Erasmus School of Economics

Master Thesis submitted to obtain the degree of:

Master of Science in Economics and Business: Policy Economics

Taxing multinationals: moving from separate accounting to sales-based formula apportionment

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Date final version: 20-08-2021

Abstract

The standard method to tax multinationals is separate accounting (i.e., profits are reported and taxed separately in the different jurisdictions where the multinational company has an affiliate). Despite a steady decline in statutory tax rates over the past decades, multinationals continue to shift a considerable part of their profits to tax havens. The French economist Gabriel Zucman proposes to switch to a globally coordinated sales-based formula apportionment (referred to hereafter as "FA") system (i.e., profits are first consolidated on the global level, then taxing rights are distributed across jurisdictions on the basis of sales records). We show in a theoretical tax model that FA with a sales-only formula can end profit shifting practices through transfer pricing and intrafirm loans, but would create distortions in the investment decisions of firms. The current inefficient race-to-the-bottom in tax rates could turn into a race-to-the-top under sales-based FA. In addition, we demonstrate that countries have no unilateral incentives to deviate after implementation of sales-based FA. Hence, Zucman's proposal could be a stable equilibrium. However, this result is obtained for symmetric countries. We cannot predict whether the outcome also holds if we relax the symmetry assumption. In short, sales-based FA counters the flaws in current tax regulation, but is not a golden bullet creating an efficient tax environment without any distortions. Therefore, other policy options to improve the international tax framework have to be considered and examined in future research.

Keywords: *taxation of multinationals, sales-based formula apportionment, separate accounting, profit shifting.*

Preface and acknowledgements

This master thesis marks the end of my master studies in policy economics at the Erasmus School of Economics. Due to the corona outbreak, most of the educational activities in the past academic year went through Zoom or Teams and education took largely place online. However, despite these restricting circumstances for both students and lecturers, I enjoyed my time at the Erasmus School of Economics in Rotterdam.

I would like to express my sincere gratitude to those who supported me on this journey and contributed along the way in the development of this master thesis. First and foremost, I am grateful to my supervisor, professor Dirk Schindler, for his stimulating and fascinating lectures on taxation of multinationals which inspired me to write this master thesis. He always answered my many questions and provided useful contributions for the writing process of this thesis. During this summer when I had to finalise my thesis, he continued to nudge me along. He offered wisdom and reassurance after reading the initial draft. I am deeply indebted to him for his valuable suggestions for the improvement of this manuscript. Thanks are also due to professor Bas Jacobs and professor Dinand Webbink, the academic directors of the Master Policy Economics at the ESE, for their inspirational and challenging courses and seminars.

In addition, I want to thank friends and family who supported me in these peculiar times. My friends and former fellow students Arthur and Christophe kindly offered to proofread a draft of my master thesis and provided useful comments. A last and special thanks goes to my parents for giving me the opportunity to follow this second master's degree after I had obtained my initial master's degree in economics at Ghent University.

For all the much-appreciated help I have received, any remaining errors belong entirely to me.

Michiel Vandenberghe

Melle, August 2021

Table of contents

Abstract 1
Preface and acknowledgements 2
Table of contents 3
List of abbreviations 5
1. Introduction 6
2. Taxation systems 10
2.1 Separate accounting 10
2.2 Formula apportionment 13
3. Literature review 15
4. Model 17
4.1 Countries and firms 17
4.2 Taxation 19
4.2.1 Separate accounting 19
4.2.2 Sales-based formula apportionment 20
4.2.3 Hybrid tax system 22
4.3 Profit maximization 23
4.4 Behavioural responses of the MNC to tax policy changes 26
4.4.1 Comparative statics for the transfer price 26
4.4.2 Comparative statics for internal leverage 27
4.4.3 Comparative statics for capital investments 29
4.4.4 Summarizing the main effects 31
5. Welfare analysis and discussion 32
5.1 Welfare maximization and stability of tax systems 32
5.1.1 Deriving the optimal tax rate for sales-based formula apportionment 32
5.1.2 Stability of a sales-based formula apportionment equilibrium 33
5.1.3 Deriving the optimal tax rate for separate accounting 34
5.1.4 Stability of a separate accounting equilibrium 35
5.2 Discussion 36
5.2.1 Comparison to related literature 36
5.2.2 Water's edge 38
5.2.3 *Implementation difficulties formula apportionment* 39
5.2.4 Symmetry assumption 39
6. Conclusion 41
References 43
Appendix A: Maximization problem of the MNC 49

Appendix B: Total differentiation FOCs and comparative statics 49
Appendix C: Sign of effect domestic tax hike on capital stock domestic affiliate of the MNC 53
Appendix D: Mathematical derivations to find the optimal tax rate 55
Appendix E: Mathematical derivations to find unilateral incentives to deviate..... 57

List of abbreviations

BEPS	Base Erosion and Profit Shifting
CCCTB	Common Consolidated Corporate Tax Base
CFC	Controlled Foreign Company
DBCFT	Destination-Based Cash Flow Taxation
EC	European Commission
EU	European Union
FA	Formula Apportionment
FOC	First Order Condition
GDP	Gross Domestic Product
LHS	Left Hand Side
MNC	Multinational Company
OECD	Organisation for Economic Co-operation and Development
RHS	Right Hand Side
SA	Separate Accounting
UK	United Kingdom
US	United States

1. Introduction

"Governments around the world agree that corporate-tax arbitrage has got out of hand and taxing rights must be better aligned with economic activity."

The Economist, June 12th 2021

Taxation of multinationals is a hotly debated policy topic on the international stage. The pressure of public opinion in the Western world to ensure that multinational corporations contribute by paying their fair share of taxes is growing. Especially now when government finances plunged due to the economic consequences of the corona crisis, new revenue sources to address fiscal deficits are much needed. Politicians rightly fear a backlash amongst voters against the combination of belt-tightening governments and tax-dodging high-profile corporations.

Over the past decades tax avoidance by multinational companies (referred to hereafter as "MNCs") via profit shifting has increased, although the average statutory corporate tax rate has decreased in OECD countries (Zucman, 2018). Tørsløv et al. (2018) estimate that around 40 percent of MNC profits[1] were shifted to tax havens in 2015 with non-tax havens in the EU losing the most in terms of potential revenue. They notice that in low-tax countries foreign affiliates of MNCs are consistently more profitable than domestic firms (e.g., profit-to-wage ratio of foreign firms in Ireland is 800 percent). The opposite trend is observed in high-tax countries (Tørsløv et al., 2018).

The current international tax framework is based on separate accounting (referred to hereafter as "SA") – i.e., profits are recorded and taxed separately in the different jurisdictions where an MNC is active – and arm's length pricing. The arm's length principle states that the price of transactions within an MNC should be similar to the price for a comparable transaction between two independent entities (Keuschnigg and Devereux, 2013). This tax framework builds on rules and methods designed in the 1930s by the League of Nations[2] (Weiner, 1999). In that time, MNCs were still rather scarce. The main objective was to avoid double taxation and liberalise international trade and capital investments (Dietsch and Rixen, 2016). Nowadays, we live in a

[1] Tørsløv et al. (2018) define profits in their study as "profits made by multinational companies outside of the country where their parent is located" (p. 3).

[2] "The League of Nations was an international organization, headquartered in Geneva, Switzerland, created after the First World War to provide a forum for resolving international disputes." Definition retrieved from: https://history.state.gov/milestones/1914-1920/league

fast globalising and digitalising world. International tax methods need adaptations in order to deal with challenges linked to globalisation and digitalisation such as the increasing amount of intangible assets and brands traded around the globe which are difficult to properly value within the current arm's length rules (Juranek et al., 2018).

The French economist Gabriel Zucman proposes to move from an SA standard to a formula apportionment (referred to hereafter as "FA") system based on sales (Zucman, 2018). More specifically, corporate profits will first be accounted and consolidated on a global level, then countries have a right to tax a portion of the MNC's global profits based on the fraction of the sales the company made in the country in question. According to Zucman (2018), this proposal would not only eliminate the incentives for profit shifting, but also reduce the tension in the current race-to-the-bottom in corporate tax rates.

In the beginning of April 2021, the incoming Biden administration formulated and submitted at the OECD a two-pillar proposal to improve taxation of MNCs (The Financial Times, 2021). The first proposal is a global minimum corporate tax rate of 21 percent. When for example an American company shifts profits to a tax haven and pays a lower effective tax rate on these profits, the difference to the 21 percent minimum rate (i.e., the tax deficit) should be paid in the US. However, this 21 percent was lowered to a less ambitious 15 percent in a common statement in July by the OECD and G20 to find more appeal for the proposed new tax rules (OECD, 2021). The second proposal is focused on the largest MNCs and would reallocate taxing rights based on the location of a company's sales (The Economist, 2021a). Estimates of Devereux and Simmler (2021) suggest that this reallocation could redirect a total of 87 billion USD in profits to countries where sales are made. The negotiations are still ongoing, but the second part of the Biden proposal would be a first step towards Zucman's proposal for a pure sales-based FA tax framework.

Gabriel Zucman is not the first advocate of FA. Earlier proposals such as a 2001 report from the European Commission endorsed an FA system with an apportionment formula based on property, employment and sales factors to map and divide economic activity of MNCs across member states (European Commission, 2001; Fuest et al., 2006). Economic research demonstrated that FA with this three-factor formula boils down to separate taxes on each of the factors in the employed formula (e.g., Gordon and Wilson, 1986). This creates distortions in resource allocation and intense tax competition resulting in an inefficient outcome (Keen and Konrad, 2013; Nielsen et al., 2010). Hence, in the end FA might even be less desirable than SA.

Some economists (e.g., Zucman, 2018; Eichner and Runkel, 2008), however, belief that a sales-only formula would be less distortive and yield more efficient tax rates. Nonetheless, hitherto pure sales-based FA is less examined in economic literature compared to FA with a three-factor or a pure capital-based formula.

This master thesis aims to contribute to the existing literature on FA by answering two research questions. The first question is the following: *what are the advantages and disadvantages of a sales-based FA tax system (Zucman's proposal) in comparison to the current SA standard in international taxation?* More specifically, we want to examine which distortions occur in both systems and weigh them against each other. We use a theoretical approach by analysing government and firm behaviour in a hybrid tax model.

A recent working paper of Gresik and Bond (2021) showed that a globally efficient destination-based cash flow taxation[3] (referred to hereafter as "DBCFT") framework would not be a robust tax system. At least one country in a DBCFT union has an incentive to deviate and move towards current source-based corporate taxation. This implies that a commitment mechanism would be needed to enforce DBCFT. Sales-based FA in Zucman's proposal also switches from source-based taxation to destination-based taxation. Therefore, the second question this master thesis wants to answer, is *whether countries have an incentive to deviate if a coordinated sales-based formula were adopted on the global or European level*. These incentives can be found by evaluating whether a pure sales-based FA is a stable equilibrium. We perform a welfare analysis and consider both SA and sales-based FA as possible equilibria.

In the following section we elaborate on the current SA tax framework with its loopholes and introduce the concept of FA by briefly discussing some concrete applications of FA taxation on the national level and previous proposals. Thereafter, we focus on Zucman's recommendation for pure sales-based FA. In Section 3 an overview of the related economic literature is given. Section 4 contains our theoretical tax model with an analysis of the profit maximising behaviour of MNCs. A welfare analysis to determine the stability of respectively sales-based FA and SA can be found in Section 5, together with a comparison of our main results to existing literature

[3] DBCFT consists of two components. The first one is the destination-based component which is "a border adjustment that exempts export revenue from taxation and does not allow a tax deduction for imported inputs" (Gresik and Bond, 2021; p. 2). The second element is the cash-flow component which states that firms can "fully deduct capital expenses from taxable income in the year the expenses are incurred" (Gresik and Bond, 2021 ; p. 2).

and some discussion on possible problems or hurdles related to FA. Section 6 gives our concluding remarks.

2. Taxation systems

In this section two taxation frameworks are considered. First, SA is described together with existing tax avoidance practices of MNCs. Secondly, the FA method is explained with a focus on Zucman's concrete proposal for sales-based FA.

2.1 Separate accounting

The current standard in international taxation is the SA framework (Riedel and Runkel, 2007). Profits are reported separately for each subsidiary of the MNC. The taxable profits are calculated via accrual accounting. This accounting method distracts incurred expenses from earned revenue in order to determine taxable income. In general, all revenues are liable to tax and all expenses are deductible from the tax base (Schreiber, 2013). Subsidiaries of an MNC are legally independent affiliates and are treated as separate entities under SA. This implies that internal transactions between affiliates of the MNC are regarded as transactions between separate enterprises (Scheiber, 2013). The primary principle of current corporate tax legislations is source-based corporate income taxation; 'source' refers to where production and investments of the MNC occur (Beer and Michielse, 2021; Schatan, 2021). Hence, countries are able to tax profits of MNCs that have a physical presence (i.e., subsidiary or permanent establishment) within their boundaries. Governments tax the profits attributed to the affiliates in their jurisdiction (Cavelti et al. 2017).

This current system causes distortions in corporate taxation. It gives MNCs the possibility to shift a considerable proportion of their profits to low-tax countries such as Ireland, Singapore, Bermuda and other tax havens (Zucman, 2014). Profit shifting mainly occurs on paper. Tørsløv et al. (2018) conclude that "globally, machines have not massively moved to low-tax places; paper profits have" (p. 3).

MNCs engage in tax planning and profit shifting via two main channels (Zucman, 2015). The first one is *intragroup loans*. MNCs use their capital structure in order to minimize tax payments (Buettner and Wamser, 2007). The MNC opens an affiliate in a low-tax country which operates as an internal bank for the company. This affiliate lends capital to other affiliates in high-tax countries which in turn have to pay interest on these internal loans. These interest payments shrink the tax bases in the high-tax country and channel profits to the tax haven (Mintz and Smart, 2004). Hence, the tax rate differential between the high- and low-tax country affects the extent of intragroup loans used to shift profits (Buettner and Wamser, 2007).

