac{1}{\alpha} (x_j(i)^*_i)^{\alpha} di \right)^{\mu} \\ &+ \frac{\gamma_j}{s_j} \int_{\theta_{d/i}}^{\theta_{max}} \left(s_j p_j(i)^*_i x_j(i)^*_i - \frac{s_j x_j(i)^*_i}{\theta(i)} \right) di \end{aligned} \tag{3.27}$$

(c) Alternative parameter configurations may result in a situation in which no MNEs enter production. Then, following conditions hold:

- The MNE strategy only exists if $(1-\gamma_j) > t^{\frac{-\alpha}{(1-\alpha)}}$ holds. Otherwise, only domestic and exporting strategies are chosen.

- Additionally, to guarantee that the export strategy exists, $\theta_{d/ex} < \theta_{max}$ must hold. This can also be written as:

$$\frac{f_{ex}^{\frac{(1-\alpha)}{\alpha}} X^{\frac{(1-\mu)}{\alpha}} t}{\alpha (s_j(1-\alpha))^{\frac{(1-\alpha)}{\alpha}}} < \theta_{max} \tag{3.28}$$

The resulting utility function of the representative household is given by:

[171] See derivation VI in Appendix 3.4.

$$U_j = m_j - \left(\int_0^{\theta_{max}} p_j(i)_d^* x_j(i)_d^* di + \int_{\theta_{d/ex}}^{\theta_{max}} p_j(i)_{ex}^* x_j(i)_{ex}^* di \right)$$
$$+ \frac{1}{\mu} \left(\int_0^{\theta_{max}} \frac{1}{\alpha} (x_j(i)_d^*)^\alpha di + \int_{\theta_{d/ex}}^{\theta_{max}} \frac{1}{\alpha} (x_j(i)_{ex}^*)^\alpha di \right)^\mu \tag{3.29}$$
$$+ \frac{\gamma_j}{s_j} \cdot 0$$

Without firms selecting MNE activities, a tax base does not exist. For this reason, a lump-sum transfer to the representative household cannot be provided independent of the size of γ_j.

(d) Alternative parameter configurations may result in a situation in which only domestic firms enter production. For this constellation to exist, the following conditions have to hold: $\theta_{d/ex} > \theta_{max}$ and $\theta_{d/i} > \theta_{max}$.

The resulting utility function of the representative household is given by:

$$U_j = m_j - \left(\int_0^{\theta_{max}} p_j(i)_d^* x_j(i)_d^* di \right)$$
$$+ \frac{1}{\mu} \left(\int_0^{\theta_{max}} \frac{1}{\alpha} (x_j(i)_d^*)^\alpha di \right)^\mu \tag{3.30}$$
$$+ \frac{\gamma_j}{s_j} \cdot 0$$

Without firms selecting MNE activities, a tax base does not exist. For this reason, a lump-sum transfer to the representative household cannot be provided independent of the size of γ_j.

3.2.4.3 The decisions of the governments

The decisions of the governments depend on the exogenous variables, such as transport costs, country size, variable costs, fixed costs, and the firm productivities, resulting in a set of optimal integration strategies.

First, prices of a single firm do not change because of the taxes levied. These are only influenced by transport costs.[172]

Transport costs are passed on to the households, whereas taxes are paid by the firms; and prices in A and B for goods from the same firm only differ if transport costs exist.

[172] For optimal prices $p_j(i)^*$ see derivations II, III and IV in Appendix 3.4.

If a strategy of production in A and B is reasonable, not all profits of a firm are taxed. Instead, only profits generated by MNEs in the foreign market are subject to taxation of the foreign government. Hence, the government in B taxes the profits gained in B of MNEs that have their origin in A and vice versa.

Governments considered the following aspects when setting their optimal tax rate $0<\gamma_j<1$:

1. Firm profits, including taxation, only change if levied taxes influence a firm to choose a strategy other than MNE activities as optimal. If this is true, government tax revenues also change because the mass of firms choosing MNE activities is influenced by the size of γ_j.
2. Prices in the differentiated sector depend on the chosen strategies of firms, and the mass of firms selecting the MNE strategy depends on γ_j. If $\theta_{d/ex} < \theta_{ex/i}$, this impact on the utility of households in j arises if firms select the export strategy instead of MNE activity as optimal because of taxation in j.
3. The degree of taxation influences the mass of firms entering the market in j because of profit taxation in j. The utility of households in j is affected by this variety effect.
4. In general a, lump-sum transfer is additional income for households in that country and is spent on x_0.
5. If firms in the differentiated sector select strategies other than at γ_j=0, the working income of households is not lowered because they can work in the homogeneous sector.
6. When selecting γ_j>0, the tax rate selected by one government depends on the tax rate of the other.
7. The market size X results endogenously and depends on the selected γ_j.

Only if the positive impacts of taxation outweigh the negative ones are governments acting as benevolent planners interested in selecting $0<\gamma_j<1$.

For this reason, each government solves $\frac{\partial U}{\partial \gamma_j}$, as in (3.26) and (3.27). In these expressions, the market size has different outcomes depending on the integration strategies heterogeneous firms choose. This endogeneity of the market size X results in a situation in which every parameter configuration results in a corresponding level of X. This implies that the mass of firms in equilibrium varies endogenously.

Due to market entry conditions, expected profits according to (3.26), (3.27), (3.29) and (3.30) are competed to zero. As an example, consider the situation in (3.26). Expected profits for all firms headquartered in A are defined by:

$$
\begin{aligned}
E\pi_A = & \int_0^{\theta_{max}} \frac{s_A(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}\theta(i)}\left(\frac{1}{\alpha}-1\right)-f_d + \int_{\theta_{d/ex}}^{\theta_{ex/i}} \frac{s_B(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}t^{\frac{\alpha}{(1-\alpha)}}\theta(i)}\left(\frac{1}{\alpha}-1\right)-f_{ex} \\
& + \int_{\theta_{ex/i}}^{\theta_{max}} \frac{s_B(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}(1-\gamma_j)}{X^{\frac{(1-\mu)}{(1-\alpha)}}\theta(i)}\left(\frac{1}{\alpha}-1\right)-f_i = 0
\end{aligned}
\tag{3.31}
$$

Vice versa, this also accounts for all firms headquartered in B.

Furthermore, market size X and the mass of firms in equilibrium are interdependent. The market size X and the mass of firms induce further interdependences to other equilibrium determining expressions (i.e., the cut-off levels and the demand of the households).

Even without the complexity induced by the linkages of the different variables, the maximization of welfare, $\frac{\partial U}{\partial \gamma_j}$, results in a problem with a dimensionality higher than fourth degree.[173] These aspects preclude an analytical solution of $\frac{\partial U}{\partial \gamma_j}$ and suggest using numerical analysis to determine the welfare maximizing tax rates γ_j and their interactions with other variables.

3.2.5 Set-up of the numerical framework

To derive a solution to this problem and to find a welfare maximizing expression for the tax rate γ_j we use Mathematica 7.0. This program is utilized to set up the numerical framework that represents the theory of the model as derived in previous sections.[174]

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[173] A derivation of a unique solution with dimensionality higher than fourth degree cannot be provided. This is proved by the theory of Galois. For a survey see Taton (1983).

[174] See derivation VIII in Appendix 3.4 for the full input sheet with given values for specific variables.

3.2.5.1 Definitions

The coding of the numerical framework starts with defining variables and making assumptions. Analogously to the assumptions of the model, the fixed costs, θ_{max}, α, and μ are set to constant numerical values, considering $f_d<f_{ex}<f_i$ and $0<\mu<\alpha<1$.

After paying the market-entry costs of f_d, a firm draws its individual productivity level θ. We apply a uniform distribution of the firms over θ, specified as `F[θ_]`. The distribution function is defined piecewise to ensure that `F[θ_]` takes the value 0 if the distribution is not reached and takes the value 1 in the boundaries of θ_{min} and θ_{max}. To guarantee continuous results, firms are ranked according to individual productivity, starting with low productive firms, reflected by the expression `θ[i_,n_]`. The productivity of the single firm `θ[i_,n_]` depends on the rank `i` of the i-th firm, given a mass of firms in the economy n.

For further analysis, a function to provide the rank of the indifferent firm that is between two strategies is computed using the expression `inr[θ_,n_]`, which reports the rank of the firm given the productivity θ and the mass of firms n founded in the country.

The demand of the representative household as in (3.2), results in optimal output for the firms as derived previously. Therefore, the computation of the profit-maximizing output is represented by `x[θ_,X_,t_,γ_]`. The optimal output of a firm i depends on its productivity θ, the market size X, the transport costs t, and the withholding tax rate γ_j. As the tax rate of country j, γ_j, is only relevant for the MNE strategy, we must consider γ_j=0 for both the domestic and the exporting strategies.

The choice of the integration strategy of firms is driven by cut-off productivity thresholds. They are coded as follows: The first threshold separates domestic producers from exporters from j and is computed as `θde[X_,s_,t_]`, considering X and s in the country in which the differentiated goods are sold. The associated firm number is reported by `ide[n_,X_,s_,t_]`. With this expression, the rank of the indifferent firm is calculated in terms of productivity, depending on the endogenous mass of firms n in j, the endogenous market size in the other country, its country size, and the transport costs t. Because the domestic and exporting strategy both are independent of the tax rate, `ide[n_,X_,s_,t_]` does not depend on it. For example, by entering `ide[25000,5000,1,1.05]`, the system calculates the rank of the indifferent firm ide with cut-off productivity $\theta_{d/ex}$ to be the 19912nd firm, given a mass of 25000 firms in this country, a market size of 5000, a country size of 1, and transport costs of 1.05. Hence, the 19913rd firm out of 25000 exports for sure.

Analogously we compute the threshold productivity $\theta_{ex/i}$ as θei[X_,s_,t_,γ_] with the associated rank iei[n_,X_,s_,t_,γ_], considering X, s, and γ in the country in which the economic activity takes place. The same notion is used to code the cut-off level $\theta_{d/i}$ as θdi[X_,s_,t_,γ_], linked to the rank idi[n_,X_,s_,t_,γ_], considering X, s, and γ in the country in which the economic activity takes place.

3.2.5.2 Consistency of market size X

The inclusion of the endogenously defined market size X from a demand perspective as in section 3.2.2, into the numerical model does not result in the consistency needed to derive results. The proof of inconsistency starts with computing market size of country j from a supply perspective for firms active in the different strategies in j, $j\in\{A,B\}$ (i.e., Yd [supply of domestic firms from A vice versa from B], Yex [supply of exporting firms from B and vice versa from A], Yin [supply of MNEs with origin in B and vice versa with origin in A]). The market size for domestic producers in A, referring to the representative household, yields Yd[nA_,X_,t_]. Yd depends on the mass of firms in the domestic market nA, the market size X in A itself and transport costs t. It is characterized by the integral over the output of all domestic firms i.

Analogously, we compute the market size of firms that export from Country B to Country A. From the perspective of firms producing in B and exporting to A, the export market size, referring to the representative household in A, is given by Yex[nB_,X_,s_,t_,γ_]. The size of the export market of firms from B in A depends on the mass of firms located in B(nB), on the market size X in A, the country size s in A, transport costs t, and the tax rate γ in A. The definition of Yex in the numerical analysis also considers the scenario that possibly no exporters exist.

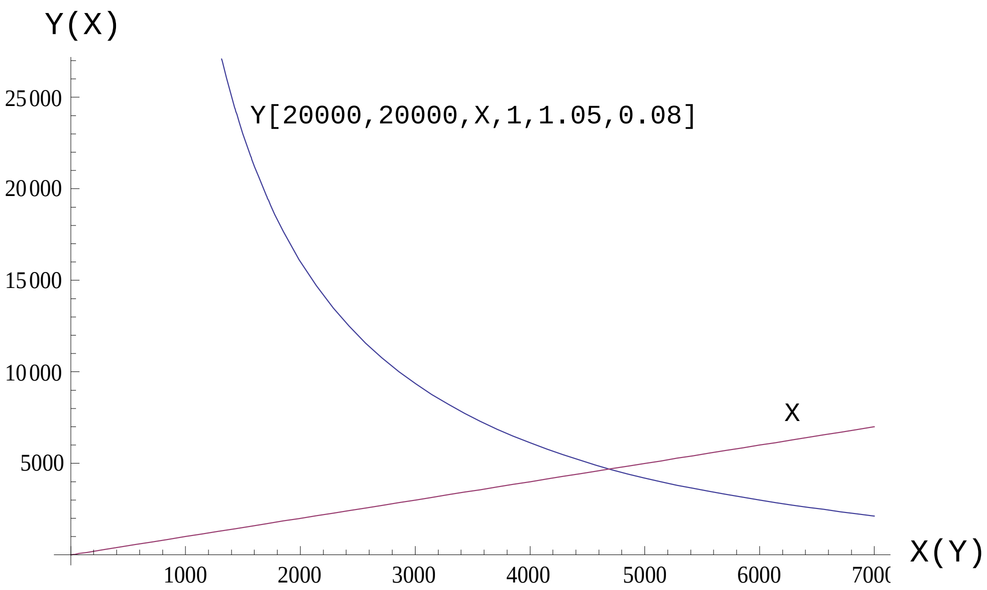
The market size for multinational firms in terms of the representative household is defined by `Yin[nB_,X_,s_,t_,γ_]`.The market for MNEs in A depends on the mass of firms located in B (nB), the market size X in A, the country size s in A, transport costs t, and the tax rate γ in A. This coding also includes conditions to guarantee that the system integrates correctly regarding prevailing integration strategies.

The entire market size from a supply perspective, referring to the representative household in A, is determined as the sum of all three market segments and is represented by:

```
Y[nA_,nB_,X_,s_,t_,γ_]:=Yd[nA,X,t]+Yex[nB,X,s,t,γ]+Yin[nB,X,s,
t,γ]
```

Inconsistency in the market size will result in differing outcomes regarding the market size from supply (Y) and demand (X) perspectives. If the configuration is consistent we should expect a result of Y=5000, for example, if X is 5000. However, using the code defined previously, inserting X=5000, Y=5000 does not necessarily occur. For example, Y[20000,20000,5000,1,1.05,0.08] results in a market size of Y= 4192.26. The inconsistency of the market size can be clarified with graphic 3.3:[175]

Graphic 3.3:

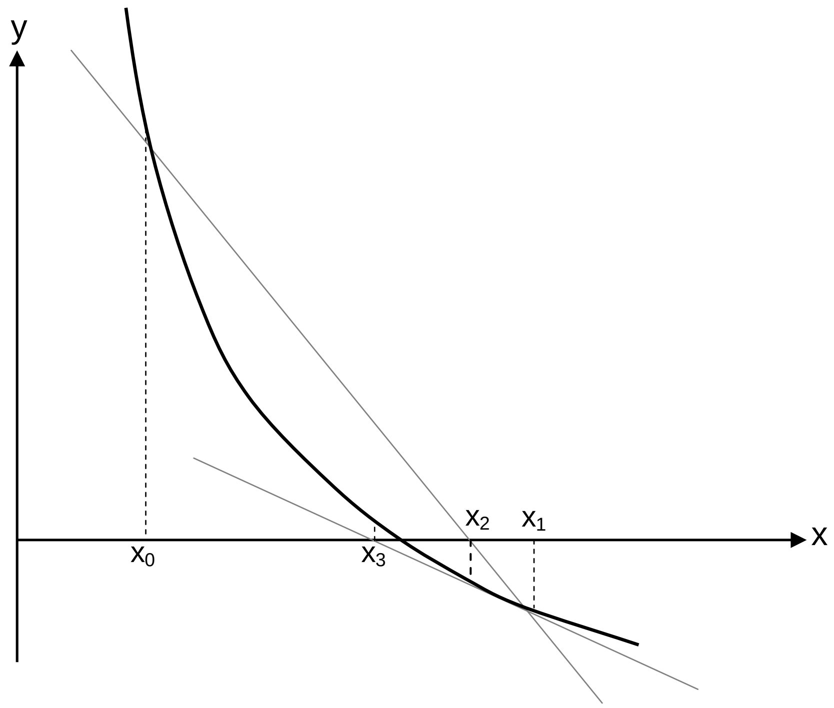


[175] The plot can be implemented using the code:
`Plot[{Y[20000,20000,X,1,1.05,0.08],X},{X,0,7000},AxesLabel→{X(Y),Y(X)}].`

The inconsistency of the market size in graphic 3.3 is obvious. The curve of the market size X itself has a different progression than the curve Y. The intersection of both curves gives the true market size for the given values, i.e. Xm=4691.47.

To achieve the essential consistency of market size, the computation uses a Quasi-Newton method, computed as `Xm[nA_,nB_,s_,t_,γ_]`.[176] The method is so named, because we use an approximation for the slope, using the gradient of the secant of the function `Xm`, for which we search. Graphic 3.4 shows the visualization of the method:[177]

Graphic 3.4:



The program is coded to find the null, starting to calculate the secant at a value of 1000 (in graphic 3.4 this corresponds to x_0), assuming a width of 20 (in graphic 3.4 this corresponds to the second value x_1). The slope of the secant results in a null, which is the next starting value (in graphic 3.4 this corresponds to x_2). The slope of the secant associated with this new starting value results in a new null (in graphic 3.4 this corresponds to x_3).

This iteration is repeated until the exact null is found. Meanwhile, the width in which the boundaries of the slope of the secants are calculated is reduced stepwise.

[176] As in Spelucci (1993) and Knorrenschild (2008).
[177] As in Knorrenschild (2008).

3.2.5.3 The mass of firms in equilibrium

Firm decisions to enter the market are based on the expectation of future profits. Heterogeneous firms enter production as long as their future earnings expectations are positive. Hence, the mass of firms in the market is determined by expected profits being equal to zero. After computing the profit function of the single firm i with its particular strategy, expected profits are determined by the profits of all firms in the specific market. The profit functions of the single firms in the different strategies are computed.

For a firm selecting the domestic strategy in Country A we apply `Gd[i_,nA_,nB_,s_,t_,γ_].` We must consider that the tax rate γ has to be set to 0 and transport costs to 1 because they both are not relevant for domestic producers. Furthermore, the rank of the i-th firm, the mass of firms in A and B and the country size of A must be considered to compute `Gd` of the i-th firm. Although this firm selects the domestic strategy in Country A, the mass of firms in B must be considered because of competitive conditions.

The profit of a firm in the export strategy is computed as `Gex[i_,nA_,nB_,sB_,t_,γB_].` Profits of an exporting firm, i, from A to B depend on the mass of firms in A and B (nA and nB), the size of B(sB), transport costs t that apply for the export strategy, and the tax rate being applied in B, i.e. γB for MNEs.

The profit function of MNEs originally located in A with subsidiaries in B is coded as `Gin[i_,nA_,nB_,sB_,t_,γB_].` Profits of an MNE, i, from A, being an MNE in B, also depend on the mass of firms in A and B (nA and nB), the size of B (sB), transport costs t that would apply for the export strategy, and the tax rate on profits of MNEs earned in B being applied in B (γB).

Expected profits (`EG`) in an economy result from the integration of profits over all firms in the different strategies.

For A they are given by:

```
EG[nA_,nB_,sA_,sB_,t_,γA_,γB_]:=EGd[nA,nB,sA,t, γA]+EGex[nA,nB,
sB,t, γB]+EGin[nA,nB,sB,t, γB].
```

The computation of expected profits includes conditions to ensure that profits are only integrated if the associated strategy exists.

Finally, coding the mass of firms in equilibrium results from expected profits being competed to zero by firms entering the market.

For firms in A, this is given by:

`Firms[nB_,sA_,sB_,t_,γA_,γB_]`.The process to find the null is coded by the instruction to test several values in defined steps. After determining the first negative value of expected profits, the program jumps back to exactly approach the null while the width of the steps is permanently reduced.

For example, the instruction to calculate the mass of firms in equilibrium in A given nB=18000, sA=1, sB=1, t=1.05, γA=0.08, γB=0.08 is depicted by

`Firms[18000,1,1,1.05,0.08,0.08].`

The example results in 12852.1 firms in A given 18000 firms in Country B, with associated expected profits of -0.00004, thus supporting the previously described method.

3.2.5.4 Equilibria

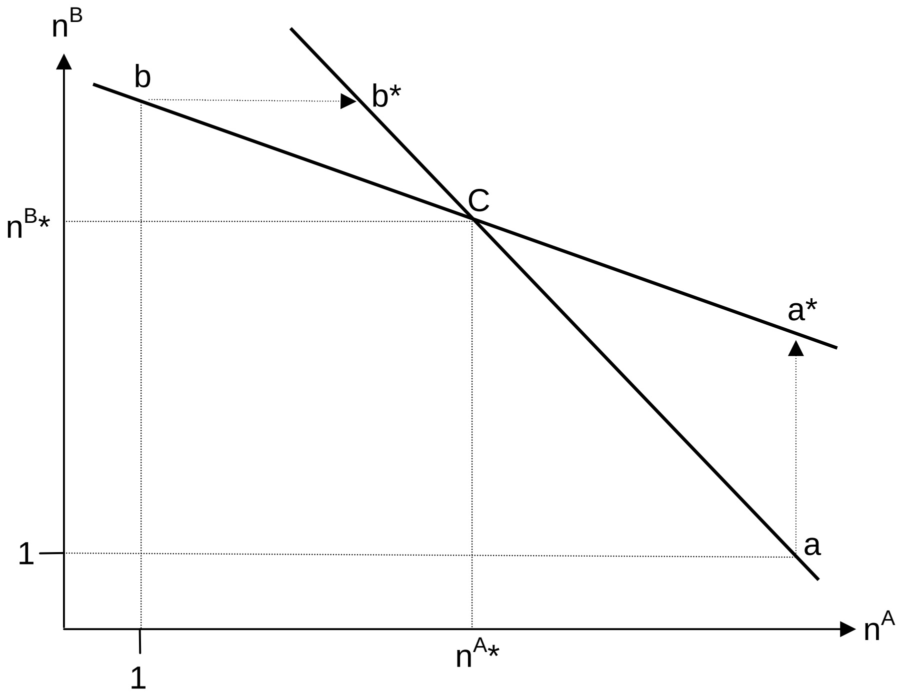
Considering the utility function in (3.1), households in the two countries benefit from consumption of homogeneous good x_0 and differentiated goods.

To implement the utility maximization process, we must first consider the stand-alone contribution of x_0. Without the existence of a differentiated sector, the representative household only generates utility by consuming x_0.

Hence, the benefit of one unit of differentiated goods is constituted by its net contribution (i.e. additional utility versus additional costs). The computation of the equilibrium utilizes this notion to implement the utility maximizing process. In this computation, the equilibrium of the model is labeled `Equilibrium[sA_,sB_,t_,γA_,γB_]` and depends on the given values of country sizes, transport costs, and tax rates in A and B. It is computed so that the system delivers data describing the equilibrium.

Given the exogenous variables, the system endogenously determines the equilibrium mass of firms in A and B. The tax rates being unequal, $\gamma_A \neq \gamma_B$, results in the mass of firms differing in both countries, nA≠nB. The programming of the mass of firms in equilibrium is visualized in graphic 3.5.

Graphic 3.5:



In computing to find the correct value for the mass of firms, nB=1 is the starting point. The program searches for the corresponding mass of firms in A conditioned on nB=1 [i.e., nA(nB)]. In the figure, this is denoted as a. Given nA(1) firms in A, the iteration proceeds by calculating the associated mass of firms in B, denoted as a*. Analogously, we assume nA=1 and search for the associated value for the mass of firms in B, denoted as b [i.e., nB(nA)]. Given nB(1) firms in B, the system calculates the corresponding mass of firms in A, denoted as b*. In the intersection of the two resulting graphs, the new starting value is given, C. This loop is repeated until the difference between the new starting value minus the old starting value is ≤ 20 (i.e., nB3-nB0≤20) in the program or C in the figure.[178]

The computation proceeds using calculations of expected profits for A and B. The system calculates expected profits and all other key figures for the different possible integration strategies and sums them up afterwards. Hence, `EGewA` denotes expected profits in A; `EGewB` denotes expected profits in B.

The next relevant variable is the consistent market size for A, which is calculated using `Xm[nA_,nB_,sA_,t_,γA],` as defined in section 3.2.5.2, and analogously for B.

---

[178] Compare with the computation in the input sheet as in derivation VIII in Appendix 3.4 for nB3-nB0 ≤ 20.

Afterwards, the contributions of the different strategies to total market size are shown, separately for A and B. For example, the share of output of all domestic firms in its market in A is computed as `YDA=Yd[NA,XMA,t]`; the capital letters denote equilibrium values. The expression depends on the mass of firms in A (`NA`), the overall market size in A (`XMA`), and transport costs t.[179]

The sum of expenses of the representative household for differentiated goods in A is represented by `MA=MYDA+MYEXA+MYINA.`

`MYDA=MYd[NA,XMA,sA,t]` denotes expenses of the representative household in A for goods from domestic producers,

`MYEXA=MYex[NB,XMA,sA,t,γA]`are expenses for imports from B to A and

`MYINA=MYin[NB,XMA,sA,t,γA]` is the calculation of expenses of the representative household in A for goods from MNEs from B. The analogous notion (`MB`) is used to compute expenses for the representative household in B.

Equilibria and, therefore, welfare are constituted by the utility of consumption of differentiated goods. Again, to determine utility, we distinguish between A and B and between the different strategies. Therefore, for A we compute the utility of consumption of differentiated goods from domestic firms, from imports from B and from MNEs in A originally located in B. Then, the overall utility of the representative household from differentiated good consumption in A is given, depending on the sum of the three sub functions, and shows `UA=1/μ(YDA+YINA+YEXA)^μ`, referring to (3.1). Analogously, the overall utility of the representative household from differentiated good consumption in B is given by `UB=1/μ(YDB+YINB+YEXB)^μ.`

In addition, the representative household benefits from a lump-sum transfer financed by profit taxation of foreign MNE production in subsidiaries. A single MNE with origin in A pays taxes according to its profits:

```
TinB[i_,nA_,nB_,sB_,t_,γB_]:=(Gin[i,nA,nB,sB,t,γB]+fin)*γB/(1-
γB)
```

Because this is tax revenue paid on profits of a single MNE with origin in A gained by its subsidiary in B and is subject to taxation in B, total tax revenue in the jurisdiction of B is defined by:

[179] Analogously, we compute YEXA for the share of output of all exporting firms located in B supplying A's market. The same notion is used to compute YINA, which denotes the share of output of all MNEs headquartered in B supplying the market in A by a subsidiary in A. The analogue computation for Country B is given as YDB, YEXB and YINB.

```
ETinB[nA_,nB_,sB_,τB_,t_,γB_]:=NIntegrate[TinB[i,nA,nB,sB,τB,t
,γB],{i,Min[nA,Max[iei[nA,Xm[nB,nA,sB,τB,t,γB],sB,τB,t,γB],idi
[nA,Xm[nB,nA,sB,τB,t,γB],sB,τB,t,γB]]],nA}]
```

and analogously for A.