The second main channel used for profit shifting is *the manipulation of transfer prices* (Zucman, 2015). A transfer of goods, services or a patent between two affiliates of the same MNC should follow the arm's length principle according to OECD guidelines. The transfer price should be the same regardless of whether the two trading parties are related or not. The OECD states that "transactions between associated enterprises should not be distorted by the special relation that exists between the parties" (OECD, 2011; p. 3).

The OECD provides several methods[4] to calculate the correct arm's length transfer price. However, for many transactions within an MNC it is difficult to determine the appropriate value. An applicable reference price between an affiliate and a non-related party is often non-existing (Zucman, 2015). Verifying the value of, e.g., patents, labels or algorithms that are traded within an MNC are challenging (Zucman, 2015). Intrafirm trade is substantial and gives MNCs ample opportunity to engage in profit shifting via incorrect transfer pricing. Up to 48 percent of imports in the US are intrafirm transactions. On the export side we get a proportion of 30 percent intrafirm trade for the US (Lanz and Miroudot, 2011). There are only a limited number of OECD countries that provide detailed information on transactions of MNCs. Based on data for these countries[5], intrafirm export would represent about half of total exports done by MNC affiliates (Lanz and Miroudot, 2011).

Besides these two profit shifting channels, MNCs also shift profit through *allocating risk disproportionally in low-tax countries*. Risk can be compensated with higher returns according to arm's length rules, which gives an incentive to the MNC to conduct its most risky activities in tax havens (Becker et al., 2020). A fourth method is choosing *a strategic location to store the intellectual property* of the firm (De Mooij et al., 2019). Countries as Ireland and the Netherlands have special 'patent boxes' taxing profits from innovation at a low rate.

The OECD and G20 have tried to reduce base erosion through illegitimate transfer pricing and internal loans by establishing the base erosion and profit shifting (referred to hereafter as "BEPS") initiative. The final BEPS reports in 2015 included 15 actions[6] to curb tax avoidance such as limiting interest deductions and obligations for MNCs to report tax payments on a country-by-country basis in order to provide transparent information to tax authorities

[4] An overview of the different transfer pricing methods can be found on: https://www.oecd.org/tax/transfer-pricing/oecd-transfer-pricing-guidelines-for-multinational-enterprises-and-tax-administrations-20769717.htm

[5] Countries in question are Israel, Italy, Japan, Poland, Slovenia, US, Canada, Sweden and the Netherlands

[6] For an overview of these 15 actions see: https://www.oecd.org/tax/beps/beps-actions/

worldwide. However, profit shifting does not seem to have declined in recent years (Clausing et al., 2021).

According to Cobham and Janský (2018), tax revenue losses for governments worldwide as a result of tax avoidance via tax havens are estimated to be around 500 billion USD annually. Zucman (2014) finds that MNCs in the US are able to reduce tax obligations by 20 percent through profit shifting. Tax avoidance through tax havens can explain two thirds of the drop in the effective tax rate faced by US enterprises since 1998 (Zucman, 2015). Beer et al. (2020) did a meta-analysis of empirical studies in order to estimate the size of profit shifting. They found that the semi-elasticity of pre-tax profits with respect to the tax differential in statutory tax rates is -1.5 in the last year of their study. Thus, if the tax differential between a high- and low-tax country increases with 1 percentage point, pre-tax profits in the high-tax country would decrease with 1.5 percent. Hence, in general we can conclude that despite recent initiatives to counter profit shifting, tax base erosion is still a prominent feature in the current SA framework.

High-tax countries have an incentive to lower their tax rate due to the negative effect of profit shifting on tax bases in their jurisdiction. This results in fierce and inefficient tax competition between countries to attract mobile tax bases with tax rates in a race-to-the-bottom (Mintz, 1999). Clausing et al. (2021) find that the global average statutory corporate tax rate has decreased from 49 percent in 1985 to 23 percent in 2020. Figure 1 shows the evolution in the statutory tax rates of some developed economies. We observe a clear downward trend over the past decades.

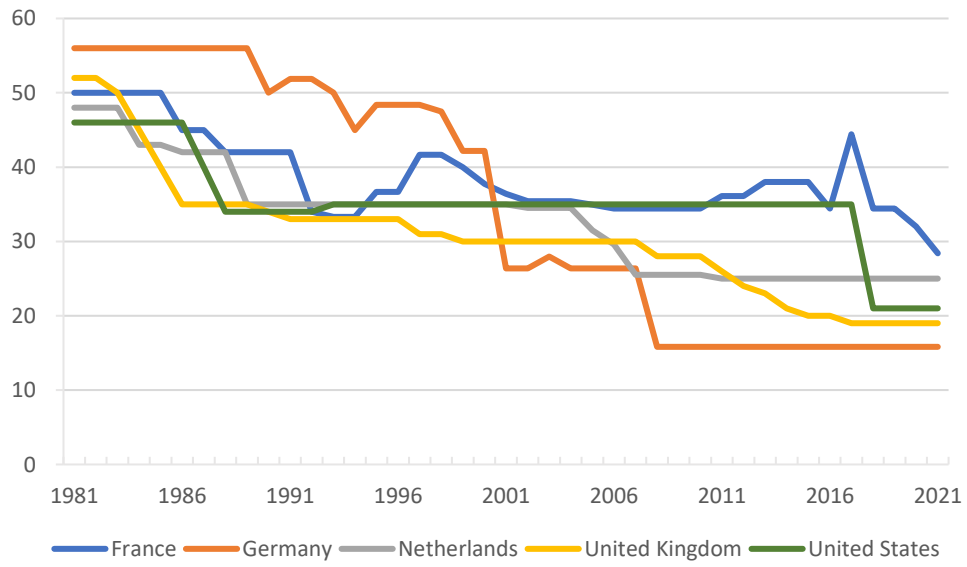

Figure 1: Statutory corporate income tax rate (in %).
Source: OECD, Tax Database.

2.2 Formula apportionment

An alternative taxation method that could potentially solve several of the current flaws in tax regulations is FA. Where SA starts from profits made within each jurisdiction, FA aggregates the MNC's profits globally on the parent level. Then, as can be derived from the name, a formula with apportionment indicators is employed to decide the portion of the global tax base that each jurisdiction can tax (Keen and Konrad, 2013). This framework has not yet been tested on an international stage, but is used within countries as the US, Canada, Germany and Switzerland in order to distribute taxable profits over the different states or provinces where a company is active (Eichfelder et al., 2018).

The apportionment formula within the US depends on the following company indicators: property, payroll and sales (Weiner, 1999). Nonetheless, the weighting of the different factors differs between states (Anand and Sensing, 2000). Some states use an equal weighting scheme for the three factors, others opt for a double weighted sales formula (1/2 sales, 1/4 property and 1/4 payroll), while a third group of states chooses a pure sales formula (Krchniva, 2014). In Canada, a two factor formula with equal proportion of payroll and sales is used by all provinces (Smart and Vaillancourt, 2021). The formula for the local corporate tax in Germany only uses the payroll (Eichfelder et al., 2018).

The idea of a common corporate tax base and FA has also been advocated in the EU. In the Bolkestein report of 2001 on corporate taxation in the EU, the European Commission (referred to hereafter as "EC") introduced the suggestion to consolidate profits and implement FA (Pethig and Wagener, 2007; European Commission, 2001). A concrete proposal of the EC on a common consolidated corporate tax base (referred to hereafter as "CCCTB") followed in 2011, but was blocked by the Council of the European Union (Chelyadina, 2019). In this original proposal, the EC intended to make the switch towards formula apportionment voluntary for firms. The formula to distribute the CCCTB across member states was based on three indicators: tangible assets, payroll and sales. Each factor would get an equal proportion in the formula. The payroll variable was divided in employment costs and number of employees, both variables would obtain equal weights to construct the payroll indicator (Krchniva, 2014). In October 2016, the EC reintroduced the idea with a modified relaunch of the 2011 proposal. The most recent proposal states that MNCs would be obligated to switch from a separate reporting standard to a consolidated tax base (Chelyadina, 2019).

The proposal evaluated in this master thesis and contrasted with the current SA framework is a pure sales-based FA supported by Zucman (2018). The consolidated worldwide profits of an MNC would be divided over the countries where the MNC operates solely based on sales. Sales would be divided according to the destination principle (i.e., location of consumers). For example, if there is an MNC with global taxable profits of 1 billion USD and 40 percent of its sales are in EU member states, 35 percent in the US and 25 percent in the UK, then EU member states are allowed to tax 400 million USD of the MNC's profits, the US 350 billion USD and the UK 250 million USD. Hence, the current source-based corporate income taxation principle would be replaced by destination-based taxation in Zucman's proposal. The French economist claims that a sales-based FA framework "would remove any incentive for firms to shift profits or move real activity to low tax places" (Zucman, 2018; p. 2). Zucman (2018) states that opting for a pure sales-based FA is ideal, because consumers cannot be transferred to tax havens and manipulation of sales records would be easy to detect for tax authorities. Leaving capital and labour out of the formula should minimize tax competition and distortions for these factors. These claims will be tested in our theoretical tax model in Section 4.

FA on a global scale is not a new concept. Already in the 1930s FA was considered by the Fiscal Committee of the League of Nations as an option for a common system to tax MNCs. However, after analysing the idea, FA was deemed unfeasible due to large economic differences between countries (Weiner, 1999). The world has changed a great deal since the report of the Fiscal Committee of the League of Nations laid the first stone for the current international corporate taxation framework (Weiner, 1999). Estimates suggest that approximately 7000 parent MNCs existed in 1970. In 2008, the number of MNCs – excluding financial transnational companies – had risen to 82.000 (Cadestin et al., 2018). Around 33 percent of global output is produced by MNCs and 23 percent of total employment is within MNCs (OECD, 2018). Economic integration surged over the past decades; we live in a (hyper)globalised world. Perhaps the time has come to shift towards a more coordinated framework with global consolidated tax bases and a common apportionment formula.

3. Literature review

The amount of studies that perform a thorough analysis of FA and make a comparison to the current SA framework is limited. Two of the first studies are McLure (1981) and Gordon and Wilson (1986); they show that FA based on three apportionment indicators can be seen as three separate taxes on each factor. This creates distortions in resource allocation. Nielsen et al. (2010) come to the same conclusion and find that tax competition under FA can result in inefficiently low or high tax rates. Comparing SA and FA leads to ambiguous results in their study. Which of the two systems is the most efficient or welfare enhancing depends on the magnitude of e.g., the concealment costs of transfer pricing. In an empirical study, based on US data, Clausing (2016) reckons that distortions in employment, investments or sales are limited under FA. This is a positive observation for those who advocate a global FA framework. However, we need to consider that corporate taxes on the state level are quite low in the US, which can dampen the tax competition effect (Clausing, 2016).

Eichner and Runkel (2008) use a theoretical model with two countries to investigate responses to different FA formulas. They identify two externalities: (1) tax base externality and (2) formula externality, which refer respectively to how unanticipated adaptations in firm behaviour impact tax bases and manipulation of the formula by MNCs. Under a capital or payroll-based formula, the sum of the externalities will be positive and result in inefficiently low corporate tax rates. Including a sales factor into the formula would give a more efficient outcome according to Eichner and Runkel (2008), because under a sales-only formula the sum of externalities is negative. Therefore, a sales factor in the formula would counteract the positive externality from payroll and capital factors. Eichner and Runkel (2008) empirically calibrate their model for the EU-15 and find that a pure sales-based formula would be the least distortive option. In this scenario, FA would lead to an increase in total welfare in comparison to SA. There is a difference between sales-based FA as proposed by Zucman (2018) and the sales-based FA in Eichner and Runkel (2008). Where Zucman (2018) chooses a destination-based sales factor (i.e., location of the consumer), Eichner and Runkel (2008) opt for an origin-based sales factor (i.e., location of the seller). In our model presented in Section 4, there is no distinction between destination and origin for sales revenue. Production and consumers are in the same jurisdiction.

An introduction of FA on the global level will have two large effects on government revenue from corporate taxation (De Mooij et al., 2019). On the one hand, the possibility of loss

consolidation within a corporate group of subsidiaries located in different countries could lead to lower tax bases. On the other hand, a reallocation of the tax base away from tax havens occurs based on the formula indicators. On the basis of firm-level data for the EU, Devereux and Loretz (2008) determine that the second reallocation effect would dominate the first tax base effect for an obligatory European FA framework. They find that on average over different formula options, tax revenue in the EU will rise by 2 percent. One important sidenote to this result is the assumption made by Devereux and Loretz (2008) that behavioural responses of the firms would be absent when a switch from SA to FA is completed. Eichner and Runkel (2008) include firm behaviour in their theoretical model. After calibration of their model for the EU-15, they conclude that a pure sales-based FA environment will increase government revenue by 1 billion EUR or 0.1 percent of GDP and the optimal average tax rate in the EU will rise by at least 2 percent .

Standard tax competition arguments indicate that a tax on a mobile factor such as capital will be shifted onto immobile components such as labour. Hence, following this line of reasoning the optimal formula should directly target immobile elements. An example is the German local corporate tax where the FA formula is solely payroll-based. Nevertheless, Runkel and Schjelderup (2011) demonstrate that both in a decentralized and centralized setting the optimal formula decision includes a mobile factor but for different reasons. When the formula choice is decentralized , each jurisdiction will include mobile and immobile indicators to attract rents of the MNC. By reducing the weight on immobile factors, a jurisdiction can capture a larger part of the MNC's rents. Under central decision making, the central planner would not opt exclusively for immobile factors, because distortions will be smaller when mobile factors are taken into account as well.

Anand and Sansing (2000) focus on the decentralized FA environment in the US and try to explain why formulas differ across states. They find both theoretically and empirically that welfare would be maximized if all states opted for a common formula. However, Anand and Sansing (2000) show that states have unilateral incentives to deviate. Net importing jurisdictions want to have a higher weight on sales, while net exporting states favour higher weights on the production factors in order to attract more of the common tax base. In our welfare analysis in Section 5, we also search for unilateral incentives to deviate from a coordinated system, but we focus on incentives to move closer to or away from the current SA system or a pure sales-based FA environment. Therefore, adding new factors or changing weights in the formula is left out of our analysis.

4. Model

4.1 Countries and firms

The model entails a tax union of three countries (A, B and C) with a common market, which can be seen as a representation of the European Union. In this common market, an MNC has an affiliate in each of the three countries. Furthermore, we assume that the tax union has well-functioning capital markets and countries are unable to influence the interest rate (i.e., small country assumption). Consequently, there is a constant rental cost per unit of capital equal to *r*.

Countries A and B are two larger jurisdictions. Affiliates A and B of the MNC each produce and sell one homogenous good to local consumers in the respective countries. The production function looks as follows: $F(K_i, S)$ for $i = A, B$. In order to produce, an affiliate needs capital (K_i) and the patent (S) which provides the necessary intellectual property for the production technology. If one of these two factors is not present, producing becomes impossible. The marginal productivity of capital is positive and decreasing (concave function): $F_K > 0$ and $F_{KK} < 0$. This production function is based on the one used in Nielsen et al. (2010). Labour is not included in the production function. Although labour is an important factor in the production process, in our analysis we can make abstraction of labour because it does not impact our results. The notation of the production function $F(K_i, S)$ is simplified to $F(K_i)$ in the equations below, because S is a fixed factor which the MNC cannot change.

Country C is a small country and is considered a tax haven. The corporate tax rate in country C is lower than the tax rates in A and B. Affiliate C of the MNC does not produce or sell goods in country C, but holds the patent (S) needed to apply the underlying technology in the production process. There is one patent, which is a fixed factor, and we set the arm's length price of the patent equal to S, which represents the fixed costs associated to the patent. These fixed costs are for example expenses made in the development process. Affiliates A and B have to pay a fee (G_iS) in order to obtain and be allowed to use the patent stored in affiliate C. This invoice is the first instrument used by the MNC to shift profits from the high-tax countries with producing affiliates A and B to the low-tax country C. Affiliates A and B can pay a certain mark-up above the arm's length price of the patent in order to transfer profits out of these countries ($G_i \geq 1$). The precise mark-up above the arm's length price equals $G_i - 1$. Accordingly, there is no profit shifting via the patent fee if G_i equals 1.

Tax authorities in country A and B might sanction this illegitimate shrinking of the tax bases due to over-invoicing the patent fee. In order to avoid potential fines, affiliates A and B have concealment costs $C^S(G_i)$ per transfer of the patent, which include for examples payments for legal advice and specialized tax lawyers. $C^S(G_i)$ will be positive if $G_i > 1$ and zero if $G_i = 1$. Furthermore, the concealment costs per patent transfer are a convex function in G_i: $C^{S'}(G_i) > 0$ and $C^{S''}(G_i) > 0$. The concealment costs grow more than proportional, when the mark-up above the arm's length price increases. This is in line with cost functions in e.g., Eichner and Runkel (2008), Riedel and Runkel (2007), and Runkel and Schjelderup (2011).

Next to profit shifting via patent fees, the lowest-taxed affiliate C also operates as an internal bank of the MNC. Affiliate C holds a capital stock (K_c) which can be lent to affiliates A and B: $K_c = D_A^I + D_B^I$ with D_i^I indicating the amount of internal debt in affiliate i. The MNC uses debt shifting from the low-tax country to the high-tax countries to reduce its tax burden. Affiliates A and B have to transfer interest rate payments (rD_A^I and rD_B^I) for borrowing capital at the internal bank C. These interest payments lower the tax base in the high-tax countries and increase the tax base in the tax haven. This mechanism generates tax savings. Exploiting the internal debt tax shield to minimize financing costs is the second channel used by the MNC to shift profits.

Tax planning through the creation of an internal bank also results in concealment costs for the borrowing affiliates A and B: $C^I(b_i^I)$ per unit of capital with b_i^I representing the internal leverage ratio in affiliate i ($b_i^I = \frac{D_i}{K_i}$). The concealment costs consist of hiring tax experts such as lawyers, consultants and accountants to create an optimal structure for the internal bank. Countries have thin capitalization[7] or CFC[8] rules which give tax authorities instruments to sanction excessive internal debt in an affiliate of the MNC. $C^I(b_i^I)$ will be positive if $b_i^I > 0$

[7] Thin capitalization rules are a set of legislation that restricts tax deductibility of (internal) interest rate payments relative to the firm's earnings commonly measured as EBITDA or EBIT (*earnings-stripping rules*) or curbs the deductibility of debt after a specified debt-to-asset ratio is surpassed (*safe-harbor rules*), see e.g., Ruf and Schindler (2015).

[8] Controlled-Foreign-Company (CFC) rules are an instrument to reduce income shifting. The application of CFC rules can be explained in three steps with the German CFC rule as example (see e.g., Forster and Schmidtmann, 2004). First, CFCs are identified. A foreign subsidiary from a domestically headquartered MNC is considered a CFC when a certain ownership threshold is reached. In the German case, this threshold is ownership of 50 percent in shares or voting rights in the foreign subsidiary. The second step defines the foreign profits that are targeted under CFC regulation. German CFC legislation targets passive income (defined negatively which means income that cannot be qualified as 'active'). The third and last step determines whether the foreign profits are low-taxed and should be taxed domestically. The German CFC rules consider passive income in the CFC low-taxed, if the effective tax rate is less than 25 percent.

and zero if $b_i^I \leq 0$. The cost function is convex in internal leverage: $C^{I'}(b_i^I) > 0$ and $C^{I''}(b_i^I) > 0$. The costs increase more than proportional, when internal leverage increases. This cost function is in line with the one used in Møen et al. (2019).

A last assumption is that the MNC is completely equity financed. There is no external debt. Previous literature on profit shifting such as e.g., Nielsen et al. (2014) makes the same assumption. This simplifies our calculations without affecting the results.

4.2 Taxation

In the previous section we focused on different features of the MNC such as the production process and profit shifting behaviour within a common market. This section introduces two different taxation frameworks that can be used within the tax union: SA and sales-based FA. First, we establish the tax bases of the affiliates in each country. Secondly, we show how the tax revenue is measured and differs between the two corporate taxation regimes. The third and last part demonstrates how the after-tax profit in each affiliate and the MNC's total after-tax profit within the tax union is calculated in a hybrid framework that combines both taxation methods and allows to switch from one tax system to the other.

4.2.1 Separate accounting

As explained in Section 2, SA is the current standard in international taxation. Profits of the MNC are reported and taxed separately for each affiliate with source-based taxation as the guiding principle. The taxable profits ($\pi_{i\,SA}^t$) in affiliate A and B in our tax union under SA are the following:

$$\pi_{i\,SA}^t = F(K_i) - G_i S - r b_i^I K_i \qquad with\ i = A, B\ . \tag{1}$$

Production in affiliates A and B equals total sales done by the MNC in these countries. From the sales revenue we need to deduct a fee for the usage of the patent and interest payments for internal debt. We assume that the costs of equity are not tax deductible, which is in line with the tax code of most OECD countries. The OECD established rules on the limitation of tax deduction in action 4 of their BEPS report in October 2015[9]. Additionally, the costs of profit shifting are excluded from the tax base in our model. Deductibility of these costs does not

[9] For more information, see: https://www.oecd.org/tax/beps/beps-actions/action4/

impact our results. These assumptions follow the tax models used in Nielsen et al. (2010) and Eichner and Runkel (2008).

The taxable profits of affiliate C are given by equation (2). Affiliate C receives passive income from patent fees and interest payments on capital lent to affiliates A and B. Affiliate C also makes per transfer of the patent fixed costs equal to S. These costs are deducted from the passive income in order to establish the taxable profits.

$$\pi^t_{C_{SA}} = (G_A + G_B - 2)S + r(b^I_A K_A + b^I_B K_B)\,. \tag{2}$$

Equations (3) and (4) show the tax revenue obtained by the three member states of the tax union under a pure SA framework. Each country can tax profits booked in their jurisdiction.

$$T^{SA}_i = t_i[F(K_i) - G_i S - r b^I_i K_i] \qquad with\ i = A, B\,, \tag{3}$$

$$T^{SA}_C = t_C[(G_A + G_B - 2)S + r(b^I_A K_A + b^I_B K_B)]\,. \tag{4}$$

Equation (5) combines tax revenues in the three member states of the tax union and gives the total amount of taxes paid by the MNC in an SA framework. The last line of equation (5) demonstrates how a higher transfer price for the patent and more internal leverage reduces the total tax burden of the MNC for given statutory tax rates.

$$\begin{aligned} T^{SA} &= t_A[F(K_A) - G_A S - r b^I_A K_A] + t_B[F(K_B) - G_B S - r b^I_B K_B] \\ &\quad + t_c[(G_A + G_B - 2)S + r(b^I_A K_A + b^I_B K_B)] \\ &= t_A F(K_A) + t_B F(K_B) - t_C 2S \\ &\quad -(t_A - t_C)(G_A S + r b^I_A K_A) - (t_B - t_C)(G_B S + r b^I_B K_B)\,. \end{aligned} \tag{5}$$

4.2.2 Sales-based formula apportionment

In a sales-based FA system as proposed by Zucman (2018), the tax bases of the three MNC's affiliates are consolidated (π^t_{FA}). The same assumptions as in the aforementioned SA environment hold; costs of equity and costs of profit shifting are excluded. The tax base is given by the following equation:

$$\pi^t_{FA} = \sum_i F(K_i) - 2\,S \qquad with\ i = A, B\,. \tag{6}$$

The tax base is total sales revenue minus the patent costs expensed in country C. Mark-ups on the arm's length price of the patent and interest payments on internal debt cancel out after

constructing the common tax base. Consequently, these terms do not appear in total taxable profits. Each member state is allowed to tax a proportion of the MNC's total profit created within the common market. This proportion is the percentage of total sales made in the member state in question. The tax base is consolidated, but the tax rates are still determined by the individual member states. Tax revenue for country A and B is described by equation (7). The treasury of country C does not receive any revenue, because no sales are reported within its jurisdiction.

$$T_i^{FA} = t_i \frac{F(K_i)}{\sum_i F(K_i)} \left[\sum_i F(K_i) - 2S \right] \qquad with\ i = A, B\ . \tag{7}$$

Equation (8) shows the total tax payment an MNC faces in a FA tax union with a formula solely based on sales.

$$\begin{aligned} T^{FA} &= t_A \frac{F(K_A)}{F(K_A) + F(K_B)} [F(K_A) + F(K_B) - 2S] \\ &\quad + t_B \frac{F(K_B)}{F(K_A) + F(K_B)} [F(K_A) + F(K_B) - 2S] \\ &= t_A \left(F(K_A) - 2S \frac{F(K_A)}{F(K_A) + F(K_B)} \right) + t_B \left(F(K_B) - 2S \frac{F(K_B)}{F(K_A) + F(K_B)} \right). \end{aligned} \tag{8}$$

A first interesting effect that can be derived from equation (8) is what happens to the tax burden of the MNC in a sales-based FA union when the MNC makes a marginal change in the capital stock in one of the two producing affiliates. Equation (9) demonstrates that the additional tax payments after a capital investment increase in affiliate A do not only depend on the production and tax rate in this domestic country but also on the production and tax rate in the other foreign producing affiliate B. This interdependence of capital investments in producing affiliates does not occur under SA in our model.

$$\begin{aligned} \frac{\partial T^{FA}}{\partial K_A} &= t_A \left(F_K(K_A) - 2S \frac{F_K(K_A)[F(K_A) + F(K_B)] - F_K(K_A)F(K_A)}{\left(F(K_A) + F(K_B)\right)^2} \right) \\ &\quad + t_B 2S \frac{F_K(K_A)F(K_B)}{\left(F(K_A) + F(K_B)\right)^2} \\ &= t_A F_K(K_A) - 2S(t_A - t_B) \frac{F_K(K_A)F(K_B)}{\left(F(K_A) + F(K_B)\right)^2}\ . \end{aligned} \tag{9}$$

Interesting to notice is that the second part of the RHS of equation (9) shows that the MNC has, ceteris paribus, an incentive to overinvest in the country with the higher tax rate. This incentive can be explained by the fact that attributing a larger part of the fixed costs to the high-tax country saves taxes. If the MNC invests more in the higher tax country, then the effective tax rate used on the patent costs will be higher in an FA system based on sales which can be seen in equation (7) and (8). This higher effective tax rate on the patent costs leads to lower tax obligations for the MNC. This tax effect under FA shows parallels to the findings of Eichner and Runkel (2008). However, their argumentation is brief. We provide further analysis and will add on their argument.