That is, `ETinB` is given by the integral over all firms selecting the MNE strategy and paying profit taxes in B and vice versa in A.

A household in B obviously receives a lump-sum transfer `TB=1/sB*ETinB` and a household in A receives `TA=1/sA*ETinA` from its government.

Finally, welfare is given as `WB=UB-MB+TB` for B and `WA=UA-MA+TA` for A.

3.2.5.5 Results of numerical analysis

Using the knowledge of the behavior of firms concerning their integration strategies, governments maximize welfare (measured per-capita) in their jurisdictions by optimally choosing withholding tax rate γ_j.

Therefore, we examine equilibria of the model resulting from a variation of the tax rates γ_j (c.p., this results in equilibria for each of the two countries, A and B).

To analyze the numerical output, we focus on the mass of firms in equilibrium, labeled NA and NB, for the mass of firms in each country, A or B, thereby indicating the mass of differentiated goods in each country. Furthermore, we focus on the consistent market size in each country, XmA and XmB, and their contributions based on the output of firms selecting different integration strategies.

3.2.5.5.1 Results with identical country sizes

In a scenario in which the two countries, A and B, behave cooperatively, referring to a social planner's perspective, the resulting numerical analysis indicates that welfare is maximized for both jurisdictions with the choice of $\gamma_A=\gamma_B=0$.[180] In this case, the welfare of the representative household in each country results in WA=WB=139.023.[181] In this scenario, an equilibrium mass of firms of NA=NB=15239 and an equilibrium market size of XmA=XmB=4313.14 come to the fore. NA=NB is constituted by ≈11139 domestic firms, no exporters from B, and ≈44100 MNEs. Furthermore, the market size in equilibrium is constituted by a domestic market share

[180] See derivation VIII in Appendix 3.4 for the full input sheet with given values for specific variables.

[181] See derivation IX in Appendix 3.4 for a table summarizing welfare implications resulting from any combination of γ_A and γ_B.

of YDA=YDB=2515.59 (≈58.32%) and a market share of MNEs of YINA=YINB=1797.54 (≈41.68%). On the one hand, these market shares consider the mass of firms; on the other hand, they also consider the output of the firms selecting each strategy. Separating these two impacts, we find 73.1% of the firms select the domestic strategy and 26.9% select the MNE strategy. Because the governments do not levy taxes on profits of MNEs, the export strategy does not exist in this equilibrium because costs associated with an MNE activity are lower than costs of exporting due to transport costs. Obviously, a lump-sum transfer to the households cannot be provided in this equilibrium because $\gamma_A=\gamma_B=0$.

Because policy makers in A attempt to maximize the welfare of households in their country, they do not consider the welfare in B and vice versa. Hence, they behave uncooperatively. Given any certain tax rate γ_B, there is incentive to determine the welfare maximizing best-response tax rate γ_A and vice versa.

We implement this approach in the numerical model, finding equilibrium because the mass of firms in A (NA), settles to a level that guarantees expected profits in both countries are competed to zero. The same iteration is repeated for the second country, B.

Using the knowledge of the existing masses of firms in both countries given the tax rates γ_A and γ_B we determine equilibrium describing variables and study welfare. Given this condition of consistency, regarding NA and NB, with the outcome of numerical analysis in terms of welfare in A and B, we can derive Nash equilibria concerning tax rates γ_A and γ_B.[182] This can be done for any combination of full-percentage tax rates.

Given a scenario in which both countries, A and B, have $\gamma_j=0$, the best response tax rate of one country, given zero taxation in the other country, is $\gamma_j=8\%$.[183] For this country, this results in welfare in equilibrium of Wj=142.555. This obvious increase of welfare from Wj=139.023 to Wj=142.555 is achieved at the expense of the other country because its welfare declines to Wj=135.183, without the application of

[182] Compare with Nash (1951). Furthermore, tests of stability of this model confirm this notion of equilibrium. A convergence of equilibria still appears if firms in A and B alternately enter and exit the market.

[183] See derivation X in Appendix 3.4 for a table summarizing all responses to $\gamma_B=0\%$.

taxation in this jurisdiction. Instead, a social planner would deviate from this solution because total welfare declines in this scenario compared to the zero taxation setting described previously.

Assuming that A is the deviator, choosing γ_A=8%, this scenario is characterized by NA=25974 varieties available in A versus NB=4316 varieties of differentiated goods in B. NA is constituted by ≈19543 domestic firms, ≈5287 exporters from B and ≈1144 MNEs. NB is constituted by ≈3077 domestic firms, no exporters from A, and ≈1239 MNEs.

This tax rate constellation shows the following implications:

The market in A is given by XmA=4494 associated with an increased market share of 90.8% domestic producers. The market share of MNEs in A declines to 2.5%; and, in this constellation, differentiated goods also are imported to A. The market share of these exporting firms from B in A is 6.7%. In contrast with zero taxation, this strategy is not existent. Again, on the one hand, these market shares consider the mass of firms; on the other hand, they also consider the output of the firms selecting each strategy. Separating these two impacts of output and masses of firms selecting single strategies, we find 75.24% of firms selecting the domestic strategy, 20.36% the from B exporting, and 4.4% selecting the MNE strategy. In comparison to a zero taxation scenario, the mass of MNEs declines and the mass of exporters from B and domestic firms increases.

Households in A benefit from more firms entering the market. This increase is associated with a larger market size and is due to the love for variety preferences. Furthermore, a positive per-capita lump-sum transfer to households in A is achieved.

Also, a negative impact of γ_A=8% is generated because fewer cheap differentiated goods from MNEs are available. Imports are more expensive than goods supplied by MNEs.

In total, the positive impact outweighs the negative for households in A. For this reason, welfare in A increases because of γ_A=8% and γ_B=0%, compared to a scenario without taxation.

In contrast, the market in Country B is given by XmB=4116, associated with a market share of 18.3% of domestic producers. The market share of MNEs in A increases to 81.7% and still no goods are imported to B.

Households in B suffer from a decreased mass of firms entering the market there because the mass of domestic firms in B declines dramatically. On the one hand, more cheap goods from MNEs are available for households in B; but, on the other hand, fewer national firms enter the market in B. Hence, households suffer from fewer available varieties of goods due to market entry conditions (i.e., expected profits are competed to zero). In addition to fewer domestically produced varieties being available, the increased market share of MNEs reflects not only more varieties from MNEs but also single MNEs output, which does not increase utility of households due to love for variety preferences. Because the increased market share of MNEs does not increase welfare to the same extent, the negative impact of market shares cannot be compensated by an increased market share of MNEs in B due to love for variety preferences. Because γ_B=0% is selected, a per-capita lump-sum transfer in B does not arise.

In sum, welfare in B declines compared to the situation without profit taxation in both countries.

Given the described situation for B, we find the best-response tax rate to γ_A=8% to be γ_B=7%.[184] Hence, the constellation of γ_A=8% and γ_B=0% is not stable.

Country B, therefore, does not select γ_B=0%; instead γ_B=7% is the best-response given γ_A=8%. The welfare of the representative household increases to WB=138.082 compared to WB=135.183 in the γ_A=8% and γ_B=0% scenario.

The welfare of the neighbor country, A, then decreases to WA=138.319 instead of WA=142.555 in the γ_A=8% and γ_B=0% scenario. The equilibrium is characterized by a market size in A of XmA=4260 in contrast to XmB=4238 associated with a mass of firms NA=16156 compared to NB=14233. NA is constituted by ≈11814 domestic firms, ≈248 exporters from B, and ≈4094 MNEs; and NB is constituted by ≈10379 domestic firms, ≈180 exporters from A, and ≈3674 MNEs.

Compared to the γ_A=8% and γ_B=0% scenario, this indicates an increased market size XmB as well as a considerable increase in the mass of firms NB. Increased welfare in B, therefore, is due to more available varieties of differentiated goods for consumers in B. Fewer products from MNEs are available for them because of taxation, but more goods from domestics and exporters are supplied.

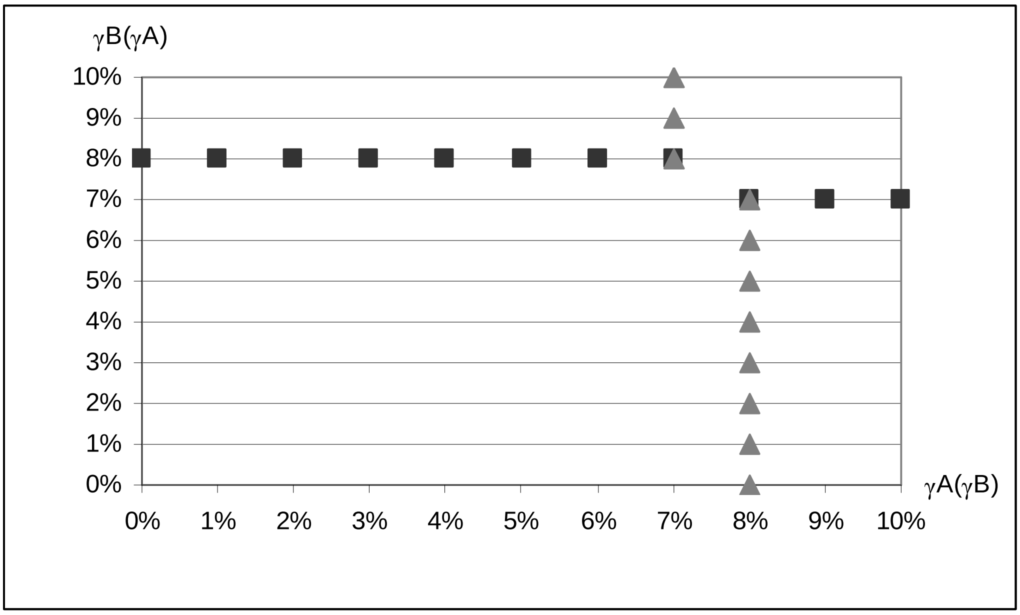
[184] See derivation XI in Appendix 3.4 for a table summarizing all responses to γ_A =8%.

In this scenario, taxation induces positive welfare implications due to love for variety preferences and positive tax revenue for households in B compared to the previous scenario.

The constellation of γ_A=8% and γ_B=7% is a stable equilibrium with a non-cooperative tax setting. This can be seen, because, the best response for A given γ_B=7% again is γ_A=8%. Hence, this combination of tax rates is a best-response for one another.[185] Because the countries are identical, obviously γ_A=7% with γ_B=8% is also a stable equilibrium. Even though both countries generate lower welfare than without taxation these are stable equilibria in contrast to a zero taxation scenario, because every country has incentive to deviate.

Graphic 3.6 summarizes the results of best-response taxes and shows the two stable equilibria:

Graphic 3.6:



From both individual and world welfare perspectives, a non-cooperative tax setting results in inefficiently high tax rates.

Governments are completely informed when setting tax rates. For this reason, they both know that the other has incentive to deviate from zero taxation. Considering this, welfare in its own jurisdiction is maximized considering the tax rate the other country is to select. Hence, zero taxation is not a stable choice for either country, even though it will deliver the highest welfare for each of them.

[185] See derivation XII in Appendix 3.4 for a table summarizing all responses to γ_B =7%.

Therefore, the zero taxation scenario should only be obtained under reliable cooperation (i.e., with a social planner) because each single government has incentive to deviate.

3.2.5.5.2 Results with different country sizes

In a scenario assuming A marginally larger than B and in which the two countries behave cooperatively, the results of numerical analysis indicate that welfare is maximized in both jurisdictions with the choice of $\gamma_A=\gamma_B=0$. In this case, the welfare of the representative household in each country results in WA=139.829 and WB=139.201.[186] Compared to the scenario with identical country sizes, this result shows that already the marginally larger country size of A delivers a positive welfare implication that also occurs for the smaller country, B. In this scenario, an equilibrium mass of firms of NA=16235 and NB=14671 and an equilibrium market size of XmA=4355 and XmB=4322 come to the fore. NA is constituted by ≈11889 domestic firms, no exporters from B, and ≈4346 MNEs; NB is constituted by ≈10735 domestic firms, no exporters from A, and ≈3936 MNEs.

The market size in equilibrium is constituted by a domestic market share of YDA=2649 (≈60.08%) and YDB=2416 (≈55.9%) and a market share of MNEs of YINA=1706 (≈39.2%) and YINB=1907 (≈44.1%). These market shares include the mass of firms selecting a strategy as well as the output of these single firms. Because the governments do not levy taxes on profits of MNEs, the export strategy does not exist in this equilibrium because the costs associated with MNE activity are lower than the costs of exporting due to transport costs and fixed costs relations. Obviously, a lump-sum transfer to the households cannot be provided in this equilibrium because $\gamma_A=\gamma_B=0$.

In comparison to the analysis with identical country sizes, the mass of firms increases in A and decreases in B. The market sizes of both countries increase, but the impact of country size results in a stronger magnitude for the market size in A than in B. Furthermore, the constitution of market shares changes. The domestic market share increases in A and declines in B in contrast to the market shares of MNEs that decline in A and increase in B in comparison to the analysis with equally sized countries.

[186] See derivation XIII in Appendix 3.4 for a table summarizing welfare implications resulting from any combination of γ_A and γ_B.

The impact of country size results in the following implications for country A:

Because country size is larger, the demand is also larger, resulting in more firms entering the market in A. Hence, NA and XMA are greater than in the previous analysis with identical country sizes; and more domestic firms are founded. Households in A benefit because more varieties are available. Furthermore, the foundation of domestic firms is stimulated because competition given by MNEs from B is not as intense. This is because fewer firms decide to enter the market in B because this is the smaller country. For these reasons, welfare in A is not higher because of the availability of cheaper differentiated goods from MNEs but because of a higher satisfaction of love for variety preferences.

The impact of country size results in the following implications for country B:

The assumption of the larger country size of A results in more firms being stimulated to enter the market in A. This is because firms in A face greater national demand. For this reason, more firms supplying demand in B with MNE activities also enter the market in A. This intensifies competition in B. For this reason, fewer domestic firms enter the market in B. Hence, NB is smaller than with identical country sizes. Although fewer varieties of differentiated goods are available in B, XMB is greater than before; and the impact on welfare is positive compared to the previous analysis. Hence, if country size in A exogenously is given marginally as being bigger than in B, welfare in B is higher, even though it is the smaller country in this analysis.

Because policy makers of countries attempt to maximize the welfare of their households, they do not consider welfare in the other jurisdictions. Given any certain tax rate γ_B, there is incentive to determine the welfare maximizing best-response tax rate γ_A and vice versa.

With the outcome of numerical analysis in terms of welfare in A and B, we can derive Nash equilibria concerning the tax rates γ_A and γ_B.[187] This can be done for any combination of full-percentage tax rates.

Given this scenario in which both countries have γ_j=0, the best response tax rate of one country, given zero taxation in the other country, is γ_j=8%.[188] The deviator achieves a welfare increase at the expense of the other country (i.e., WA= 143.078

[187] Furthermore, tests of stability of this model confirm this notion of equilibrium. A convergence of equilibria still appears if firms in A and B alternately enter and exit the market. Because this model consists of one period only, entry and exit happens immediately off the reel.

[188] See derivations XIV and XV in Appendix 3.4 for tables summarizing all responses to γ_B =0% or γ_A =0%.

with WB=135.185 if A deviates and WB=142.566 with WA=135.687 if B deviates). Instead, a social planner will deviate from this solution because total welfare declines in this scenario compared to the zero taxation setting described previously.

Selecting γ_j=8%, the deviator achieves a welfare increase in its jurisdiction because households in this country benefit from a bigger mass of firms entering the market. This is associated with a larger market size and is due to love for variety preferences. Furthermore, a positive per-capita lump-sum transfer to households in this country is achieved.

Also a negative impact of γ_j=8% is generated in this jurisdiction because fewer cheap differentiated goods from MNEs are available. Although imports also occur, these are more expensive than goods supplied by MNEs.

In total, the positive impact outweighs the negative. For this reason, welfare in j increases because of γ_j=8% if profits in the other country are not taxed.

In this scenario, households in the other country suffer from fewer firms entering the market there because the mass of their domestic firms declines dramatically. On the one hand, more cheap goods from MNEs are available for households in this country. On the other hand, as expected profits are competed to zero, fewer national firms enter this market; and households suffer from fewer available varieties. In addition to fewer domestically produced varieties being available, the increased market share of the MNEs reflects not only more varieties from MNEs but also single MNEs output, which does not increase utility of household due to love for variety preferences. Because the increased market share of MNEs does not increase welfare to the same extent, the negative impact of market shares cannot be compensated by an increased market share of MNEs in B due to love for variety preferences. Because taxation in this country is not applied, a per-capita lump-sum transfer does not arise here. In sum, welfare in this country declines compared to the situation without profit taxation in both countries.

Given the described situation for the heretofore non-deviating country, we find the best-response tax rate to γ_j=8% at 7% instead of zero taxation.[189] Hence, the constellation of γ_j=8% as response to zero taxation is not stable.

[189] See derivations XVI and XVII in Appendix 3.4 for tables summarizing all responses to γ_B =8% and γ_A =8%.

The country responding on γ_j=8% achieves a welfare increase at the expense of the other country (i.e., WA= 138.555 with WB=138.326 if A responds with γ_j=7%, and WB=138.129 with WA=138.847 if B responds with γ_j=7%).

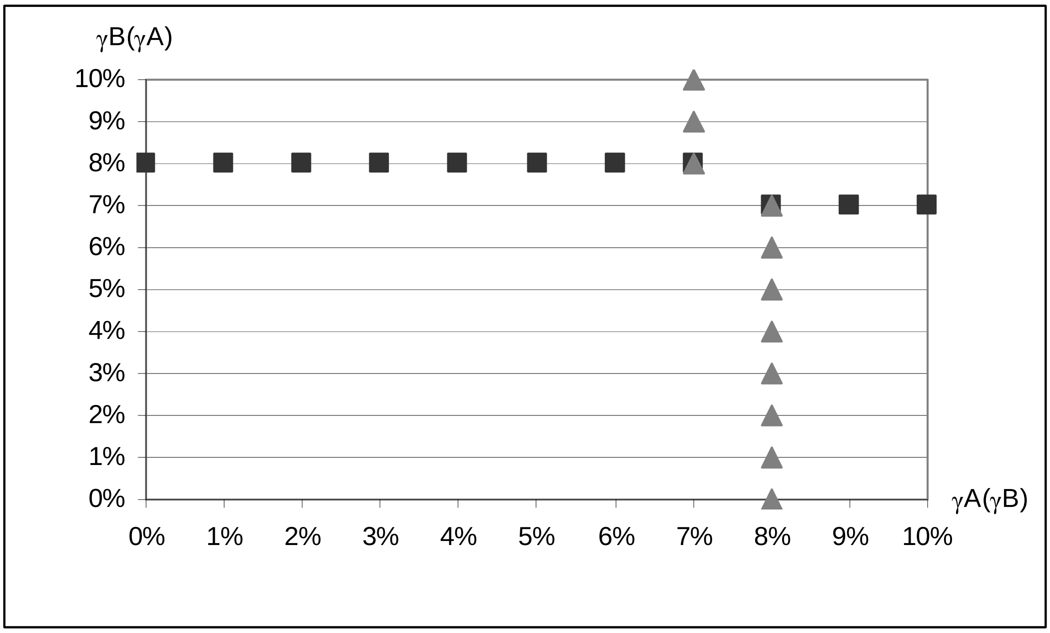
Increased welfare in the country selecting a tax rate of 7% instead of zero taxation, therefore, is due to more available varieties of differentiated goods for consumers there. Because of taxation, fewer products from MNEs are available for them, but more goods from domestic and exporting firms are supplied.

In this scenario, taxation induces positive welfare implications due to love for variety preferences and positive tax revenue compared to the previous scenario without taxation in this jurisdiction.

The 8%-7% tax rate constellation is a stable equilibrium. This can be seen, because the best response for A given γ_B=7% again is γ_A=8% and the best response for B given γ_A=7% again is γ_B=8%. Hence, this combination of tax rates is the best-response for one another.[190] Although both countries generate lower welfare than without taxation these are stable equilibria in contrast to a zero taxation scenario, because every country has incentive to deviate.

Graphic 3.7 is a summary of the results of best-response taxes and shows the two stable equilibria.

Graphic 3.7:



190 See derivations XVIII and XIX in Appendix 3.4 for tables summarizing all responses to γ_B =7% and γ_A =7%.

These stable equilibrium tax rates are identical with those for symmetric countries; but the conditions of consistency, foremost the implications on welfare, differ in magnitude to the previous analysis. Obviously, the exact values of optimal tax rates, as well as the results of these values in both settings with symmetric and asymmetric countries, only occur due to the selected parameter configurations.

From both individual and world welfare perspectives, a non-cooperative tax setting results in inefficiently high tax rates.

Governments are completely informed when setting tax rates. For this reason, they both know that the other has an incentive to deviate from zero taxation. Considering this, welfare in its own jurisdiction is maximized considering the tax rate the other country selects. Hence, zero taxation is not a stable choice for either country, even though it will deliver the highest welfare for each of them.

Therefore, the zero taxation scenario can only be obtained under reliable cooperation (i.e., with a social planner) because each single government has incentive to deviate.

3.2.6 Outline

Support for the here derived result of inefficient tax rates selected by governments in a non-cooperative tax setting is found in other trade literature and empirical studies.[191]

In this analysis, we utilize an alternative approach depending on exogenously given parameters such as transport costs, fixed costs, the resulting endogeneity of integration strategies, endogenous market entry, and heterogeneity of firms.

3.2.6.1 The role of the constellation of exogenously given parameters

In our model, cut-off levels are derived between domestic, exporting producers, and MNE producers. These depend on exogenously given parameters.

At the first cut-off, firm productivity is such that additional profits of exporting exactly results in zero profits:

$$\theta_{d/ex} = \frac{f_{ex}^{\frac{(1-\alpha)}{\alpha}} tX^{\frac{(1-\mu)}{\alpha}}}{\alpha\left(s_j(1-\alpha)\right)^{\frac{(1-\alpha)}{\alpha}}} \tag{3.20}$$

[191] For a survey see Davies and Eckel (2007), Zodrow (2003), Wilson (1999), Sinn (1990) and Razin and Sadka (1991).

The critical productivity level in (3.20) increases with increasing t, f_{ex}, and market size X. Hence, the indifferent firm must be more productive to break even.

Additionally, the cut-off productivity depends on the country size s_j. The larger the foreign country s_j, the smaller productivity of a firm must be for the export strategy to become reasonable.

The next threshold is the productivity level at which profits of an exporting firm equal the profits of an MNE:

$$\theta_{ex/i} = \frac{(f_i - f_{ex})^{\frac{(1-\alpha)}{\alpha}} \cdot X^{\frac{(1-\mu)}{\alpha}}}{s_j^{\frac{(1-\alpha)}{\alpha}} \alpha(1-\alpha)^{\frac{(1-\alpha)}{\alpha}} \left((1-\gamma_j) - t^{\frac{-\alpha}{(1-\alpha)}} \right)^{\frac{(1-\alpha)}{\alpha}}} \tag{3.21}$$

The critical productivity level in (3.21) increases with increasing overhead costs (f_i – f_{ex}), an increasing market size X, decreasing transport costs t, increasing γ_j, and a decreasing s_j. An increasing $\theta_{ex/i}$ is associated with a smaller mass of firms selecting MNE strategies.

Furthermore, only if $(1-\gamma_j) > t^{\frac{-\alpha}{(1-\alpha)}}$ does a real and unique solution exist. If the parameter configuration of the transport costs t, the tax rate γ_j, and α does not satisfy this condition, MNE activities do not exist.

Alternatively, certain configurations of parameters may result in a situation in which domestic firms integrate directly as MNEs instead of choosing the export strategy. The following cut-off level is the relevant productivity threshold if $\theta_{d/i} < \theta_{d/ex}$:

$$\theta_{d/i} = \frac{f_i^{\frac{(1-\alpha)}{\alpha}} X^{\frac{(1-\mu)}{\alpha}}}{\alpha\left(s_j(1-\gamma_j)(1-\alpha)\right)^{\frac{(1-\alpha)}{\alpha}}} \tag{3.22}$$

The critical productivity level in (3.22) increases with increasing f_i and an increasing market size X. Additionally, the cut-off productivity depends on the country size s_j and γ_j. The smaller the foreign country s_j and the higher the tax rate γ_j, the higher the productivity of a firm must be for the MNE strategy to become reasonable.

For $\theta_{d/i} < \theta_{d/ex}$ so that this cut-off level exists, the following condition must hold:

$$(1-\gamma_j) \geq \frac{f_i}{f_{ex} t^{\frac{\alpha}{(1-\alpha)}}} \tag{3.23}$$

As can be seen from the cut-off levels the mass of firms selecting an integration strategy, as well as which strategies are optimal to select at all, depends on exogenously given parameters. These dependencies in a setting with heterogeneous firms distinguish this model from the latest literature.[192]

3.2.6.2 The role of endogenous market entry and market size

In this model, the mass of firms in equilibrium results endogenously because expected profits are competed to zero until the last firm entering the market generates zero profits. With the inclusion of this endogeneity, we can analyze the implications of national and international policy decisions on integration modi of heterogeneous firms. Taxation influences not only entry of MNEs and exporting firms into the market but also the mass of domestic firms.

Given a specific tax rate, the exact composition of prevailing integration strategies in this country is due to the constitution of competition. For example, if a tax rate increases, fewer MNEs enter the market; and, depending on the size of transport costs, they also may refrain from becoming exporters. Then, fewer firms will supply demand in this country and expected profits will increase. Therefore, the output of each single firm is influenced; and more domestic firms can enter the market, competing expected profits to zero. Hence, equilibria with different tax rates are determined by other compositions of integration strategies and other masses of firms producing individual optimal outputs. This endogenous market size and especially further entry of domestic firms in a setting with heterogeneous firms distinguishes this model from the latest literature.[193]

3.2.6.3 The role of heterogeneity

In our model, stable equilibria are obtained with a 8%-7% tax setting scenario. This is driven by the incentive of each government to deviate unilaterally from zero taxation to induce positive impacts on welfare in its jurisdiction. This influence on welfare is characterized by following implications:

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[192] As in Davies and Eckel (2007).