4.2.3 Hybrid tax system

Equation (10) is a weighted hybrid tax function which combines the two corporate taxation systems: SA and sales-based FA. This hybrid tax function makes it possible for the tax union to switch from one system to the other or implement a hybrid system combining elements of both methods. If the policy parameter α equals zero, then a pure SA standard is employed. If the parameter α changes to one, then a pure FA system is used.

$$T^{FA+SA} = \alpha \sum_i T_i^{FA} + (1-\alpha)\left(\sum_i T_i^{SA} + T_c^{SA}\right) \qquad with\ i = A, B\ . \tag{10}$$

Equations (11) and (12) give the after-tax profits for the different affiliates of the MNC, when both taxation systems are a policy option. The first parts of the equations give the economic profits. For country A and B the economic profits equal sales revenue minus the patent fee, equity costs and profit shifting costs. For country C economic profits are the passive income from patent fees and interest charges minus the costs associated with the patent and the rental costs of the capital stock in the internal bank. The second part of equations (11) and (12) describes the tax obligations for a hybrid tax function based on equations (3), (4) and (7).

$$\pi_i = F(K_i) - G_i S - rK_i - C^S(G_i)S - C^I(b_i^I)K_i - \alpha T_i^{FA} - (1-\alpha)T_i^{SA}$$

$$with\ i = A, B, \tag{11}$$

$$\pi_c = (G_A + G_B - 2)S + r(b_A^I K_A + b_B^I K_B - K_C) - (1-\alpha)T_c^{SA}. \tag{12}$$

Based on the individual tax bases of the three MNC's affiliates and the hybrid tax function, we can calculate the total after-tax profit of the MNC within the entire tax union (Π_p), see equation (13). The first part of equation (13) demonstrates that the patent fees and interest

payments cancel out ($\sum_i G_i S = 0$ and $\sum_i r D_i^I = 0$) in the economic profits before taxation. This indicates the presence of respectively an internal shifting constraint and internal lending constraint.

$$\Pi_p = \sum_i (F(K_i) - rK_i - C^S(G_i)S - C^I(b_i^I)K_i) - 2S$$
$$-\alpha \sum_i T_i^{FA} - (1-\alpha)\left(\sum_i T_i^{SA} + T_c^{SA}\right) \qquad with\ i = A, B\ . \qquad (13)$$

4.3 Profit maximization

The MNC chooses the mark-up on the arm's length price of the patent fee (G_i), internal leverage (b_i^I) and the capital stock (K_i) in order to maximize its after-tax profits (equation 13). Thus, the maximization problem[10] looks as follows: $\underset{G_i, b_i^I, K_i}{max}\ \Pi_p$ with $i = A, B$.

Equations (14) – (16) are the first order conditions (referred to hereafter as "FOCs") for the interior solution of the maximization problem. In total, six FOCs describe the maximization problem of the MNC, two FOCs for each variable the MNC is able to alter in affiliate A or B.

Equation (14) describes the condition for the optimal transfer price of the patent. The left hand side (referred to hereafter as "LHS") of the equation shows the marginal tax savings of an increase in the transfer price of the patent. The additional tax savings after a marginal increase in the transfer price are given by the difference between the tax rate in the high-tax country and the tax haven. Hence, a higher tax differential results in larger tax savings and by consequence a higher optimal transfer price. The right hand side (referred to hereafter as "RHS") gives the marginal tax planning costs associated with a higher mark-up on the patent fee. The optimal transfer price is the price where marginal benefits equal the marginal costs. In a pure sales-based FA system ($\alpha = 1$) the mark-up charged above the arm's length price for the patent will be zero. Due to the internal shifting constraint, over-invoicing the patent does not create any tax savings for the MNC in an FA union. Profits of the MNC are aggregated on the parent level. Consequently, profit shifting through transfer pricing disappears under FA in our model. The optimal mark-up used by the MNC is at its highest level in a pure SA environment ($\alpha = 0$).

$$\frac{\partial \Pi_p}{\partial G_i} = -\frac{\partial C^S}{\partial G_i} S - (1-\alpha)(-St_i + t_c S) = 0$$

[10] The expanded form of the maximization problem with all explicit expressions can be found in Appendix A.

$$\Leftrightarrow (1-\alpha)(t_i - t_c) = \frac{\partial C^S}{\partial G_i} \qquad with\ i = A, B\ . \tag{14}$$

The FOCs for the optimal level of internal leverage are given by equation (15). The LHS gives the marginal tax benefits of an increase in internal leverage in affiliate A or B. The optimal level of internal leverage will be zero under a pure sales-based FA system ($\alpha = 1$), because internal leverage does not create any tax savings in this framework. The FA method consolidates profits. Interest expenses in affiliates A and B and interest income in affiliate C cancel each other out and cannot reduce the global tax base. This means that the internal debt tax shield does not work in an FA environment. Hence, affiliate C will not operate as an internal bank under FA in our model. Under SA the marginal tax savings of an increase in internal leverage equal the tax differential between the high-tax country and the lowest-taxed affiliate C multiplied with the interest rate per unit of capital. The RHS of equation (15) represents the marginal tax planning cost of internal leverage. Thus, the optimal level of internal leverage will be reached when marginal benefits equal marginal costs. The higher the tax difference between the high-tax country and the tax haven and the closer to a pure SA environment ($\alpha = 0$), the larger is the internal debt tax shield in affiliates A and B. This results in more internal debt in the optimum.

$$\frac{\partial \Pi_p}{\partial b_i^I} = -\frac{\partial C^I}{\partial b_i^I} K_i - (1-\alpha)[-t_i r K_i + t_c r K_i] = 0$$

$$\Leftrightarrow (1-\alpha)(t_i - t_c) r = \frac{\partial C^I}{\partial b_i^I} \qquad with\ i = A, B\ . \tag{15}$$

The last two FOCs of the maximization problem describe the optimal level of capital investment in the producing affiliates A and B (equations 16a-b). The LHS of the equations gives the marginal benefits of an increase in the capital stock. The first part of the marginal benefit side is the marginal product of capital after tax. The second part will be zero under a pure SA system ($\alpha = 0$) or when the tax rates in country A and B are the same. This second part ($2S(t_A - t_B)X_{AB}$) shows that in a corporate tax framework with sales-based FA the marginal benefits of an increase in capital investment will be larger in the country with the higher tax rate, ceteris paribus. Hence, the MNC has an incentive to invest relatively more in this country. Through strategic investment the MNC is able to shift a larger part of the fixed costs to the

highest-taxed affiliate. This yields tax savings[11]. The RHS of equations (16a-b) represents the effective capital costs. The optimal capital stock level is reached when marginal benefits equal marginal costs of capital investment.

$$\frac{\partial \Pi_p}{\partial K_A} = [1-(1-\alpha)t_A]F_K(K_A) - [1-(1-\alpha)(t_A-t_C)b_A^I]r - C^I(b_A^I) - \alpha\frac{\partial T^{FA}}{\partial K_A} = 0$$

$$\Leftrightarrow (1-t_A)F_K(K_A) + \alpha 2S(t_A-t_B)X_{AB} = r_A^e\,, \qquad (16a)$$

$$\frac{\partial \Pi_p}{\partial K_B} = 0 \Leftrightarrow (1-t_B)F_K(K_B) + \alpha 2S(t_B-t_A)X_{BA} = r_B^e\,, \qquad (16b)$$

with $r_i^e = [1-(1-\alpha)(t_i-t_C)b_i^I]r + C^I(b_i^I)$, which represents the effective capital costs, and $X_{ij} = \frac{F_K(K_i)F(K_j)}{\left(F(K_i)+F(K_j)\right)^2} > 0$ for $i = A, B$.

In the special case that the two high-tax countries opt for the same corporate tax rate ($t_A = t_B$), the marginal benefits from capital investments will be the same under both taxation systems (equation 17). However, the effective capital costs are lower under SA. In a sales-based FA environment r_i^e equals *r*, while under SA r_i^e equals $[1 - (t_i - t_c)b_i^I]r + C^I(b_i^I)$. Debt shifting under SA reduces the corporate tax distortion and lowers the capital costs of the MNC, because the interest expenses on internal debt are tax deductible in the high-tax countries. Internal debt can be seen as tax-favoured equity in an SA union (see Schindler and Schjelderup, 2012). In contrast to SA, the FA framework does not provide an internal debt tax shield to the MNC. Therefore, the incentives for capital investments are in general lower in an FA union.

Substitute $t_A = t_B$ in equations (16a-b); we obtain the following equation:

$$(1-t_i)F_K(K_i,) = r_i^e \qquad with\ i = A, B\,. \qquad (17)$$

The main conclusions that can be drawn from the FOCs of the MNC's after-tax profit maximization problem are the following: (1) profit shifting via transfer pricing and internal leverage disappears in the optimum under sales-based FA, (2) the MNC has an incentive to overinvest in the producing affiliate located in the country with the higher tax rate in a sales-based FA union, and (3) effective capital costs are larger under sales-based FA than under SA, which makes capital investments less attractive under FA compared to the current SA standard.

[11] More intuition for these tax savings can be found in subsection 4.2.2 where we described the effect of a marginal change in the capital stock on the MNC's tax burden under sales-based FA.

4.4 Behavioural responses of the MNC to tax policy changes

In the previous subsection we demonstrated how the MNC optimizes capital investments, transfer pricing and internal leverage in order to maximize after-tax profits for given tax rates. In this section we describe how the MNC's optimizing behaviour will change when a tax policy parameter ($\alpha, t_A, t_B \; or \; t_C$) in one of the tax union member states increases. The comparative statics for the six endogenous variables that the MNC can adapt after a policy change ($G_i, b_i^I \; and \; K_i \; with \; i = A, B$) are computed after totally differentiating the FOCs and using Cramer's rule for a system of two equations[12].

To simplify our analysis, we assume that the two large countries A and B will be symmetric. As a result of this symmetry, they will opt for the same tax rate in equilibrium. This assumption helps us to identify clear behavioural responses of the MNC. The symmetry assumption is frequently used in tax competition models and analysis, because symmetry keeps the model tractable (e.g., Eggert and Schjelderup, 2003; Kolmar and Wagener, 2007; Nielsen et al., 2010).

4.4.1 Comparative statics for the transfer price (G_A and G_B)

Equations (18) – (21) indicate how policy changes impact the optimal transfer price for internal trading of the patent. If we move towards FA and away from SA, then the optimal mark-up above the arm's length price of the patent will decrease and eventually become zero in a pure sales-based FA environment ($\alpha = 1$), see equation (18). Under FA tax bases are consolidated. Therefore, the more the taxation system evolves towards FA, the fewer tax savings profit shifting via transfer pricing creates. This effect will be stronger the larger the tax differential and the flatter the marginal tax planning costs curve for transfer pricing (i.e., lower $C_{GG}^S(G_i)$). In a pure FA environment the MNC would only have concealment costs without any benefits from profit shifting through the transfer price. We showed in the previous subsection that in the optimum the transfer price of the patent will be the arm's length price in a sales-based FA union (equation 14). Hence, the MNC's usage of transfer pricing to shift profits will be at its highest point in a pure SA framework.

$$\frac{dG_i}{d\alpha} = \frac{t_C - t_i}{C_{GG}^S(G_i)} \leq 0\,, \tag{18}$$

[12] The calculations can be found in Appendix B.

$$\frac{dG_i}{dt_i} = \frac{1-\alpha}{C_{GG}^S(G_i)} \geq 0\,, \tag{19}$$

$$\frac{dG_i}{dt_j} = 0\,, \tag{20}$$

$$\frac{dG_i}{dt_C} = -\frac{1-\alpha}{C_{GG}^S(G_i)} \leq 0\,, \tag{21}$$

$with\ i = A, B\,.$

Equation (19) demonstrates that a tax increase in the domestic high-tax country results in a higher optimal transfer price. A higher tax difference between affiliate *i* and the lowest-taxed affiliate C will increase tax savings for given tax planning costs of profit shifting through the transfer price. Therefore, the optimal mark-up charged above the arm's length price of the patent will become larger. Only in a pure sales-based FA environment a tax increase will have no impact on the transfer price; the arm's length price will be used. The change in the transfer price will be stronger the flatter the marginal tax planning costs curve for transfer pricing and the closer to a pure SA environment (i.e., low α).

A similar effect but in the other direction occurs when the tax rate in the tax haven increases (equation 21). Tax savings achieved by charging a mark-up above the arm's length price decrease after a tax hike in country C, because the tax differential between the high-tax country and tax haven has declined. Hence, the incentive to shift profits via transfer pricing diminishes, which leads to a lower optimal transfer price. The absolute value of the effect is the same whether the high-tax country or the tax haven increases its statutory tax rate (equation 22). Only the sign of the effect differs. A tax hike in the foreign high-tax country *j* has no effect on the transfer price of the patent in country *i* (equation 20), because the different transfer prices used for the patent are separable.

$$\left|\frac{dG_i}{dt_i}\right| = \left|\frac{dG_i}{dt_C}\right| \qquad with\ i = A, B\,. \tag{22}$$

4.4.2 Comparative statics for internal leverage (b_A^I and b_B^I)

Equations (23) – (26) describe how the optimal level of internal debt adjusts after a policy change. If we move towards sales-based FA and away from SA, then the optimal level of internal leverage will decrease and eventually become zero in a pure FA environment (equation 23). An FA framework consolidates tax bases. On aggregate over the three affiliates

interest payments on internal debt will balance out (i.e., internal lending constraint). Hence, the more the taxation system evolves towards FA, the more the internal debt tax shield diminishes. This effect will be stronger the larger the tax differential, the larger the exogenous interest rate per unit of capital, and the flatter the marginal concealment cost curve for internal leverage (i.e., lower $C_{bb}^{I}(b_A^I)$). In a pure sales-based FA environment debt shifting does not create any tax savings. The MNC's usage of internal leverage to shift profits will attain its peak in a pure SA framework.

$$\frac{db_i^I}{d\alpha} = \frac{(t_C - t_i)r}{C_{bb}^{I}(b_i^I)} \leq 0\,, \tag{23}$$

$$\frac{db_i^I}{dt_i} = \frac{(1-\alpha)r}{C_{bb}^{I}(b_i^I)} \geq 0\,, \tag{24}$$

$$\frac{db_i^I}{dt_j} = 0\,, \tag{25}$$

$$\frac{db_i^I}{dt_C} = -\frac{(1-\alpha)r}{C_{bb}^{I}(b_i^I)} \leq 0\,, \tag{26}$$

$with\ i = A, B$.

Equation (24) shows that internal leverage in affiliate *i* will increase after a tax hike in the domestic country. A tax increase enlarges the tax differential between the high- and low-tax country. Therefore, tax savings through internal debt augment for given tax planning costs and debt shifting from the lowest-taxed affiliate C to affiliate *i* becomes more profitable. Hence, the optimal level of internal leverage increases, unless the taxation system is pure sales-based FA. In such a corporate tax environment there will be no internal leverage in the optimum. The tax effect on internal leverage will be stronger the flatter the marginal tax planning costs curve for internal leverage, the larger the exogenous interest rate per unit of capital and the closer to a pure SA environment (i.e., low α).

The same effect but in the other direction occurs when the tax rate in the tax haven increases (equation 26). Potential tax savings decline when the tax differential decreases. This discourages debt shifting. The absolute value of the effect is the same whether the high-tax country or the tax haven increases the statutory tax rate (equation 27). A tax hike in the foreign high-tax country *j* has no effect on internal leverage in affiliate *i* (equation 25), because the different internal leverage ratios in affiliates *i* and *j* are separable.

$$\left|\frac{db_i^I}{dt_i}\right| = \left|\frac{db_i^I}{dt_C}\right| \qquad with\ i = A, B\ . \tag{27}$$

4.4.3 Comparative statics for capital investments (K_A and K_B)

Equations (28) – (31) demonstrate how the optimal capital stock level reacts on a tax policy change. If we move towards sales-based FA and away from SA, then the optimal level of capital investments will decrease and reach its lowest level in a pure FA environment (equation 28). Under SA debt shifting diminishes tax distortions. Equations (16a-b) showed that the effective capital costs will be higher under FA. Hence, an increase in α leads to higher corporate tax distortions in comparison to pure SA. Therefore, the more the taxation system moves towards FA, the fewer internal debt the MNC will use (see subsection 4.4.2) and the lower the optimal capital stock in affiliate *i* will be. The effect will be stronger the larger the tax differential, the higher the initial level of internal leverage, the higher the exogenous rental cost per unit of capital and the flatter the marginal product of capital curve (i.e., lower $|F_{KK}(K_i)|$). The effect will be zero if we start from a pure sales-based FA union and marginally introduce a hybrid system (i.e., decreasing α marginally). There is no effect on the optimal level of the capital stock under symmetry in an FA union, because b_i^I will be zero. Any effect from debt shifting on the capital stock disappears also on the margin.

$$\frac{dK_i}{d\alpha} = \frac{(t_i - t_C)b_i^I r}{(1 - t_i)F_{KK}(K_i)} \leq 0\ , \tag{28}$$

$$\frac{dK_i}{dt_i} = \frac{F_K(K_i) - 2\alpha S X_{ij} - (1-\alpha)b_i^I r}{(1 - t_i)F_{KK}(K_i)} < 0\ , \tag{29}$$

$$\frac{dK_i}{dt_j} = \frac{\alpha 2 S X_{ij}}{(1 - t_i)F_{KK}(K_i)} \leq 0\ , \tag{30}$$

$$\frac{dK_i}{dt_C} = \frac{(1-\alpha)b_i^I r}{(1 - t_i)F_{KK}(K_i)} \leq 0\ , \tag{31}$$

$with\ X_{ij} = \frac{F_K(K_i)F(K_j)}{\left(F(K_i)+F(K_j)\right)^2} > 0$ and $i = A, B$.

Equation (29) gives the change in capital investments in affiliate *i* after a tax hike in the domestic country. Under all tax regimes (SA, sales-based FA and hybrid system), a domestic tax increase results in a lower optimal capital stock in the domestic affiliate of the MNC. In an SA framework a higher tax rate in the domestic country increases corporate tax distortions,

which reduces the incentive for capital investments. In contrast, a tax hike in the domestic country also makes internal leverage more attractive (see subsection 4.4.2). However, the former negative effect on capital investments dominates the latter positive effect, because $F_K(K_i)$ is larger than rb_i^I[13]. Hence, a higher domestic tax rate results in a lower optimal capital stock under SA.

In a sales-based FA framework the effect on capital investments in the domestic affiliate will be negative as well. As under SA, a higher domestic tax rate creates larger tax distortions and makes capital investments less profitable. Although, under sales-based FA the MNC has an incentive to shift capital investments to the highest-taxed affiliate in order to attribute its fixed costs there. Hence, a higher domestic tax rate steals investments and tax base from other countries. Nevertheless, the negative effect of the tax hike dominates the positive effect on capital investments in the domestic affiliate of the MNC. The second effect would dominate or neutralise the first effect in our model if $S \geq 2F(K_i)$[14]. This is, however, an irrelevant scenario. If the patent costs are larger than or equal to twice the sales revenues in affiliate *i*, the MNC would make massive losses. We assume that the patent costs are not sunk and the MNC has perfect foresight. Therefore, the MNC would decide not to produce in this case.

Equation (30) shows that a tax hike in the foreign high-tax country results in a decrease of the optimal capital stock in the domestic affiliate under sales-based FA. The MNC has an incentive to shift investments to the other producing affiliate in order to attribute more of the fixed costs there, which leads to tax savings. This effect reverses the traditional capital export externality, where foreign countries lower their tax rate to steal investment and shrink the domestic tax base. Under SA the tax rate for the other producing affiliate does not influence optimal investments in the domestic affiliate, because K_A and K_B are separable. Thus, the more the taxation system moves towards sales-based FA and away from SA, the larger the shift of capital investments from affiliate *i* to affiliate *j* after a tax hike in country *j*.

The opposite is true for a tax hike in the tax haven (equation 31). Under pure sales-based FA there are no internal loans in the optimum; the tax haven does not play any role. Therefore, a tax hike in country C will not impact the optimal capital stock in country A or B. In contrast, under SA a tax hike in the tax haven results in a lower optimal capital stock in the high-tax countries, because the internal debt tax shield diminishes. The effect will be stronger the higher

[13] Proof of this statement is provided in Appendix C.
[14] Calculations can be found in Appendix C.

the initial level of internal leverage, the higher the exogenous interest rate and the flatter the marginal product of capital curve.

We are unable to make a clear ranking of the three different tax effects on the optimal capital stock in affiliate *i* (equations 29-31). A ranking of the effects would depend on the value of the fixed patent costs, amount of internal leverage and the value of α (how close is the hybrid tax system respectively to pure SA or pure sales-based FA).

4.4.4 Summarizing the main effects

The main results of our comparative static analysis are the following: (1) an increase in the tax differential between the domestic country and the tax haven results in more profit shifting in an SA or hybrid tax union, (2) profit shifting and the optimal capital stock in the producing affiliates decrease the closer we move to a pure sales-based FA system, (3) the transfer prices of the patent and the internal leverage ratios in the two producing countries are separable, while the optimal capital stocks in the producing affiliates are interdependent under sales-based FA, as a result of this interdependence (4) foreign countries are able to steal capital investments and shrink the domestic tax base by raising their tax rate in a sales-based FA union.

5. Welfare analysis and discussion

5.1 Welfare maximization and stability of tax systems

In this section welfare maximization of the two non-tax haven countries (A and B) is analysed. These countries have two policy instruments at their disposal in order to maximize welfare. The corporate tax rate (t_i) and parameter α which defines the design of their taxation system. The welfare function is given by equation (32). The first part of the equation is the tax revenue collected by country *i* after taxing the MNC in the tax union. The second part represents the tax revenue obtained from taxing an exogenous tax base of domestic firms (Π_d), which is the sum of taxable profits from purely domestic enterprises.

In equation (32) government revenue equals welfare, which can be seen as a Rawlsian welfare function. The government wants to attract as much revenue as possible to improve the situation of the worst off through redistribution. The structure of our welfare function largely follows the analysis done in Keen and Konrad (2013). In line with a large literature in public finance such as Nielsen et al. (2010) and Eichner and Runkel (2008), we assume revenue maximization. To simplify our welfare analysis, we assume that the two high-tax countries are symmetric as in the previous section. The welfare analysis is evaluated in two scenarios: a pure sales-based FA and a pure SA taxation system.

$$W_i = \alpha T_i^{FA} + (1-\alpha) T_i^{SA} + t_i \Pi_d \qquad with\ i = A, B\ . \tag{32}$$

5.1.1 Deriving the optimal tax rate for sales-based formula apportionment

In the first scenario the members of the tax union agree to implement the pure sales-based FA method ($\alpha = 1$). Through the FOC of the welfare function for the statutory tax rate, the optimal tax rate can be determined. The FOC of the welfare function for the optimal corporate tax rate consists of two parts. The first part shows the direct tax effect ($\frac{\partial W_i^d}{\partial t_i}$) and the second part incorporates behavioural responses of the MNC on a marginal change in the tax rate (equation 33). A change in the tax rate affects the optimal level of the endogenous firm variables. The RHS of equation (33) shows that after a marginal increase in the domestic tax rate there is a trade-off between revenue gains from the direct tax effect (first part) and an increase in corporate tax distortions (second part) which leads to more profit shifting and/or changes in capital investment decisions of the MNC.

$$\frac{\partial W_i}{\partial t_i} = \frac{\partial W_i^d}{\partial t_i} + \frac{\partial W_i}{\partial \mathrm{K}_i}\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} + \frac{\partial W_i}{\partial \mathrm{K}_j}\frac{\partial \mathrm{K}_j}{\partial \mathrm{t}_i} + \frac{\partial W_i}{\partial \mathrm{G}_i}\frac{\partial \mathrm{G}_i}{\partial \mathrm{t}_i} + \frac{\partial W_i}{\partial b_i^I}\frac{\partial b_i^I}{\partial \mathrm{t}_i} = 0 \qquad with\ i = A, B\ . \tag{33}$$

Equation (34) shows the optimal tax rate in the Nash equilibrium for symmetric countries in a pure sales-based FA system[15]. Both numerator and denominator of equation (34) are negative. From the previous section we know that $\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} < 0$ and $\frac{\partial \mathrm{K}_j}{\partial \mathrm{t}_i} < 0$. The terms between brackets in the denominator are positive, because $F_K(K_i)$ is larger than $2SX_{ij}$ for optimal firm behaviour. $F_K(K_i)$ would be smaller than or equal to $2SX_{ij}$ in our model if $S \geq 2F(K_i)$, which is an irrelevant scenario. The MNC would decide not to produce in order to prevent massive losses.

Equation (34) can be seen as a Ramsey formula that balances revenue gains (numerator) against capital investment distortions (denominator) under sales-based FA. Distortions from profit shifting do not occur under FA. The 'Ramsey rule' states that more elastic tax bases will have lower optimal tax rates (Ramsey, 1927). Hence, the larger the change in capital investments after a domestic tax hike, the lower the optimal tax rate for given direct revenue gains.

$$t^*_{i,\alpha=1} = \frac{-F(K_i) + S - \Pi_d}{\left[F_K(K_i) - 2SX_{ij}\right]\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} + \left[2SX_{ji}\right]\frac{\partial \mathrm{K}_j}{\partial \mathrm{t}_i}} \tag{34}$$

$$with\ X_{ij} = \frac{F_K(K_i)F(K_j)}{\left(F(K_i)+F(K_j)\right)^2} > 0\ and\ i = A, B.$$

Ceteris paribus, the optimal tax rate under FA solely based on sales will be higher the larger the exogenous tax base of domestic firms. A higher capital stock in the domestic and/or foreign affiliate of the MNC also results in a higher optimal tax rate, all else equal. A last observation is that higher fixed patent costs lead, ceteris paribus, to a lower optimal tax rate.

5.1.2 Stability of a sales-based formula apportionment equilibrium

We determined the optimal tax rate for symmetric countries under sales-based FA. In this subsection we examine the stability of this Nash equilibrium. First, the optimal corporate tax rate under FA is implemented in the welfare function. Secondly, the welfare function is totally differentiated (equation 35). The first term $\frac{\partial W_i}{\partial t_i}$ will be zero, because the initial tax rate is the optimal tax rate. A marginal change in the optimal tax rate will not result in a change in welfare. This is an application of the envelope theorem.

[15] The calculations made to establish this optimal tax rate can be found in Appendix D.

$$dW_i = \frac{\partial W_i}{\partial t_i} dt_i^* + \frac{\partial W_i}{\partial \mathrm{K}_i} dK_i + \frac{\partial W_i}{\partial \mathrm{K}_j} dK_j + \frac{\partial W_i}{\partial \mathrm{G}_i} dG_i + \frac{\partial W_i}{\partial b_i^I} db_i^I + \frac{\partial W_i}{\partial \alpha} d\alpha \;\; with\; i = A, B \;. \quad (35)$$

In the third and last step the result of total differentiation is evaluated for sales-based FA ($\alpha = 1$)[16]. Equation (36) demonstrates that a sales-based FA union will be a stable equilibrium in our set-up with symmetric high-tax countries; $\frac{dW_i}{d\alpha}$ equals zero. The terms between brackets on the RHS of equation (36) are both positive, because $F_K(K_i)$ is larger than $2SX_{ij}$ for optimal firm behaviour[17]. In the comparative static analysis we showed that $\frac{dK_i}{d\alpha} = \frac{dK_j}{d\alpha} = 0$ for pure sales-based FA, because $b_i^I = b_j^I = 0$ in the optimum. In a sales-based FA union internal debt has no effect on capital investments also on the margin. Introducing a hybrid system by decreasing α marginally does not affect optimal capital investment under symmetry. Hence, the high-tax countries have no unilateral incentive to deviate from the agreed FA method by moving towards SA to improve welfare. Otherwise $\frac{dW_i}{d\alpha}$ would be a negative term.

$$\frac{dW_i}{d\alpha} = \left[t^*_{i,\alpha=1}\left(F_K(K_i) - 2SX_{ij}\right)\right]\frac{dK_i}{d\alpha} + \left[t^*_{i,\alpha=1} 2SX_{ji}\right]\frac{dK_j}{d\alpha} \quad (36)$$

$$with\; X_{ij} = \frac{F_K(K_i)F(K_j)}{\left(F(K_i)+F\left(K_j\right)\right)^2} > 0 \; and \; i = A, B.$$

5.1.3 Deriving the optimal tax rate for separate accounting

In the second scenario the members of the tax union agree to implement an SA system ($\alpha = 0$). Through the FOC of the welfare function for the statutory tax rate, the optimal tax rate for the Nash equilibrium in an SA environment can be determined[18].