[193] As in Davies, Egger, and Egger (2009).

The mass of firms in its country increases. Increased welfare, therefore, results in more available varieties of differentiated goods for consumers there. Although more goods from domestic and exporting firms are supplied, fewer products from MNEs are available for them, induced by taxation. For the unilaterally deviating country, the overall impact in this scenario is that taxation induces positive welfare implications due to love for variety preferences and positive tax revenue, even though fewer cheap goods supplied by MNEs are available.

The extent of more domestic firms entering the market in this analysis also depends on the distribution of firms over productivity levels. In this analysis, a uniform distribution $F(\theta)$ is assumed. The specification of an alternative distribution function, therefore, may induce different results. The assumption of a distribution $G(\theta)$ in which the mass of firms increases with productivity so that many MNEs and few domestic firms exist, will slow the stimulating effect on domestic firms to enter the market if positive tax rates are selected.

Hence, an increase in the profit tax rate of a single government has the following implications:

Because an increase in the profit tax rate induces some MNEs not to enter the market and expected profits are competed to zero, alternatively integrated firms can enter the market and the outputs of single firms are adjusted. Depending on the distribution function, the composition of the mass of firms selecting different integration strategies then differs. For this reason, if $G(\theta)$ instead of $F(\theta)$ is applied, fewer domestic firms can enter the market and single optimal output adjusts according to endogenous market entry conditions. Obviously, the extent of the resulting implications depends on the exact parameter configuration. However, the impact of $F(\theta)$ with more firms with lower single output is always positive for consumers due to love for variety preferences. If, instead of $F(\theta)$, now $G(\theta)$ is applied, this impact on welfare concerning more available varieties is dampened. Instead, the outputs of the single firms will be increasingly influenced.

Another positive impact on utility of the representative household is achieved by providing a lump-sum transfer. An additional lump-sum transfer only is used to finance the consumption of x_0 and the homogeneous good is appreciated less than differentiated goods. According to (3.1), the impact of transfer on welfare is not extensive.

The third impact of taxation on welfare concerns some MNEs providing cheaper goods not entering the market. This has negative implications for the representative household, because these relatively cheap varieties are not supplied.

In an analysis with the here described distribution function G(θ), love for variety preferences will be satisfied less than in the analysis with F(θ). Previously, in the analysis with F(θ), the positive impact on welfare by unilaterally deviating from the cooperative zero tax setting scenario is mainly driven by higher satisfaction of these preferences. With this alternative distribution of firms G(θ), fewer domestic firms will enter the market and far fewer cheap varieties supplied by MNEs will be available for consumers in this jurisdiction.
Hence, in contrast to F(θ), this distribution function G(θ) will more likely result in a negative impact of taxation (i.e., the negative impact of fewer cheaper varieties provided by MNEs can be more influential than the positive implication given by tax revenue and stimulated market entry satisfying love for variety preferences). Obviously, the results depend on the exact parameter configurations; but for configurations that ensure this described impact of G(θ) zero taxation will result in a stable equilibrium. In the previous analysis, zero taxation is optimal from a world welfare perspective but, unfortunately, is unstable in a non-cooperative tax setting. Hence, the results in this analysis are mainly constituted by the exact specification of the distribution of firms over productivity and, therefore, due to heterogeneity.

3.3 Conclusion

We develop a model with heterogeneous firms to derive welfare maximizing profit tax rates set by benevolent planners. Heretofore, governments levy withholding tax rates on profits earned by subsidiaries of MNEs located in their countries. When selecting these optimal tax rates governments take their impact on the optimal integration strategies of firms, as well as on market entry and market sizes, into account.
The integration strategies chosen depend on the individual productivity level of a firm. Given their productivity levels, firms maximize profits, considering relative sizes of fixed costs, transport costs, country and market sizes, per-unit variable costs, and the degree of profit taxation of governments.

Therefore, each firm individually either selects domestic production, an exporting strategy, or MNE activities as optimal; the composition of the prevailing strategies is determined endogenously, depending on the withholding profit tax rates chosen by the governments. These described behavioral modifications of integration strategies of heterogeneous firms responding to economic policy interventions are included in the considerations of the government. Due to the incorporation of several endogenous variables, especially market entry and market size, this utilitarian maximization of welfare is solved numerically in this analysis, considering identical and differing country sizes.

Numerical analysis with identical country sizes results in a zero taxation scenario that can only be obtained under cooperation of governments (i.e., from a social planner's perspective). An incentive for a government to deviate unilaterally from a zero taxation scenario is given in a non-cooperative setting. Because this can be anticipated by the other government, both governments deviate from the zero taxation scenario, resulting in inefficiently high tax rates, which are stable Nash equilibria. The constellation of these profit tax rates is characterized by lower welfare for both jurisdictions than without taxation. Because of the unilateral incentive to deviate from a scenario without taxation, the zero taxation scenario is not stable in a non-cooperative setting, although it generates the highest welfare from a world welfare perspective.

Numerical analysis, assuming one country to be marginally larger than the other, results in the same optimal tax rates in equilibrium (i.e., a social planner selects a zero taxation scenario to be optimal considering welfare in both countries; and in a non-cooperative tax setting, stable Nash equilibria with inefficiently high tax rates are obtained). In comparison to the analysis with identical country sizes, we emphasize the implication of these differing country sizes on welfare of the representative household in both countries. Our main finding in this context is that not only the welfare of the assumed marginally larger country is given to be higher but also the welfare in the exogenously given smaller country is higher because of a larger world demand than in the numerical analysis with identical country sizes.

In conclusion, using our model, we derive inefficiently high tax rates in a non-cooperative setting and zero taxation from a social planner's perspective when governments act as benevolent planners and set withholding tax rates on profits earned by subsidiaries of MNEs in their countries. Based on our results and the existence of only a little research regarding withholding tax rates with MNE activity, we are motivated to do further research.

3.4 Appendix

Derivation I:

We use the utility function in (3.1), $U_j = x_0 + \frac{1}{\mu}\left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)^{\mu}$ and the standard side condition to derive the demand of a representative household for the goods of the i-th firm:

$$L = x_0 + \frac{1}{\mu}\left[\int_0^{\theta_{max}} \frac{1}{\alpha}(x_j(i) + \beta\varsigma_j(i))^{\alpha} di\right]^{\mu} + \lambda\left[m_j - x_0 - \int_0^{\theta_{max}} p_j(i)(x_j(i) + \beta\varsigma_j(i))di\right]$$

$$\frac{\partial L}{\partial x_0} = 1 - \lambda = 0 \quad \Rightarrow \lambda = 1$$

$$\frac{\partial L}{\partial \lambda} = m_j - x_0 - \int_0^{\theta_{max}} p_j(i)(x_j(i) + \beta\varsigma_j(i))di = 0 \quad \Rightarrow x_0 = m_j - \int_0^{\theta_{max}} p_j(i)(x_j(i) + \beta\varsigma_j(i))di$$

$$\frac{\partial L}{\partial \beta} = \left[\int_0^{\theta_{max}} \frac{1}{\alpha}(x_j(i) + \beta\varsigma_j(i))^{\alpha} di\right]^{(\mu-1)} \left[\int_0^{\theta_{max}} (x_j(i) + \beta\varsigma_j(i))^{(\alpha-1)} \varsigma_j(i) di\right] - \int_0^{\theta_{max}} p_j(i)\varsigma_j(i) di = 0$$

If $\beta = 0$:

$$\frac{\partial L}{\partial \beta} = \left[\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right]^{(\mu-1)} \int_0^{\theta_{max}} x_j(i)^{(\alpha-1)} \varsigma_j(i) di - \int_0^{\theta_{max}} p_j(i)\varsigma_j(i) di = 0$$

$$\Rightarrow \int_0^{\theta_{max}} \left[\frac{x_j(i)^{(\alpha-1)}}{\left[\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right]^{(1-\mu)}} - p_j(i)\right] \varsigma_j(i) di = 0$$

$$\Rightarrow x_j(i)^{(\alpha-1)} = p_j(i) X^{(1-\mu)}$$

$$\Rightarrow \frac{1}{x_j(i)^{(1-\alpha)}} = p_j(i) X^{(1-\mu)}$$

$$\Rightarrow x_j(i)^{(1-\alpha)} = \frac{1}{X^{(1-\mu)} p_j(i)}$$

$$\Rightarrow x_j(i) = \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}} p_j(i)^{\frac{1}{(1-\alpha)}}}$$

$$\Rightarrow p_j(i) = \frac{1}{X^{(1-\mu)} x_j(i)^{(1-\alpha)}}$$

This paper applies $X=\left(\int_0^{\theta_{max}} \frac{1}{\alpha} x_j(i)^{\alpha} di\right)$ which denotes the sub-utility, respectively the market size as specifiable as $X_{d,ex,i}$ in (3.4), $X_{d,i}$ in (3.5) and $X_{d,ex}$ in (3.6).

Derivation II:

The derivation of the profit maximizing output is shown in the following:

$$\pi_j(i)_d = s_j p_j(i)_d x_j(i)_d - \frac{s_j x_j(i)_d}{\theta(i)} - f_d$$

$$= s_j \frac{1}{X^{(1-\mu)} x_j(i)_d^{(1-\alpha)}} x_j(i)_d - \frac{s_j x_j(i)_d}{\theta(i)} - f_d$$

$$\frac{\partial \pi_j(i)_d}{\partial x_j(i)_d} = s_j \alpha x_j(i)_d^{(\alpha-1)} \frac{1}{X^{(1-\mu)}} - \frac{s_j}{\theta(i)} = 0$$

$$x_j(i)_d^{(\alpha-1)} = \frac{s_j}{\theta(i)} \frac{X^{(1-\mu)}}{\alpha s_j}$$

$$x_j(i)_d^{(\alpha-1)} = \frac{X^{(1-\mu)}}{\alpha\theta(i)}$$

$$x_j(i)_d^{*} = \frac{(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}}$$

The derivation of the optimal price is shown in the following:

$$\pi_j(i)_d = s_j p_j(i)_d x_j(i)_d - \frac{s_j x_j(i)_d}{\theta(i)} - f_d$$

$$\pi_j(i)_d = s_j p_j(i)_d \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}} p_j(i)_d^{\frac{1}{(1-\alpha)}}} - \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}} p_j(i)_d^{\frac{1}{(1-\alpha)}}} \frac{s_j}{\theta(i)} - f_d$$

$$\frac{\partial \pi_j(i)_d}{\partial p_j(i)_d} = \frac{-\alpha}{(1-\alpha)} p_j(i)_d^{\frac{-1}{(1-\alpha)}} s_j \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} + \frac{1}{(1-\alpha)} p_j(i)_d^{(-1)} \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} p_j(i)_d^{\frac{-1}{(1-\alpha)}} \frac{s_j}{\theta(i)} = 0$$

$$\alpha s_j \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} = p_j(i)_d^{(-1)} \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} \frac{s_j}{\theta(i)}$$

$$p_j(i)_d^{*} = \frac{1}{\alpha} \frac{1}{\theta(i)}$$

The domestic firm i applies the price $p_j(i)$ in country j.

The maximum attainable profits for a domestic firm i from country j therefore are given by:

$$\pi_j(i)_d^{*} = \frac{s_j(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}} \frac{1}{\alpha} \frac{1}{\theta(i)} - \frac{s_j(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} \theta(i)} - f_d = \frac{s_j(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} \theta(i)} \left(\frac{1}{\alpha} - 1\right) - f_d$$

Derivation III:

The derivation of the optimal output of exports of a firm i from country A is derived as following:

$$\begin{aligned}\pi_A(i)_{ex} &= s_B x_B(i)_{ex} p_B(i)_{ex} - \frac{s_B t x_B(i)_{ex}}{\theta(i)} - f_{ex} + \pi_A(i)_d \\ &= s_B x_B(i)_{ex} \frac{1}{X^{1-\mu} x_B(i)_{ex}{}^{(1-\alpha)}} - \frac{s_B t x_B(i)_{ex}}{\theta(i)} - f_{ex} + \pi_A(i)_d \\ &= s_B x_B(i)_{ex}{}^{\alpha} \frac{1}{X^{1-\mu}} - \frac{s_B t x_B(i)_{ex}}{\theta(i)} - f_{ex} + \pi_A(i)_d\end{aligned}$$

$$\frac{\partial \pi_A(i)_d}{\partial x_B(i)_{ex}} = \frac{\alpha s_B}{X^{(1-\mu)}} x_B(i)_{ex}{}^{(\alpha-1)} - \frac{s_B t}{\theta(i)} = 0$$

$$x_B(i)_{ex}{}^{(\alpha-1)} = \frac{s_B t}{\theta(i)} \frac{X^{(1-\mu)}}{\alpha s_B}$$

$$x_B(i)_{ex} = \left(\frac{s_B t}{\theta(i)} \frac{X^{(1-\mu)}}{\alpha s_B}\right)^{\frac{1}{(\alpha-1)}}$$

$$x_B(i)^*_{ex} = \left(\frac{\theta(i)}{t} \frac{\alpha}{X^{(1-\mu)}}\right)^{\frac{1}{(1-\alpha)}}$$

$$x_j(i)^*_{ex} = \frac{(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{1}{(1-\alpha)}}}$$