Equation (37) gives the expression for the optimal tax rate. Both the numerator and the denominator are positive, because we know from Section 4 that $\frac{\partial G_i}{\partial t_i} > 0$, $\frac{\partial b_i^I}{\partial t_i} > 0$, $F_K(K_i) > rb_i^I$[19] and $\frac{\partial K_i}{\partial t_i} < 0$ under SA. Equation (37) can be seen as a Ramsey formula that balances revenue gains (numerator) against profit shifting and capital investment distortions (denominator). Under SA a domestic tax increase does not distort capital investments in the foreign producing affiliate, because the two capital stocks are separable. However, a domestic

[16] The intermediate calculations can be found in Appendix E.
[17] More intuition and proof for this statement can be found in subsection 4.4.3 and Appendix C.
[18] The calculations made to establish this optimal tax rate can be found in Appendix D.
[19] Proof is provided in Appendix C.

tax hike in an SA framework leads to higher profit shifting distortions through transfer pricing and internal leverage.

$$t^*_{i,\alpha=0} = \frac{F(K_i) - G_i S - r b_i^I K_i + \Pi_d}{S\frac{\partial G_i}{\partial t_i} + r K_i \frac{\partial b_i^I}{\partial t_i} - (F_K(K_i) - r b_i^I)\frac{\partial K_i}{\partial t_i}} \qquad with\ i = A, B\ . \tag{37}$$

Ceteris paribus, the optimal tax rate under SA will be higher if the exogenous tax base of purely domestic firms is larger or when the capital stock in the domestic affiliate of the MNC increases. The optimal tax rate will be lower for a higher mark-up on the arm's length price of the patent, higher fixed patent costs, more internal leverage or a higher exogenous interest rate.

5.1.4 Stability of a separate accounting equilibrium

In this subsection the stability of a pure SA taxation system with symmetric high-tax countries is evaluated. The same procedure as in subsection 5.1.2 is implemented[20]. Equation (38) shows how the total welfare of country *i* changes under SA when the member state decides to marginally introduce a hybrid tax system by increasing α marginally. The first term on the RHS of equation (38) is negative, because the comparative static analysis in Section 4 showed that $\frac{dK_i}{d\alpha} < 0$ and $F_K(\mathrm{K}_i) > r b_i^I$[21]. This first term represents the negative capital investment effect that occurs when we move away from SA and towards sales-based FA. The internal debt tax shield decreases and the user costs of capital rise for the MNC, which will result in a lower optimal capital stock and by consequence tax base. The second, third and fourth term on the RHS of equation (38) are positive, because the comparative static analysis in Section 4 showed that $\frac{dG_i}{d\alpha} < 0$ and $\frac{db_i^I}{d\alpha} < 0$. We also know that $G_i \geq 1$ in our model. These three terms represent the positive effect on total welfare caused by a reduction in profit shifting. Profit shifting via internal leverage and transfer pricing decreases after a marginal increase in α, which has a positive effect on the tax base.

Hence, the effect on total welfare of deviating from the SA union and marginally introduce a hybrid system is ambiguous. The investment effect and the reduction in profit shifting work in opposite directions. The sign of the aggregate effect depends on which of the two effects is

[20] Calculations can be found in Appendix E.
[21] Proof is provided in Appendix C.

stronger. This will depend on the shape of the cost functions and the production function (see equations 18, 23 and 28).

$$\frac{dW_i}{d\alpha} = \left[t^*_{i,\alpha=0}(F_K(\mathrm{K}_i) - rb^I_i)\right]\frac{dK_i}{d\alpha} - \left[t^*_{i,\alpha=0}S\right]\frac{dG_i}{d\alpha} - \left[t^*_{i,\alpha=0}rK_i\right]\frac{db^I_i}{d\alpha}$$

$$+ t^*_{i,\alpha=0}[(G_i - 1)S + rb^I_i K_i] \qquad with\ i = A, B\ . \qquad (38)$$

Contrary to sales-based FA, it is not clear whether SA will be a stable equilibrium in our set-up or not. If the positive effect of reducing profit shifting dominates the negative investment effect on total welfare, then the countries A and B in the SA union will each have an unilateral incentive to deviate. Enforcement measures would be needed to avoid deviations from the coordinated SA system. The SA union will be a stable equilibrium if the negative investment effect on welfare dominates or neutralises the positive effect of a decline in profit shifting. Hence, in this scenario there are no enforcement measures needed. Enforcement would also not be necessary under sales-based FA, which is a remarkable result. However, we need to consider that these results are for symmetric countries and do not guarantee a stable equilibrium for a tax union with asymmetric high-tax countries.

5.2 Discussion

In this discussion part we first compare our main results and observations to related literature. Secondly, we consider a potential water's edge problem when a part of the world would introduce FA and the other part keeps SA. Thirdly, we name some possible difficulties related to implementing FA. In the fourth and last subsection we briefly evaluate the symmetry assumption we made and the possible consequences of asymmetry.

5.2.1 Comparison to related literature

The incentive to overinvest in the high-tax country (see equations 9 and 16a-b) in our model contradicts the tax competition behaviour under FA described in Keen and Konrad (2013). They predict that FA would result in more intense tax competition and lower optimal tax rates in comparison to SA. In our set-up, however, a higher tax rate can attract capital from the foreign MNC's affiliate. Hence, a race-to-the-bottom does not occur. A more likely scenario is a race-to-the-top in tax rates. The reason for this difference in results is twofold. First, Keen and Konrad (2013) use a pure capital-based FA system, which increases tax competition to attract capital. Second, they did not explicitly model any patent or other fixed costs made by the MNC.

Therefore, the mechanism where the MNC wants to book most of its fixed costs in the high-tax country to make tax savings, is absent in their analysis. When comparing the optimal tax rate under FA (equation 34) with SA (equation 37), we cannot conclude that FA "leads to an unambiguously lower equilibrium tax rate" (Keen and Konrad, 2013; p. 316).

The cross-effect on the capital stock in the domestic country after a tax hike in the foreign country has no clear sign in the analysis of Nielsen et al. (2010) for pure FA. This can be explained by the solely capital-based formula in their analysis. On the one hand, an increase in the foreign tax rate gives the MNC an incentive to shift capital to the domestic affiliate. On the other hand, the overall effective tax rate increases which gives an incentive to reduce capital investments in general. In our analysis the cross-effect has a clear negative sign for sales-based FA (equation 30). The MNC has an incentive to shift investments to the foreign country with the tax hike in order to attribute its fixed costs there and make tax savings. Hence, incentives are clearly negative in our model, whereas the incentives in Nielsen et al. (2010) work in opposite directions.

Despite our somewhat contradicting results with Keen and Konrad (2013) and Nielsen et al. (2010), our findings are in line with Eichner and Runkel (2008). They show that a sales-only formula in a theoretical model with two countries results in over-taxation, because the sum of created externalities is negative. If production inputs such as capital and/or labour are used as factors in the apportionment formula, then the MNC can easily manipulate the division of its profits over the different tax union members in its favour. In the case of pure sales-based FA, these inputs are indirectly targeted, which makes it less easy for the MNC to game the tax system. The negative tax base externality under sales-based FA dominates the positive formula externality in this scenario (Eichner and Runkel, 2008).

If we compare the optimal tax rate under sales-based FA and SA in our model, we believe that the tax rate in a sales-based FA union will be larger based on the negative externality this tax system creates. A higher domestic tax rate steals investment and tax base from the other countries. Therefore, tax competition could result in a race-to-the-top in corporate tax rates. This confirms the reasoning and results of Eichner and Runkel (2008). Kolmar and Wagener (2007) formulate a condition to determine whether tax competition under FA will emerge in inefficiently high or low tax rates. When a tax hike in a country of the tax union results in changes in the foreign and domestic capital stocks in the same direction (i.e., an increase or decrease in both capital stocks), then there is a negative externality as identified in Eichner and

Runkel (2008) leading to race-to-the-top tax competition. Kolmar and Wagener (2007) stress that the interplay between the formula and the definition of the tax base (e.g., deductibility of certain costs) decides if we get race-to-the-bottom or race-to-the-top competition in tax rates. In our analysis a tax increase in the domestic country leads to lower investments in the foreign country (equation 30) and lower investments in the domestic country as well (equation 29). Hence, our results point to an inefficiently high tax rate in the Nash equilibrium for pure sales-based FA.

5.2.2 Water's edge

A possible policy scenario is that some countries such as the EU and the US introduce a common FA union, but other parts of the world - including tax havens - could decide to stick to SA. The borders between FA and SA are then called water's edge. In order to avoid double taxation, profits are consolidated within the FA union and profits outside this union are taxed according to SA principles (Riedel and Runkel, 2007). We showed in Section 4 that FA can eliminate profit shifting in our tax union, but what happens when the MNC has subsidiaries outside the FA union? To what extent could this undermine the results of FA?

Riedel and Runkel (2007) analyse water's edge in a set-up with three countries; two countries form an FA union and one country stays with SA. They show that profit shifting with countries outside the FA union will still be present, but at a lower rate than before in a pure SA environment. This follows from a lower tax differential between the tax haven outside the union and the high-tax country inside the union. The tax differential decreases due to the fact that you need to consider the effective tax rate for the MNC in the entire tax union based on the employed formula and not the separate tax rates of each member state. Important to notice is that this would not occur in our model due to the symmetry assumption we made. Thus, the decrease in the tax difference between the tax haven outside the FA union and the high-tax country only happens under asymmetry when there are differences in tax rate between the FA union members. For asymmetric countries the MNC's incentives to minimize its effective tax rate within the FA union reduces its incentive to shift profit outside the union (Riedel and Runkel, 2007). Thus, we can conclude that water's edge creates an externality. However, this externality will be relatively modest. Furthermore, this externality could potentially reduce the incentive to implement inefficiently high tax rates under FA. Hence, in the end water's edge might even contribute to a more efficient tax system.

5.2.3 *Implementation difficulties formula apportionment*

One of the implementation difficulties is constructing a global tax base for FA. On the EU level this seems a feasible task, because a lot of information sharing and common regulation regarding corporations is already in place. Nevertheless, a global agreement on what to include in the tax base and which expenses would be deductible seems a more complicated endeavour.

A second question is which institution should be responsible for auditing the correct MNC's global consolidated income. Checking the declared taxable profits of an MNC active in many jurisdictions together with verifying the correct calculation and implementation of the FA formula would be an extremely difficult task for national tax authorities (Spencer, 2019). Validating arm's length pricing in the current SA framework is not simple as well, but switching to FA will not make life easier in terms of administration. We will probably become more dependent on multinational auditing firms (Spencer, 2019).

Another difficulty is the political power and willingness needed to introduce FA on a global or European level. A first proposal of the EC to implement FA was blocked by the Council of the EU, and there is still no final agreement on the reboot of the proposal launched in 2016. Moreover, the OECD concluded in its action plan on BEPS in 2013 that "there is consensus among governments that moving to a system of formulary apportionment of profits is not a viable way forward" (OECD, 2013; p. 14).

Nonetheless, in recent months earlier hesitations towards FA, such as its considerable administrative costs, seem to have been set aside by policy makers. FA is considered as a possible solution to address challenges linked to a rapidly digitalising economy. A recent tax agreement by the OECD and G20 targets "the multinational enterprises with global turnover above 20 billion euros and profitability above 10% (i.e., profit before tax/revenue) with the turnover threshold to be reduced to 10 billion euros" (OECD, 2021; p. 1). Sales-based FA as evaluated in this master thesis will be used to distribute a part of the profits made by these MNCs, more precisely: "between 20-30% of residual profit defined as profit in excess of 10% of revenue will be allocated to market jurisdictions with nexus using a revenue-based allocation key" (OECD, 2021; p. 2).

5.2.4 Symmetry assumption

Symmetry for the two high-tax countries is a strong assumption in our model. In reality countries can differ quite a lot from each other. When we relax symmetry and allow for

asymmetry, profit shifting behaviour via transfer pricing and internal leverage would be exactly the same since both G_i and b_i^I are separable in our set-up. Only the magnitude of profit shifting would differ between the asymmetric high-tax countries. This will depend on their respective tax rates and the tax difference with the tax haven. Also the identified distortions in capital investment will appear under asymmetry. Decision making on capital investments under SA will not change under asymmetry, because K_i is separable in that case. Hence, the profit shifting and investments effects that we identified will not change under asymmetry. Nevertheless, the symmetry assumption can mask some additional behavioural responses of the MNC in capital investments under the sales-based FA method where the optimal capital stocks K_A and K_B are interdependent.