The derivation of the optimal price for exports to B of a firm i from A:

$$\pi_A(i)_{ex} = s_B p_B(i)_{ex} x_B(i)_{ex} - \frac{s_B x_B(i)_{ex} t}{\theta(i)} - f_{ex} + \pi_A(i)_d$$

$$\pi_A(i)_{ex} = s_B p_B(i)_{ex} \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}} p_B(i)_{ex}^{\frac{1}{(1-\alpha)}}} - \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}} p_B(i)_{ex}^{\frac{1}{(1-\alpha)}}} \frac{s_B t}{\theta(i)} - f_{ex} + \pi_A(i)_d$$

$$\pi_A(i)_{ex} = \frac{s_B}{X^{\frac{(1-\mu)}{(1-\alpha)}}} p_B(i)_{ex}^{\frac{-\alpha}{(1-\alpha)}} - \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} p_B(i)_{ex}^{\frac{-1}{(1-\alpha)}} \frac{s_B t}{\theta(i)} - f_{ex} + \pi_A(i)_d$$

$$\frac{\partial \pi_A(i)_{ex}}{\partial p_B(i)_{ex}} = -\left(\frac{\alpha}{1-\alpha}\right) p_B(i)_{ex}^{\frac{-1}{(1-\alpha)}} \frac{s_B}{X^{\frac{(1-\mu)}{(1-\alpha)}}} + \left(\frac{1}{1-\alpha}\right) p_B(i)_{ex}{}^{(-1)} p_B(i)_{ex}^{\frac{-1}{(1-\alpha)}} \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} \frac{s_B t}{\theta(i)} = 0$$

$$\alpha = \frac{1}{\theta(i)} t p_B(i)_{ex}{}^{(-1)}$$

$$p_B(i)^*_{ex} = \frac{t}{\alpha\theta(i)}$$

$$p_j(i)^*_{ex} = \frac{t}{\alpha\theta(i)}$$

Maximum attainable profits of an exporting firm i from country A therefore are given by:

$$\pi_A(i)_{ex}^* = \frac{s_B(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{\alpha}{(1-\alpha)}} \theta(i)} \left(\frac{1}{\alpha} - 1\right) - f_{ex} + \pi_A(i)_d^*$$

Derivation IV:

In contrast to a domestic firm, multinational profits of an MNE bear higher fixed costs $f_i > f_d$ and an MNE pays taxes γ_j on the difference between sales and variable costs.

The derivation of the optimal output of an MNE from A supplying the market in B by a subsidiary in B is given by:

$$\pi_A(i)_i = \left(s_B p_B(i)_i x_B(i)_i - \frac{s_B x_B(i)_i}{\theta(i)}\right)(1-\gamma_B) - f_i + \pi_A(i)_d$$

$$= \left(s_B \frac{1}{X^{(1-\mu)} x_B(i)_i^{(1-\alpha)}} x_B(i)_i - \frac{s_B x_B(i)_i}{\theta(i)}\right)(1-\gamma_B) - f_i + \pi_A(i)_d$$

$$\frac{\partial \pi_A(i)_i}{\partial x_B(i)_i} = s_B \alpha x_B(i)_i^{(\alpha-1)} \frac{1}{X^{(1-\mu)}}(1-\gamma_B) - \frac{s_B}{\theta(i)}(1-\gamma_B) = 0$$

$$x_B(i)_i^{(\alpha-1)} = \frac{s_B(1-\gamma_B)}{\theta(i)} \frac{X^{(1-\mu)}}{\alpha s_B(1-\gamma_B)}$$

$$x_B(i)_i^{(\alpha-1)} = \frac{X^{(1-\mu)}}{\alpha\theta(i)}$$

$$x_B(i)_i^* = \frac{(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}}$$

The derivation of the optimal price supplying the market in B therefore is shown by:

$$\pi_A(i)_i = \left(s_B p_B(i)_i x_B(i)_i - \frac{s_B x(i)_i}{\theta(i)}\right)(1-\gamma_B) - f_i + \pi_A(i)_d$$

$$\pi_A(i)_i = \left(s_B \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}} p_B(i)_i^{\frac{1}{(1-\alpha)}}}\left(p_B(i)_i - \frac{1}{\theta(i)}\right)\right)(1-\gamma_B) - f_i + \pi_A(i)_d$$

$$\frac{\partial \pi_A(i)_i}{\partial p_B(i)_i} = \left(\frac{-\alpha}{(1-\alpha)} p_B(i)_i^{\frac{-1}{(1-\alpha)}} s_B \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}}\right)(1-\gamma_B) +$$

$$\left(\frac{1}{(1-\alpha)} p_B(i)_i^{(-1)} \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} p_B(i)_i^{\frac{-1}{(1-\alpha)}} \frac{s_B}{\theta(i)}\right)(1-\gamma_B) = 0$$

$$\alpha s_B \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} = p_B(i)_i^{(-1)} \frac{1}{X^{\frac{(1-\mu)}{(1-\alpha)}}} \frac{s_B}{\theta(i)}$$

$$p_B(i)_i^* = \frac{1}{\alpha}\frac{1}{\theta(i)}$$

Maximum attainable profits of an MNE i from country A therefore are given by:

$$\pi_A(i)_i^* = \left(\frac{s_B(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}} \frac{1}{\alpha}\frac{1}{\theta(i)} - \frac{s_B(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}}\theta(i)} \right)(1-\gamma_B) - f_i + \pi_A(i)_d^*$$

$$= \frac{s_B(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}(1-\gamma_B)}{X^{\frac{(1-\mu)}{(1-\alpha)}}\theta(i)}\left(\frac{1}{\alpha}-1\right) - f_i + \pi_A(i)_d^*$$

Derivation V:

Derivation of cut-off level $\theta_{d/ex}$

We derive the productivity level that at least additionally guarantees zero profit from exporting. In this situation the exporting firm generates zero profit from D and, hence, is indifferent whether to engage in export activities or not. Firms with productivity levels just above this threshold benefit from exporting:

$$D = s_j x_j(i)_{ex}^* p_j(i)_{ex}^* - \frac{s_j x_j(i)_{ex}^* t}{\theta(i)} - f_{ex} \geq 0$$

$$= \frac{s_j(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{\alpha}{(1-\alpha)}} \theta(i)}\left(\frac{1}{\alpha}-1\right) - f_{ex} \geq 0$$

$$\frac{s_j(\alpha\theta(i))^{\frac{1}{1-\alpha}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{\alpha}{(1-\alpha)}} \theta(i)}\left(\frac{1-\alpha}{\alpha}\right) \geq f_{ex}$$

$$\theta(i)^{\frac{\alpha}{(1-\alpha)}} \frac{s_j \alpha^{\frac{\alpha}{(1-\alpha)}}(1-\alpha)}{X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{\alpha}{(1-\alpha)}}} \geq f_{ex}$$

$$\theta(i)^{\frac{\alpha}{(1-\alpha)}} \geq \frac{f_{ex} X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{\alpha}{(1-\alpha)}}}{s_j \alpha^{\frac{\alpha}{(1-\alpha)}}(1-\alpha)}$$

$$\theta_{d/ex} \geq \frac{f_{ex}^{\frac{(1-\alpha)}{\alpha}} X^{\frac{(1-\mu)}{\alpha}} t}{\alpha(s_j(1-\alpha))^{\frac{(1-\alpha)}{\alpha}}}$$

Firms that are at least as productive as $\theta_{d/ex} < \theta_{d/i}$ engage in the exporting strategy.

Derivation VI:

Derivation of cut-off level $\theta_{ex/i}$

The next threshold is characterized by a productivity level at which exporting and multinational firms have the same profit. Firms with productivity levels above this level engage in a multinational activity.

$$\pi_{ex} \le \pi_i$$

$$\frac{s_j(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}}{X^{\frac{(1-\mu)}{(1-\alpha)}} t^{\frac{\alpha}{(1-\alpha)}} \theta(i)} \left(\frac{1-\alpha}{\alpha}\right) - f_{ex} \le \frac{s_j(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}(1-\gamma_j)}{X^{\frac{(1-\mu)}{(1-\alpha)}} \theta(i)} \left(\frac{1-\alpha}{\alpha}\right) - f_i$$

$$\frac{s_j(\alpha\theta(i))^{\frac{\alpha}{(1-\alpha)}}(1-\alpha)}{X^{\frac{(1-\mu)}{(1-\alpha)}}} \left((1-\gamma_j) - t^{-\frac{\alpha}{(1-\alpha)}}\right) \ge f_i - f_{ex}$$

$$\theta(i)^{\frac{\alpha}{(1-\alpha)}} \ge \frac{(f_i - f_{ex}) X^{\frac{(1-\mu)}{(1-\alpha)}}}{s_j \alpha^{\frac{\alpha}{(1-\alpha)}}(1-\alpha)\left((1-\gamma_j) - t^{-\frac{\alpha}{(1-\alpha)}}\right)}$$

$$\theta_{ex/i} \ge \frac{(f_i - f_{ex})^{\frac{(1-\alpha)}{\alpha}} \cdot X^{\frac{(1-\mu)}{\alpha}}}{\alpha(s_j(1-\alpha))^{\frac{(1-\alpha)}{\alpha}} \left((1-\gamma_j) - t^{-\frac{\alpha}{(1-\alpha)}}\right)^{\frac{(1-\alpha)}{\alpha}}}$$

Firms producing with productivity $\theta_{ex/i}$ are indifferent whether to choose the multinational or exporting strategy or not. A firm with productivity $\theta(i)$ just above $\theta_{ex/i}$ engages in a multinational strategy and generates positive profits from this activity.

Derivation VII:

Derivation and analysis of cut-off level $\theta_{d/i}$

The next cut-off level characterizes a situation where the export strategy does not exist. Firms in this scenario directly integrate their firm following an MNE activity. The following condition has to be satisfied:

$$E \ge 0$$

$$\frac{s_j(\alpha\theta(i))^{\frac{1}{(1-\alpha)}}(1-\gamma_j)}{X^{\frac{(1-\mu)}{(1-\alpha)}} \theta(i)} \left(\frac{1-\alpha}{\alpha}\right) - f_i \ge 0$$

$$\frac{s_j(\alpha\theta(i))^{\frac{\alpha}{(1-\alpha)}}(1-\alpha)(1-\gamma_j)}{X^{\frac{(1-\mu)}{(1-\alpha)}}} \ge f_i$$

$$\theta^{\frac{\alpha}{(1-\alpha)}} \geq \frac{f_i \cdot X^{\frac{(1-\mu)}{(1-\alpha)}}}{(1-\alpha)\alpha^{\frac{\alpha}{(1-\alpha)}} s_j (1-\gamma_j)}$$

$$\theta_{d/i} \geq \frac{f_i^{\frac{(1-\alpha)}{\alpha}} \cdot X^{\frac{(1-\mu)}{\alpha}}}{\left((1-\gamma_j)(1-\alpha)s_j\right)^{\frac{(1-\alpha)}{\alpha}} \alpha}$$

Firms that satisfy the following condition integrate their firm as an MNE, the export strategy does not exist:

$$\theta_{d/i} < \theta_{d/ex}$$

$$\frac{f_i^{\frac{(1-\alpha)}{\alpha}} \cdot X^{\frac{(1-\mu)}{\alpha}}}{\left((1-\gamma_j)(1-\alpha)s_j\right)^{\frac{(1-\alpha)}{\alpha}} \alpha} \leq \frac{f_{exi}^{\frac{(1-\alpha)}{\alpha}} X^{\frac{(1-\mu)}{\alpha}} t}{\alpha\left(s_j(1-\alpha)\right)^{\frac{(1-\alpha)}{\alpha}}}$$

$$\frac{f_i^{\frac{(1-\alpha)}{\alpha}}}{(1+\gamma_j)^{\frac{(1-\alpha)}{\alpha}}} \leq f_{ex}^{\frac{(1-\alpha)}{\alpha}} t$$