Our welfare analysis indicated that a pure sales-based FA would be a stable equilibrium under symmetry. We are unable to extend this conclusion for asymmetric countries. As mentioned above asymmetry might lead to more tax competition effects through changes in capital investments, which could make the equilibrium under sales-based FA unstable. Anand and Sansing (2000) show that countries under a coordinated FA system with a common distribution formula have strong incentives to deviate and alter the formula in their favour. The results of Anand and Sansing (2000) suggest that under asymmetry sales-based FA could be unstable.

Next to an analysis of the Nash equilibrium under FA, we showed that the stability of an SA union under symmetry depends on the magnitude of the negative investment effect and the positive effect from a decline in profit shifting after marginally introducing sales-based FA. Likewise, the same contradicting forces will determine the robustness of an SA union under asymmetry.

6. Conclusion

In this master thesis we evaluated Zucman's proposal to reform the way governments tax MNCs by shifting from separate accounting to formula apportionment solely based on sales. The sales component would be applied according to the destination principle (i.e., location of the consumer).

A model with a hybrid tax function representing a tax union of three countries (two high-tax countries and one tax haven) was used to study firm and government behaviour under sales-based FA in comparison to SA. Our model indicates that existing profit shifting distortions under SA would disappear under FA. Whereas Nielsen et al. (2010) showed that profit shifting via transfer pricing would not occur under FA, we demonstrated that next to transfer pricing also internal loans would cease to be used by MNCs. Elimination of these profit shifting practices is a clear advantage of sales-based FA.

However, implementing Zucman's proposal will create distortions elsewhere. The optimal capital stocks in the producing affiliates become interdependent. We identified an incentive for MNCs to overinvest in the highest-taxed affiliate. The MNC wants to attribute the largest part of its fixed costs there in order to minimize tax obligations. Hence, profit shifting on paper changes to investment shifting across borders. Changes in the capital stock impact wages due to adjustments in the marginal product of labour if the elasticity between capital and labour is finite (Tørsløv et al., 2018). Therefore, investment distortions under sales-based FA can negatively affect workers' productivity, while profit shifting under SA may foster wages due to the investment effect of debt shifting. Incentives for capital investments are in general lower under sales-based FA. The effective capital costs for MNCs would increase in an FA union, because the internal debt tax shield vanishes.

The comparative static analysis also showed that the traditional capital export externality (i.e., foreign countries lower their tax rate to steal capital from the domestic country) is reversed. In a sales-based FA environment countries can attract capital from foreign affiliates by increasing their domestic statutory tax rate. Hence, instead of the current race-to-the-bottom under SA, countries might engage in a race-to-the-top in tax rates. The inefficient over-taxation under sales-based FA in our model is in line with the findings of Eichner and Runkel (2008). They indicated that a sales formula is more difficult to manipulate for MNCs than a formula based on capital and payroll factors which an MNC can influence directly.

Whether SA or sales-based FA yields the most efficient outcome, depends on the magnitude of the distortions. In our analysis we cannot make a clear ranking. Estimating the magnitudes of the different distortions under respectively SA and sales-based FA could be an alley for future empirical studies.

In a welfare analysis we searched for unilateral incentives to deviate from a coordinated sales-based FA system to determine whether enforcement measures are needed. Remarkably, we found that sales-based FA is a stable equilibrium in our tax union. In contrast, the stability of an SA union depends on the respective magnitudes of the negative investment effect on welfare and the positive effect of a reduction in profit shifting after marginally introducing a hybrid system. However, we need to take into account that these results are under symmetry. Examining whether our results remain the same under asymmetry would be an interesting topic for further research. The impact of new tax policies on different countries such as small compared to large countries and the developed world in comparison to the developing world are important to examine in future analysis.

Besides symmetric countries, another limitation of the model is that we are unable to make a distinction between destination-based (e.g., Zucman, 2018) and origin-based (e.g., Eichner and Runkel, 2008) sales-based FA. In order to evaluate the potential differences between the two taxation principles, the model should be adapted to account for international trade. This is left for future research.

In conclusion, sales-based FA has some appealing features, but besides some possible implementation issues it also creates new problems. It is not a golden bullet creating an efficient tax environment without any distortions. The outcome is mixed. Coordination on the global level to tackle the current flaws in taxation of MNCs caused by the limits of arm's length pricing remains much needed. In the past months unexpected progress has been achieved. The agreement which was reached in July 2021 at the OECD introduces a sales-based FA approach for large MNCs and lays out a tentative way forward.

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Appendix A: Maximization problem of the MNC

This appendix constructs and writes the maximization problem the MNC faces in full. The MNC chooses the mark-up on the arm's length price of the patent fee (G_i), internal leverage (b_i^I) and the capital stock (K_i) in order to maximize its after-tax profits (Π_p).

In order to determine the after-tax profits of the MNC, we need the economic profits in the three affiliates (equations 11-12) and total tax payments under SA (equation 5) and under sales-based FA (equation 8). The economic profits minus the tax payments give the after-tax profits of the MNC in the tax union. Equation (A.1) gives the expanded form of the maximization problem.

$$\begin{aligned}\max_{G_i,b_i^I,K_i} \Pi_p = {} & F(K_A)+F(K_B)-r(K_A+K_B)-2S \\ & -[C^S(G_A)+C^S(G_B)]S - C^I(b_A^I)K_A - C^I(b_B^I)K_B \\ & -\alpha\left[t_A\left(F(K_A)-2S\frac{F(K_A)}{F(K_A)+F(K_B)}\right)+t_B\left(F(K_B)-2S\frac{F(K_B)}{F(K_A)+F(K_B)}\right)\right] \\ & -(1-\alpha)\begin{bmatrix} t_AF(K_A)+t_BF(K_B)-t_C2S-(t_A-t_C)(G_AS+rb_A^IK_A) \\ -(t_B-t_C)(G_BS+rb_B^IK_B)\end{bmatrix}. \end{aligned} \quad (A.1)$$

Appendix B: Total differentiation FOCs and comparative statics

In this appendix we show the total differentiation of the FOCs (equations 14-16) and use Cramer's rule to derive the comparative statics.

A. Total differentiation

1. *Total differentiation of FOC for the optimal transfer price (equation 14):*

$$-C_{GG}^S(G_i)dG_i-(t_i-t_C)d\alpha+(1-\alpha)dt_i-(1-\alpha)dt_C=0 \qquad with\ i=A,B\ .$$

2. *Total differentiation of FOC for the optimal internal leverage ratio (equation 15):*

$$-C_{bb}^I(b_i^I)db_i^I-(t_i-t_C)rd\alpha+(1-\alpha)rdt_i-(1-\alpha)rdt_C=0 \quad with\ i=A,B\ .$$

3. *Total differentiation of FOC for the optimal level of capital investments in affiliate A (equation 16a):*

$$\left[(1-t_A)F_{KK}(K_A)+\alpha 2S(t_A-t_B)\frac{F_{KK}(K_A)F(K_B)\left(F(K_A)+F(K_B)\right)^2-2F_K(K_A)^2F(K_B)\left(F(K_A)+F(K_B)\right)}{\left(F(K_A)+F(K_B)\right)^4}\right]dK_A$$

$$+\left[\alpha 2S(t_A - t_B)\frac{F_K(K_A)F_K(K_B)\left(F(K_A)+F(K_B)\right)^2 - 2F_K(K_A)F(K_B)F_K(K_B)\left(F(K_A)+F(K_B)\right)}{\left(F(K_A)+F(K_B)\right)^4}\right]dK_B$$

$$+\left[(1-\alpha)(t_A - t_C)r - C_b^I(b_A^I)\right]db_A^I + [2S(t_A - t_B)X_{AB} - (t_A - t_C)b_A^I r]d\alpha$$

$$-[F_K(K_A) - \alpha 2SX_{AB} - (1-\alpha)b_A^I r]dt_A - [\alpha 2SX_{AB}]dt_B - [(1-\alpha)b_A^I r]dt_C = 0$$

$$with\ X_{AB} = \frac{F_K(K_A)F(K_B)}{\left(F(K_A)+F(K_B)\right)^2} > 0\ and\ (1-\alpha)(t_A - t_C)r - C_b^I(b_A^I) = 0 \text{ (see equation 15).}$$

4. *Total differentiation of FOC for the optimal level of capital investments in affiliate B (equation 16b):*

$$\left[\alpha 2S(t_B - t_A)\frac{F_K(K_B)F_K(K_A)\left(F(K_A)+F(K_B)\right)^2 - 2F_K(K_B)F(K_A)F_K(K_A)\left(F(K_A)+F(K_B)\right)}{\left(F(K_A)+F(K_B)\right)^4}\right]dK_A$$

$$+\left[(1-t_B)F_{KK}(K_B) + \alpha 2S(t_B - t_A)\frac{F_{KK}(K_B)F(K_A)\left(F(K_A)+F(K_B)\right)^2 - 2F_K(K_B)^2F(K_A)\left(F(K_A)+F(K_B)\right)}{\left(F(K_A)+F(K_B)\right)^4}\right]dK_B$$

$$+\left[(1-\alpha)(t_B - t_C)r - C_b^I(b_B^I)\right]db_B^I + [2S(t_B - t_A)X_{BA} - (t_B - t_C)b_B^I r]d\alpha$$

$$-[F_K(K_B) - \alpha 2SX_{BA} - (1-\alpha)b_B^I r]dt_B - [\alpha 2SX_{BA}]dt_A - [(1-\alpha)b_B^I r]dt_C = 0$$

$$with\ X_{BA} = \frac{F_K(K_B)F(K_A)}{\left(F(K_A)+F(K_B)\right)^2} > 0\ and\ (1-\alpha)(t_B - t_C)r - C_b^I(b_B^I) = 0 \text{ (see equation 15).}$$

B. Comparative statics

1. *Comparative statics for the transfer price (G_A and G_B)*

We can rewrite the expressions of the totally differentiated FOCs for the transfer price in the following matrix notation of a system of two equations:

$$\begin{pmatrix} -C_{GG}^S(G_A) & 0 \\ 0 & -C_{GG}^S(G_B) \end{pmatrix}\begin{pmatrix} dG_A \\ dG_B \end{pmatrix} = \begin{pmatrix} t_A - t_C \\ t_B - t_C \end{pmatrix}d\alpha + \begin{pmatrix} -(1-\alpha) \\ 0 \end{pmatrix}dt_A + \begin{pmatrix} 0 \\ -(1-\alpha) \end{pmatrix}dt_B + \begin{pmatrix} 1-\alpha \\ 1-\alpha \end{pmatrix}dt_C .$$

Using Cramer's rule gives the following comparative statistics:

$$\frac{dG_i}{d\alpha} = \frac{\begin{vmatrix} t_i - t_C & 0 \\ t_j - t_C & -C_{GG}^S(G_j) \end{vmatrix}}{C_{GG}^S(G_i)C_{GG}^S(G_j)} = \frac{t_C - t_i}{C_{GG}^S(G_i)} \leq 0 ,$$

$$\frac{dG_i}{dt_i} = \frac{\begin{vmatrix} -(1-\alpha) & 0 \\ 0 & -C_{GG}^S(G_j) \end{vmatrix}}{C_{GG}^S(G_i)C_{GG}^S(G_j)} = \frac{1-\alpha}{C_{GG}^S(G_i)} \geq 0\,,$$

$$\frac{dG_i}{dt_j} = \frac{\begin{vmatrix} 0 & 0 \\ -(1-\alpha) & -C_{GG}^S(G_j) \end{vmatrix}}{C_{GG}^S(G_i)C_{GG}^S(G_j)} = 0\,,$$

$$\frac{dG_i}{dt_C} = \frac{\begin{vmatrix} 1-\alpha & 0 \\ 1-\alpha & -C_{GG}^S(G_j) \end{vmatrix}}{C_{GG}^S(G_i)C_{GG}^S(G_j)} = -\frac{1-\alpha}{C_{GG}^S(G_i)} \leq 0 \qquad with\ i = A, B.$$

2. Comparative statics for internal leverage (b_A^I and b_B^I)

We can rewrite the expressions of the totally differentiated FOCs for internal leverage in the following matrix notation of a system of two equations:

$$\begin{pmatrix} -C_{bb}^I(b_A^I) & 0 \\ 0 & -C_{bb}^I(b_B^I) \end{pmatrix}\begin{pmatrix} db_A^I \\ db_B^I \end{pmatrix} = \begin{pmatrix} (t_A - t_C)r \\ (t_B - t_c)r \end{pmatrix} d\alpha + \begin{pmatrix} -(1-\alpha)r \\ 0 \end{pmatrix} dt_A$$
$$+ \begin{pmatrix} 0 \\ -(1-\alpha)r \end{pmatrix} dt_B + \begin{pmatrix} (1-\alpha)r \\ (1-\alpha)r \end{pmatrix} dt_C\,.$$

Using Cramer's rule gives the following comparative statistics:

$$\frac{db_i^I}{d\alpha} = \frac{\begin{vmatrix} (t_i - t_C)r & 0 \\ (t_j - t_C)r & -C_{bb}^I(b_j^I) \end{vmatrix}}{C_{bb}^I(b_i^I)C_{bb}^I(b_j^I)} = \frac{(t_C - t_i)r}{C_{bb}^I(b_i^I)} \leq 0\,,$$

$$\frac{db_i^I}{dt_i} = \frac{\begin{vmatrix} -(1-\alpha)r & 0 \\ 0 & -C_{bb}^I(b_j^I) \end{vmatrix}}{C_{bb}^I(b_i^I)C_{bb}^I(b_j^I)} = \frac{(1-\alpha)r}{C_{bb}^I(b_i^I)} \geq 0\,,$$

$$\frac{db_i^I}{dt_j} = \frac{\begin{vmatrix} 0 & 0 \\ -(1-\alpha)r & -C_{bb}^I(b_j^I) \end{vmatrix}}{C_{bb}^I(b_i^I)C_{bb}^I(b_j^I)} = 0\,,$$

$$\frac{db_i^I}{dt_C} = \frac{\begin{vmatrix} (1-\alpha)r & 0 \\ (1-\alpha)r & -C_{bb}^I(b_j^I) \end{vmatrix}}{C_{bb}^I(b_i^I)C_{bb}^I(b_j^I)} = -\frac{(1-\alpha)r}{C_{bb}^I(b_i^I)} \leq 0 \qquad with\ i = A, B.$$