$$(1-\gamma_j) \geq \frac{f_i}{f_{ex} t^{\frac{\alpha}{(1-\alpha)}}}$$

<u>Derivation VIII:</u> Mathematica- Input

```
fd:=0.0014
fex:=.0015
fin:=.0017
α :=0.75
μ :=0.6
θmin:=0
θmax:=30
F[θ_]:=(θ-θmin)/(θmax-θmin)
inr[θ_,n_]:=n F[θ]
θ[i_,n_]:=Piecewise[{{-1,i<0||i>n},{i (θmax-θmin)/n +θmin,i≥0 &&i≤n}}]
x[θ_, X_,t_]:= (α θ)^(1/(1-α))/((t)^(1/(1-α)) X^((1-μ)/(1-α)))
θde[ X_,s_,t_] :=t fex^((1-α) / α) X^((1-μ) / α) /(α (s (1-α))^((1-α)/α))
ide[n_,X_,s_,t_]:=inr[θde[X,s,t],n]
θei [ X_,s_,t_,γ_]:=If[γ≥1-t^(-α/(1-α)),∞, (fin-fex)^((1-α)/α) X^((1-μ)/α)/(α (s (1-α))^((1-α) /α) (1-γ-t^(-α/(1-α)))^((1-α)/α))]
iei[n_,X_,s_,t_,γ_]:=inr[θei[X,s,t,γ],n]
```

```
θdi[X_,s_,t_,γ_] :=fin^((1-α)/α) X^((1-μ)/α)/(α (s (1-γ) (1-α))^((1-α)/α))
idi[n_,X_,s_,t_,γ_]:=inr[θdi[X,s,t,γ],n]
Yd[nA_,X_,t_]:=NIntegrate[(1/α) (x[ θ[i,nA],X,0,1])^α,{i,0,nA}]
Yex[nB_,X_,s_,t_,γ_]:=If[ide[nB,X,s,t]<Min[iei[nB,X,s,t,γ],nB],NIntegrate[(1/α) (x[
θ[i,nB],X,t])^α,{i,ide[nB,X,s,t],Min[iei[nB,X,s,t,γ],nB]}],0]
Yin[nB_,X_,s_,t_,γ_]:= NIntegrate[(1/α) (x[
θ[i,nB],X,0,1])^α,{i,Min[nB,Max[iei[nB,X,s,t,γ],idi[nB,X,s,t,γ]]],nB}]
Y[nA_,nB_,X_,s_,t_,γ_]:=Yd[nA,X,t]+Yex[nB,X,s,t,γ]+Yin[nB,X,s,t,γ]
Xm[nA_,nB_,s_,t_,γ_]:=(k=0;X0=1000;Z0=Y[nA,nB,X0,s,t,γ]-X0;d=20*2^(-
k);X1=X0+d;Z1=Y[nA,nB,X1,s,t,γ]-X1;X2=N[(d Z0+X0 Z0-X0 Z1)/(Z0-
Z1)];While[Abs[X2-X0]>.00001&&k<15,X0=X2;k++;Z0=Y[nA,nB,X0,s,t,γ]-
X0;d=20*2^(-k);X1=X0+d;Z1=Y[nA,nB,X1,s, t, γ]-X1;X2=N[(d Z0+X0 Z0-X0 Z1)/(Z0-
Z1)]];X2)
Gd[i_,nA_,nB_,s_,t_,γ_]:=s x[θ[i,nA],Xm[nA,nB,s,t,γ],0,1] (1/(α θ[i,nA]))-s
x[θ[i,nA],Xm[nA,nB,s,t,γ],0,1]/θ[i,nA]-fd
Gin[i_,nA_,nB_,sB_,t_,γB_]:=(1-γB) (sB x[θ[i,nA],Xm[nB,nA,sB,t,γB],0,1] (1/(α
θ[i,nA]))-sB x[θ[i,nA],Xm[nB,nA,sB,t,γB],0,1]/θ[i,nA])-fin
Gex[i_,nA_,nB_,sB_,t_,γB_]:= sB x[θ[i,nA],Xm[nB,nA,sB,t,γB],τB,t] (t/(α θ[i,nA]))-  sB
x[θ[i,nA],Xm[nB,nA,sB,t,γB],t] t/θ[i,nA]-fex
EGd[nA_,nB_,sA_,t_,γA_]:=NIntegrate[Gd[i,nA,nB,sA,t,γA],{i,0,nA}]
EGex[nA_,nB_,sB_,t_,γB_]:=If[ide[nA,Xm[nB,nA,sB,t,γB],sB,t]<Min[iei[nA,Xm[nB,nA,
sB,t,γB],sB,t,γB],nA],NIntegrate[Gex[i,nA,nB,sB,t,γB],{i,ide[nA,Xm[nB,nA,sB,t,γB],sB
t],Min[iei[nA,Xm[nB,nA,sB,t,γB],sB,t,γB],nA]}],0]
EGin[nA_,nB_,sB_,t_,γB_]:=NIntegrate[Gin[i,nA,nB,sB,t,γB],{i,Min[nA,Max[iei[nA,Xm[
nB,nA,sB,t,γB],sB,t,γB],idi[nA,Xm[nB,nA,sB,t,γB],sB,t,γB]]],nA}]
EG[nA_,nB_,sA_,sB_,t_,γA_,γB_]:=EGd[nA,nB,sA,t,γA]+EGex[nA,nB,sB,t,γB]+EGin
[nA,nB,sB,t,γB]
Firms[nB_,sA_,sB_,t_,γA_,γB_]:=(N1=2^10;K=10;While[EG[N1,nB,sA,sB,t,γA,γB]>0,
N1=2 N1;K=K+1];K=K-2;N1=N1-2^K;While[K>-4,K=K-1;
If[EG[N1,nB,sA,sB,t,γA,γB]>0,N1=N1+2^K,N1=N1-2^K]];Return[N1])
MYd[nA_,X_,s_,t_]:= NIntegrate[1/(α  θ[i,nA]) x[ θ[i,nA],X,0,1],{i,0,nA}]
MYex[nB_,X_,s_,t_,γA_]:=If[ide[nB,X,s,t]<Min[iei[nB,X,s,t,γA],nB],NIntegrate[ t/(α
θ[i,nB]) (x[ θ[i,nB],X,t]),{i,ide[nB,X,s,t],Min[iei[nB,X,s,t,γA],nB]}],0]
```

```
MYin[nB_,X_,s_,t_,γA_]:= NIntegrate[1/(α θ[i,nB]) (x[
θ[i,nB],X,0,1]),{i,Min[nB,Max[iei[nB,X,s,t,γA],idi[nB,X,s,t,γA]]],nB}]
TinB[i_,nA_,nB_,sB_,t_,γB_]:=(Gin[i,nA,nB,sB,t,γB]+fin)*γB/(1-γB)
ETinB[nA_,nB_,sB_,t_,γB_]:=NIntegrate[TinB[i,nA,nB,sB,t,γB],{i,Min[nA,Max[iei[nA,X
m[nB,nA,sB,t,γB],sB,t,γB],idi[nA,Xm[nB,nA,sB,t,γB],sB,t,γB]]],nA}]

Targetfile="DatenPIII.dat"
Equilibrium[sA_,sB_,t_,γA_,γB_]:=(nA0=2000;nB0=2000;J=0;nA1=N[Firms[nB0,sA,s
B,t,γA_,γB_]];nB1=N[Firmsl[nA0,sB,sA,t,γB,γA]];nA2=N[Firms[nB1,sA,sB,t,γA,γB]];n
B2=N[Firms[nA1,sB,sA,t,γB,γA]];nA3=N[nA2-nA1 nA2-nA1 nB1+nA1 nA2 nB1+nA1
nB2-nA2 nB2/(1-nA1-nB1+nA2 nB1+nA1 nB2-nA2 nB2)];nB3=N[(nB1-1)/(nA2-nA1)
(nA3-nA1)+1];Print[{J,N[nA3],N[nB3]}];While[(Abs[nA3-nA0] >20|| Abs [nB3-
nB0]>20)&&J<50, nA0=nA3; nB0=nB3; nA1=Firms[nB0,sA,sB,t,γA,γB] ;
nB1=Firms[nA0,sB,sA,t,γB,γA];nA2=Firms[nB1,sA,sB,t,γA_,γB_] ;nB2=Firms[nA1,s
B,sA,,t,γB,γA];nA3=N[nA2-nA1 nA2-nA1 nB1+nA1 nA2 nB1+nA1 nB2-nA2 nB2/(1-
nA1-nB1+nA2 nB1+nA1 nB2-nA2 nB2)];nB3=N[(nB1-1)/(nA2-nA1) (nA3-nA1)+1];
J++;Print[{J,nA3,nB3}]];Print[{"Equilibrium",J,nA3,nB3}];NA=nA3;NB=nB3;EGewA=E
G[NA,NB,sA,sB,t,γA,γB];EGewB=EG[NB,NA,sB,sA,t,γB,γA];XMA=Xm[NA,NB,sA,t,γ
A];XMB=Xm[NB,NA,sB,t,γB];YINA=Yin[NB,XMA,sA,t,γA];YINB=Yin[NA,XMB,sB,t,γB]
;YEXA=Yex[NB,XMA,sA,t,γA];YEXB=Yex[NA,XMB,sB,t,γB];YDA=Yd[NA,XMA,t];YD
B=Yd[NB,XMB,t];MYDA=MYd[NA,XMA,sA,t];MYDB=MYd[NB,XMB,sB,t];MYEXA=MY
ex[NB,XMA,sA,t,γA];MYEXB=MYex[NA,XMB,sB,t,γB];MYINA=MYin[NB,XMA,sA,t,γ
A];MYINB=MYin[NA,XMB,sB,t,γB];UA=1/μ (YDA+YINA+YEXA)^μ;UB=1/μ
(YDB+YINB+YEXB)^μ;MA=MYDA+MYEXA+MYINA;MB=MYDB+MYEXB+MYINB;W
A=UA-MA+(1/sA) ETinB[NB,NA,sA,t,γA];WB=UB-MB+(1/sB)
ETinB[NA,NB,sB,t,γB];Ergebnis={DateString[],sA,sB,t,γA,γB,NA,NB,EGewA,EGewB,
XMA,XMB,YDA,YDB,YEXA,YEXB,YINA,YINB,MYDA,MYDB,MYEXA,MYEXB,MYINA
,MYINB,(1/sA) ETinB[NB,NA,sA,t,γA],(1/sB) ETinB[NA,NB,sB,t,γB],
UA,UB,MA,MB,WA,WB};Print[Result];PutAppend[Result,Targetfile])
```

Derivation IX:

Welfare implications with identical country sizes

γA/γB	0%	1%	2%	3%	4%	5%
0%	**139.023; 139.023**	138.508; 139.793	137.843; 140.411	137.204; 140.970	136.631; 141.449	136.128; 141.862
1%	139.793; 138.508	138.934; 138.934	138.442; 139.654	137.825; 140.219	137.256; 140.701	136.752; 141.118
2%	140.411; 137.843	139.654; 138.442	138.842; 138.842	138.388; 139.508	137.836; 139.994	137.337; 140.404
3%	140.970; 137.204	140.219; 137.825	139.508; 138.388	138.742; 138.742	138.337; 139.326	137.854; 139.740
4%	141.449; 136.631	140.701; 137.256	139.994; 137.836	139.326; 138.337	138.633; 138.633	138.281; 139.132
5%	141.862; 136.128	141.118; 136.752	140.404; 137.337	139.740; 137.854	139.132; 138.281	138.519; 138.519
6%	142.194; 135.707	141.443; 136.329	140.729; 136.912	140.057; 137.432	139.463; 137.875	138.916; 138.223
7%	142.432; 135.386	141.678; 135.999	140.955; 136.580	140.281; 137.097	139.675; 137.541	139.130; 137.903
8%	142.555; 135.183	141.788; 135.791	141.049; 136.365	140.369; 136.876	139.747; 137.318	139.155; 137.607
9%	142.545; 135.134	141.744; 135.737	140.986; 136.302	140.274; 136.808	139.616; 137.247	139.046; 137.607
10%	142.544; 135.135	141.754; 135.734	140.987; 136.303	140.275; 136.810	139.617; 137.254	139.041; 137.611

γA/γB	6%	7%	8%	9%	10%
0%	135.707; 142.194	135.386; 142.432	135.183; 142.555	135.134; 142.545	135.135; 142.544
1%	136.329; 141.443	135.999; 141.678	135.791; 141.788	135.737; 141.744	135.734; 141.754
2%	136.912, 140.729	136.580; 140.955	136.365; 141.049	136.302; 140.986	136.303; 140.987
3%	137.432; 140.057	137.097; 140.281	136.876; 140.369	136.808; 140.274	136.810; 140.275
4%	137.875; 139.463	137.541; 139.675	137.318; 139.747	137.247; 139.616	137.254; 139.617
5%	138.223; 138.916	137.903; 139.130	137.681; 139.197	137.607; 139.046	137.611; 139.041
6%	138.356; 138.356	138.162; 138.662	137.953; 138.727	137.875; 138.553	137.881; 138.533
7%	138.662; 138.162	138.204; 138.204	138.082; 138.319	138.023; 138.153	138.033; 138.118
8%	138.727; 137.953	138.319; 138.083	138.002; 138.002	137.996; 137.853	138.010; 137.804
9%	138.553; 137.875	138.153; 138.023	137.853; 137.996	137.689; 137.689	137.712; 137.634
10%	138.533; 137.881	138.118; 138.033	137.804; 138.010	137.634; 137.712	137.635; 137.635

Derivation X:

Best-response tax rates given $\gamma_B = 0\%$

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	15239	15239	4313	4313	2516	2516	0	0	1798	1798	0	0	139.023	139.023
1%	17038	13538	4348	4287	2786	2251	0	0	1562	2035	0.102	0	139.793	138.508
2%	18784	11742	4376	4252	3047	1972	0	0	1329	2281	0.174	0	140.411	137.843
3%	20454	10014	4403	4219	3293	1697	49	0	1061	2522	0.208	0	140.971	137.204
4%	21954	8455	4428	4190	3511	1445	99	0	818	2745	0.213	0	141.449	136.631
5%	23292	7065	4451	4164	3703	1216	144	0	604	2948	0.197	0	141.862	136.128
6%	24427	5887	4470	4143	3863	1020	188	0	419	3123	0.163	0	142.194	135.707
7%	25328	4960	4485	4127	3990	863	236	0	259	3263	0.118	0	142.432	135.386
8%	25974	4316	4494	4116	4081	753	301	0	112	3363	0.057	0	142.555	135.183
9%	26251	4070	4497	4114	4122	711	375	0	0	3403	0	0	142.545	135.134
10%	26250	4071	4497	4114	4122	711	375	0	0	3403	0	0	142.544	135.135

Derivation XI:

Best-response tax rates given $\gamma_A = 8\%$

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	25974	4316	4494	4116	4081	753	301	0	112	3363	0.058	0	142.555	135.183
1%	24374	4316	4452	4137	3873	1026	409	0	170	3111	0.088	0.208	141.787	135.789
2%	24374	4316	4412	4157	3662	1290	513	0	237	2867	0.124	0.384	141.049	136.365
3%	21277	8991	4374	4176	3453	1542	612	99	308	2534	0.161	0.507	140.369	136.876
4%	19832	10445	4340	4195	3249	1782	706	220	385	2193	0.202	0.585	139.747	137.317
5%	18501	11740	4307	4209	3059	1996	788	358	460	1855	0.243	0.617	139.155	137.607
6%	17267	13073	4283	4227	2874	2211	873	522	536	1494	0.283	0.596	138.727	137.953
7%	16156	14233	4260	4238	2707	2400	946	728	608	1110	0.322	0.516	138.319	138.082
8%	15225	15225	4242	4242	2564	2564	1008	1008	671	671	0.356	0.356	138.002	138.002
9%	16236	14538	4250	4241	2728	2449	1431	1074	91	717	0.054	0.381	137.852	137.995
10%	16356	14469	4250	4241	2748	2437	1502	1082	0	722	0	0.383	137.804	138.012

Derivation XII:

Best-response tax rates given γ_B = 7%

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	4960	25328	4127	4485	863	3990	0	236	3263	259	0	0.118	135.386	142.432
1%	6624	23641	4148	4443	1146	3766	0	312	3002	364	0.201	0.166	135.999	141.678
2%	8254	21984	4169	4402	1419	3541	0	385	2749	476	0.367	0.218	136.581	140.955
3%	9838	20380	4189	4364	1682	3317	95	456	2412	592	0.482	0.271	137.097	140.281
4%	11332	18877	4208	4330	1927	3102	210	521	2072	707	0.551	0.325	137.541	139.674
5%	12732	17474	4226	4299	2154	2896	339	582	1733	822	0.576	0.379	137.903	139.129
6%	14005	16212	4240	4272	2360	2707	492	636	1389	929	0.553	0.431	138.161	138.661
7%	15084	15084	4246	4246	2537	2537	681	681	1028	1028	0.477	0.477	138.204	138.204
8%	16156	14233	4260	4238	2707	2400	946	728	608	1110	0.322	0.516	138.319	138.082
9%	17143	13490	4266	4233	2867	2277	1333	772	66	1184	0.039	0.550	138.153	138.023
10%	17235	13434	4266	4234	2882	2268	1384	776	0	1190	0	0.550	138.117	138.032

Derivation XIII:

Welfare implications with asymmetric country sizes

γA/γB	0%	1%	2%	3%	4%	5%
0%	**139.829; 139.201**	139.002; 139.787	138.353; 140.421	137.714; 140.981	137.141; 141.461	136.637; 141.876
1%	140.322; 138.524	139.521; 139.065	138.928; 139.653	138.327; 140.232	137.758; 140.725	137.255; 141.132
2%	140.938; 137.847	140.179; 138.464	139.425; 138.975	138.863; 139.495	138.332; 140.013	137.835; 140.421
3%	141.486; 137.206	140.742; 137.836	140.016; 138.414	139.298; 138.858	138.803; 139.313	138.344; 139.758
4%	141.965; 136.631	141.215; 137.265	140.503; 137.854	139.832; 138.367	139.188; 138.754	138.741; 139.118
5%	142.371; 136.131	141.623; 136.761	140.914; 137.352	140.246; 137.876	139.634; 138.316	139.071; 138.632
6%	142.706; 135.712	141.952; 136.338	141.233; 136.928	140.566; 137.452	139.967; 137.901	139.418; 138.261
7%	142.948; 135.388	142.194; 136.008	141.463; 136.595	140.794; 137.115	140.184; 137.565	139.636; 137.933
8%	143.078; 135.185	142.306; 135.798	141.573; 136.376	140.883; 136.895	140.348; 137.289	139.711; 137.707
9%	143.075; 135.136	142.282; 135.741	141.521; 136.312	140.796; 136.826	140.236; 137.215	139.561; 137.631
10%	143.075; 135.137	142.281; 135.742	141.521; 136.313	140.797; 136.828	140.240; 137.218	139.557; 137.635

γA/γB	6%	7%	8%	9%	10%
0%	136.278; 142.132	135.893; 142.452	135.687; 142.565	135.642; 142.537	135.642; 142.537
1%	136.832; 141.456	136.503; 141.689	136.293; 141.791	136.236; 141.747	136.238; 141.747
2%	137.410; 140.744	137.078; 140.966	136.860; 141.062	136.798; 140.993	136.799; 140.990
3%	137.924; 140.083	137.591; 140.294	137.370; 140.373	137.304; 140.267	137.306; 140.269
4%	138.359; 139.468	138.031; 139.689	137.808; 139.757	137.738; 139.620	137.741; 139.622
5%	138.687; 138.918	138.387; 139.145	138.167; 139.204	138.097; 139.042	138.101; 139.034
6%	138.919; 138.481	138.623; 138.663	138.428; 138.721	138.362; 138.547	138.369; 138.526
7%	139.166; 138.199	138.766; 138.319	138.555; 138.326	138.508; 138.149	138.513; 138.095
8%	139.226; 137.978	138.847; 138.129	138.541; 138.083	138.452; 137.823	138.473; 137.773
9%	139.077; 137.901	138.675; 138.052	138.375; 138.029	138.243; 137.754	138.234; 137.673
10%	139.045; 137.907	138.628; 138.058	138.328; 138.042	138.185; 137.763	138.183; 137.695

Derivation XIV:

Best-response tax rates given γ_B = 0% (sB=1, sA=1.01)

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	16235	14671	4355	4322	2649	2416	0	0	1706	1907	0	0	139.829	139.201
1%	17781	13061	4375	4287	2885	2164	0	0	1490	2123	0.098	0	140.322	138.524
2%	19550	11191	4404	4252	3147	1879	0	0	1257	2373	0.164	0	140.938	137.847
3%	21212	9464	4431	4220	3390	1604	46	0	995	2616	0.195	0	141.486	137.206
4%	22717	7897	4456	4190	3606	1350	91	0	758	2841	0.197	0	141.965	136.631
5%	24039	6518	4478	4165	3793	1122	132	0	553	3042	0.179	0	142.371	136.131
6%	25170	5340	4496	4143	3951	925	169	0	377	3218	0.147	0	142.706	135.712
7%	26060	4419	4512	4127	4075	769	208	0	229	3358	0.104	0	142.948	135.388
8%	26688	3787	4522	4117	4162	661	263	0	97	3455	0.050	0	143.078	135.185
9%	26945	3555	4525	4114	4199	621	325	0	0	3493	0	0	143.075	135.136
10%	26944	3557	4525	4114	4199	622	325	0	0	3493	0	0	143.075	135.136

Derivation XV:

Best-response tax rates given γ_A = 0% (sB=1, sA=1.01)

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	16235	14671	4355	4322	2649	2416	0	0	1706	1907	0	0	139.829	139.201
1%	14230	16540	4312	4347	2350	2705	0	0	1962	1642	0	0.108	139.002	139.787
2%	12435	18300	4278	4376	2073	2969	0	0	2206	1407	0	0.184	138.354	140.423
3%	10700	19980	4246	4403	1800	3217	0	52	2446	1134	0	0.222	137.714	140.981
4%	9129	21494	4216	4428	1548	3438	0	107	2668	883	0	0.233	137.141	141.461
5%	7723	22850	4190	4450	1320	3633	0	157	2871	660	0	0.215	136.637	141.876
6%	6529	24004	4168	4469	1122	3796	0	207	3046	464	0	0.181	136.216	142.207
7%	5567	24945	4152	4485	962	3929	0	265	3190	291	0	0.132	135.889	142.449
8%	4902	25619	4142	4494	850	4025	0	342	3292	127	0	0.066	135.687	142.566
9%	4655	25903	4140	4496	807	4068	0	429	3333	0	0	0	135.641	142.537
10%	4656	25901	4140	4496	807	4067	0	429	3332	0	0	0	135.642	142.537

Derivation XVI:

Best-response tax rates given γ_B = 8% (sB=1, sA=1.01)

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	4902	25619	4142	4494	850	4025	0	342	3292	127	0	0.066	135.687	142.566
1%	6520	23992	4162	4452	1123	3813	0	451	3039	188	0.203	0.098	136.293	141.791
2%	8078	22422	4183	4412	1383	3602	0	555	2799	256	0.374	0.134	136.864	141.062
3%	9613	20881	4203	4374	1637	3389	97	655	2469	330	0.493	0.173	137.374	140.374
4%	11068	19430	4221	4340	1875	3184	214	748	2133	408	0.567	0.215	137.808	139.753
5%	12430	18086	4238	4309	2095	2989	347	835	1796	486	0.596	0.256	138.168	139.209
6%	13693	16850	4253	4282	2299	2806	506	914	1448	562	0.576	0.297	138.428	138.721
7%	14821	15768	4263	4260	2481	2642	705	985	1077	633	0.499	0.336	138.555	138.326
8%	15825	14889	4271	4246	2643	2505	979	1048	649	696	0.343	0.368	138.544	138.083
9%	16820	14172	4277	4242	2805	2387	1385	1113	87	742	0.052	0.394	138.375	138.029
10%	16938	14102	4277	4242	2824	2375	1453	1121	0	746	0	0.396	138.328	138.043

Derivation XVII:

Best-response tax rates given γ_A = 8% (sB=1, sA=1.01)

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	26688	3787	4522	4117	4162	661	263	0	97	3455	0	0	143.078	135.185
1%	25075	5396	4480	4137	3955	936	371	0	154	3200	0.081	0.215	142.306	135.798
2%	23500	6962	4440	4157	3747	1201	474	0	219	2956	0.114	0.396	141.573	136.376
3%	21952	8508	4402	4179	3536	1460	575	102	290	2615	0.152	0.524	140.881	136.895
4%	20693	9787	4372	4193	3361	1671	658	230	354	2292	0.186	0.611	140.348	137.289
5%	19150	11348	4337	4213	3141	1927	757	351	440	1915	0.231	0.637	139.711	137.707
6%	17893	12646	4310	4227	2956	2138	838	541	514	1548	0.272	0.617	139.226	137.978
7%	16791	13825	4288	4239	2791	2330	912	757	585	1153	0.309	0.536	138.847	138.129
8%	15825	14889	4271	4246	2643	2505	979	1048	649	696	0.343	0.368	138.544	138.083
9%	15088	15866	4265	4248	2525	2667	1041	1485	698	96	0.371	0.057	138.452	137.823
10%	15022	15990	4266	4249	2513	2688	1050	1561	702	0	0.372	0	138.473	137.773

Derivation XVIII:

Best-response tax rates given γ_B = 7% (sB=1, sA=1.01)

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	5567	24945	4152	4485	962	3929	0	265	3190	291	0	0.132	135.889	142.445
1%	7255	23233	4174	4442	1246	3702	0	342	2928	399	0.196	0.182	136.503	141.689
2%	8891	21567	4195	4402	1518	3474	0	415	2677	512	0.357	0.235	137.078	140.966
3%	10478	19957	4215	4364	1778	3248	93	485	2345	630	0.468	0.290	137.591	140.294
4%	11972	18451	4235	4330	2020	3032	204	550	2010	748	0.534	0.344	138.031	139.689
5%	13366	17049	4251	4299	2244	2825	328	610	1678	862	0.557	0.399	138.387	139.145
6%	14620	15783	4265	4271	2446	2636	475	664	1344	971	0.534	0.453	138.623	138.66
7%	15720	14734	4276	4251	2622	2475	661	711	993	1066	0.463	0.495	138.766	138.316
8%	16791	13825	4288	4239	2791	2330	912	757	585	1153	0.309	0.536	138.847	138.129
9%	17750	13088	4293	4234	2946	2209	1284	799	63	1225	0.038	0.570	138.675	138.052
10%	17823	13042	4293	4234	2959	2201	1334	802	0	1230	0	0.572	138.628	138.058

Derivation XIX:
Best-response tax rates given γ_A = 7% (sB=1, sA=1.01)

Tax rate	NA	NB	XmA	XmB	YdA	YdB	YexA	YexB	YINA	YINB	TinA/sa	TinB/sb	WA	WB
0%	26060	4419	4512	4127	4075	769	208	0	229	3358	0.104	0	142.948	135.388
1%	24360	6099	4470	4148	3852	1055	285	0	333	3093	0.151	0.207	142.193	136.008
2%	22688	7745	4429	4169	3627	1332	359	0	443	2837	0.202	0.379	141.463	136.595
3%	21086	9331	4392	4189	3406	1595	429	99	557	2496	0.255	0.499	140.794	137.115
4%	19565	10845	4357	4209	3190	1844	495	218	679	2147	0.309	0.572	140.184	137.565
5%	17049	13365	4298	4251	2825	2244	610	328	862	1678	0.398	0.557	139.145	138.387
6%	16857	13574	4299	4241	2793	2286	612	511	894	1443	0.413	0.575	139.166	138.199
7%	15720	14734	4276	4251	2622	2475	661	711	993	1066	0.463	0.495	138.766	138.316
8%	14821	15768	4263	4260	2481	2642	705	985	1077	633	0.499	0.336	138.555	138.326
9%	14074	16776	4259	4266	2359	2806	750	1390	1151	69	0.534	0.041	138.508	138.149
10%	14022	16855	4259	4265	2350	2820	753	1445	1156	0	0.536	0	138.513	138.095

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