3. Comparative statics for capital investments (K_A and K_B)

In our analysis of the comparative statistics for capital investments, we assume symmetry: $t_A = t_B$. Consequently, the following conditions hold: $F(K_A) = F(K_B)$, $F_K(K_A) = F_K(K_B)$ and $F_{KK}(K_A) = F_{KK}(K_B)$. We can rewrite the expressions of the totally differentiated FOCs for capital investments in the following matrix notation of a system of two equations:

$$\begin{pmatrix} (1-t_A)F_{KK}(K_A) & 0 \\ 0 & (1-t_B)F_{KK}(K_B) \end{pmatrix}\begin{pmatrix} dK_A \\ dK_B \end{pmatrix}$$

$$= \begin{pmatrix} (t_A - t_C)b_A^I r \\ (t_B - t_c)b_B^I r \end{pmatrix} d\alpha + \begin{pmatrix} F_K(K_A) - \alpha 2SX_{AB} - (1-\alpha)b_A^I r \\ \alpha 2SX_{BA} \end{pmatrix} dt_A$$

$$+ \begin{pmatrix} \alpha 2SX_{AB} \\ F_K(K_B) - \alpha 2SX_{BA} - (1-\alpha)b_B^I r \end{pmatrix} dt_B + \begin{pmatrix} (1-\alpha)b_A^I r \\ (1-\alpha)b_B^I r \end{pmatrix} dt_C\,.$$

Using Cramer's rule gives the following comparative statistics:

$$\frac{dK_i}{d\alpha} = \frac{\begin{vmatrix} (t_i - t_C)b_i^I r & 0 \\ (t_j - t_C)b_j^I r & (1-t_j)F_{KK}(K_j) \end{vmatrix}}{(1-t_i)(1-t_j)F_{KK}(K_i)F_{KK}(K_j)} = \frac{(t_i - t_C)b_i^I r}{(1-t_i)F_{KK}(K_i)} \leq 0\,,$$

$$\frac{dK_i}{dt_i} = \frac{\begin{vmatrix} F_K(K_i) - 2\alpha SX_{ij} - (1-\alpha)b_i^I r & 0 \\ \alpha 2SX_{ji} & (1-t_j)F_{KK}(K_j) \end{vmatrix}}{(1-t_i)(1-t_j)F_{KK}(K_i)F_{KK}(K_j)}$$

$$= \frac{F_K(K_i) - 2\alpha SX_{ij} - (1-\alpha)b_i^I r}{(1-t_i)F_{KK}(K_i)} < 0\,,$$

$$\frac{dK_i}{dt_j} = \frac{\begin{vmatrix} \alpha 2SX_{ij} & 0 \\ F_K(K_j) - \alpha 2SX_{ji} - (1-\alpha)b_j^I r & (1-t_j)F_{KK}(K_j) \end{vmatrix}}{(1-t_i)(1-t_j)F_{KK}(K_i)F_{KK}(K_j)}$$

$$= \frac{\alpha 2SX_{ij}}{(1-t_i)F_{KK}(K_i)} \leq 0\,,$$

$$\frac{dK_i}{dt_C} = \frac{\begin{vmatrix} (1-\alpha)b_i^I r & 0 \\ (1-\alpha)b_j^I r & (1-t_j)F_{KK}(K_j) \end{vmatrix}}{(1-t_i)(1-t_j)F_{KK}(K_i)F_{KK}(K_j)} = \frac{(1-\alpha)b_i^I r}{(1-t_i)F_{KK}(K_i)} \leq 0\,,$$

$$with\ X_{ij} = \frac{F_K(K_i)F(K_j)}{\left(F(K_i)+F(K_j)\right)^2} > 0\ and\ i = A, B\,.$$

Appendix C: Sign of effect domestic tax hike on capital stock domestic affiliate of the MNC

In this appendix we elaborate on the sign of $\frac{dK_i}{dt_i}$ in a pure SA framework and a pure sales-based FA system. The change in capital investments in the domestic affiliate of the MNC after a tax hike in the domestic country looks as follows:

$$\frac{dK_i}{dt_i} = \frac{F_K(K_i) - 2\alpha SX_{ij} - (1-\alpha)b_i^I r}{(1-t_i)F_{KK}(K_i)} \qquad with\ i = A, B. \qquad (C.1)$$

A. Separate accounting ($\alpha = 0$)

$$\frac{dK_i}{dt_i} = \frac{F_K(K_i) - b_i^I r}{(1-t_i)F_{KK}(K_i)}\,. \qquad (C.2)$$

We know that the denominator is negative. The numerator will be positive, because we can prove that $F_K(K_i) > b_i^I r$. From the FOCs for the optimal level of capital investments under SA (equations 16 a-b), we can derive the following expression for the marginal product of capital:

$$F_K(K_i) = \frac{(1-(t_i - t_C)b_i^I)r + C^I(b_i^I)}{1-t_i}.$$

We will show that the following term is positive:

$$\frac{(1-(t_i-t_C)b_i^I)r+C^I(b_i^I)}{1-t_i}-b_i^I r\,.$$

Multiplying this term with $1-t_i$ gives the following result:

$$(1-(t_i-t_C)b_i^I)r+C^I(b_i^I)-(1-t_i)b_i^I r\,.$$

This can be simplified to $r-(1-t_C)b_i^I r+C^I(b_i^I)$.

We know that $(1-t_C)\leq 1$ and $b_i^I \leq 1$. This gives us the subsequent inequality:

$$r-(1-t_C)b_i^I r+C^I(b_i^I)>0\,.$$

Hence, the following inequality holds as well:

$$\frac{(1-(t_i-t_C)b_i^I)r+C^I(b_i^I)}{1-t_i}-b_i^I r>0$$

$$\Leftrightarrow F_K(K_i)>b_i^I r\,. \qquad Q.E.D. \qquad (C.3)$$

Inequality (C.3) shows that the numerator of $\frac{dK_i}{dt_i}$ (equation C.2) will be positive under SA. Thus, $\frac{dK_i}{dt_i}$ will be negative. A domestic tax increase results in a lower optimal capital stock in the domestic affiliate of the MNC under SA.

$$\frac{dK_i}{dt_i}=\frac{F_K(K_i)-b_i^I r}{(1-t_i)F_{KK}(K_i)}<0\,. \qquad (C.4)$$

B. Sales-based formula apportionment ($\alpha = 1$)

$$\frac{dK_i}{dt_i}=\frac{F_K(K_i)-2SX_{ij}}{(1-t_i)F_{KK}(K_j)}\,. \qquad (C.5)$$

We know that the denominator is negative. In order to determine the sign of the numerator, we make the following calculations:

$$F_K(K_i)-2SX_{ij}=F_K(K_i)-2S\frac{F_K(K_i)F(K_j)}{\left(F(K_i)+F(K_j)\right)^2}\,. \qquad (C.6)$$

Under the symmetry assumption for the two high-tax countries the following conditions hold: $F(K_i) = F(K_j)$ and $F_K(K_i) = F_K(K_j)$. Hence, we can simplify expression (C.6).

$$F_K(K_i) - 2S\frac{F_K(K_i)F(K_j)}{4F(K_i)^2} \gtreqless 0$$

$$\Rightarrow 1 - \frac{S}{2F(K_i)} \gtreqless 0\,. \qquad (C.7)$$

Via expression (C.7) we can determine conditions for the sign of $\frac{dK_i}{dt_i}$ under sales-based FA.

- If $S > 2F(K_i)$, then $\frac{dK_i}{dt_i} > 0$,
- If $S < 2F(K_i)$, then $\frac{dK_i}{dt_i} < 0$,
- If $S = 2F(K_i)$, then $\frac{dK_i}{dt_i} = 0$.

The second scenario is the only economically relevant case for optimal firm behaviour. If the patent costs are larger than or equal to twice the sales revenues in affiliate *i*, the MNC would make massive losses. Producing in these scenarios is not compatible with optimal behaviour. We assume that the patent costs are not sunk and the MNC has perfect foresight. Consequently, the MNC would decide not to produce in these cases. Thus, the numerator of equation (C.5) will be positive. Hence, a domestic tax increase results in a lower optimal capital stock in the domestic affiliate of the MNC under sales-based FA.

$$\frac{dK_i}{dt_i} = \frac{F_K(K_i) - 2SX_{ij}}{(1-t_i)F_{KK}(K_j)} < 0. \qquad (C.8)$$

Appendix D: Mathematical derivations to find the optimal tax rate

In this appendix we derive an expression for the optimal tax rate under a pure sales-based FA and under a pure SA taxation system. Governments in the symmetric high-tax countries A and B choose a statutory tax rate in order to maximize welfare. The maximization problem looks as follows:

$$\max_{t_i} W_i = \alpha t_i \left(F(K_i) - 2S\frac{F(K_i)}{F(K_i) + F(K_j)} \right) + (1-\alpha)t_i(F(K_i) - G_iS - rb_i^lK_i) + t_i\Pi_d$$

$$with\ i = A, B. \qquad (D.1)$$

The FOC of the welfare function (D.1) for the optimal tax rate is the following:

$$\frac{\partial W_i}{\partial t_i} = \frac{\partial W_i^d}{\partial t_i} + \frac{\partial W_i}{\partial \mathrm{K}_i}\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} + \frac{\partial W_i}{\partial \mathrm{K}_j}\frac{\partial \mathrm{K}_j}{\partial \mathrm{t}_i} + \frac{\partial W_i}{\partial \mathrm{G}_i}\frac{\partial \mathrm{G}_i}{\partial \mathrm{t}_i} + \frac{\partial W_i}{\partial b_i^I}\frac{\partial b_i^I}{\partial \mathrm{t}_i} = 0 \quad with\ i = A, B\ .$$

Solving the first derivates gives the subsequent expression:

$$\frac{\partial W_i}{\partial t_i} = \alpha\left(F(K_i) - 2S\frac{F(K_i)}{F(K_i) + F\left(K_j\right)}\right) + (1-\alpha)\ (F(\mathrm{K}_i) - G_i S - r b_i^I K_i) + \Pi_d$$

$$+\left[\alpha t_i\left(F_K(K_i) - 2SX_{ij}\right) + (1-\alpha)t_i(F_K(\mathrm{K}_i) - r b_i^I)\right]\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} + \left[\alpha t_i 2SX_{ji}\right]\frac{\partial \mathrm{K}_j}{\partial \mathrm{t}_i}$$

$$-[(1-\alpha)t_i S]\frac{\partial \mathrm{G}_i}{\partial \mathrm{t}_i} - [(1-\alpha)t_i r K_i]\frac{\partial b_i^I}{\partial \mathrm{t}_i} = 0 \qquad (D.2)$$

$$with\ X_{ij} = \frac{F_K(K_i)F(K_j)}{\left(F(K_i)+F\left(K_j\right)\right)^2} > 0\ and\ i = A, B.$$

A. Sales-based formula apportionment ($\alpha = 1$)

We determine the optimal corporate tax rate in a pure sales-based FA system by substituting α with 1 in the FOC for the optimal tax rate (equation D.2).

$$F(K_i) - 2S\frac{F(K_i)}{F(K_i) + F\left(K_j\right)} + \Pi_d + \left[t_i\left(F_K(K_i) - 2SX_{ij}\right)\right]\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} + \left[t_i 2SX_{ji}\right]\frac{\partial \mathrm{K}_j}{\partial \mathrm{t}_i} = 0. \ (D.3)$$

Rewriting equation (D.3) to t_i gives us the following expression for the optimal tax rate under sales-based FA:

$$t^*_{i,\alpha=1} = \frac{-F(K_i) + 2S\frac{F(K_i)}{F(K_i) + F\left(K_j\right)} - \Pi_d}{\left[F_K(K_i) - 2SX_{ij}\ \right]\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} + \left[2SX_{ji}\right]\frac{\partial \mathrm{K}_j}{\partial \mathrm{t}_i}}\ . \qquad (D.4)$$

We also know that in a pure sales-based FA system with symmetric high-tax countries, the following conditions hold in the optimum: $t_i^* = t_j^*$ and $F(K_i) = F\left(K_j\right)$. After implementing these conditions in equation (D.4), we obtain the following expression:

$$t^*_{i,\alpha=1} = \frac{-F(K_i) + S - \Pi_d}{\left[F_K(K_i) - 2SX_{ij}\right]\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} + \left[2SX_{ji}\right]\frac{\partial \mathrm{K}_j}{\partial \mathrm{t}_i}} . \qquad (D.5)$$

B. Separate accounting ($\alpha = 0$)

We determine the optimal corporate tax rate in a pure SA system by substituting α with 0 in the FOC for the optimal tax rate (equation D.2).

$$F(\mathrm{K}_i) - G_i S - r b_i^I K_i + \Pi_d + [t_i(F_K(\mathrm{K}_i) - r b_i^I)]\frac{\partial \mathrm{K}_i}{\partial \mathrm{t}_i} - t_i S\frac{\partial \mathrm{G}_i}{\partial \mathrm{t}_i} - t_i r K_i \frac{\partial b_i^I}{\partial \mathrm{t}_i} = 0 . \quad (D.6)$$

Rewriting equation (D.6) to t_i gives us the following expression for the optimal tax rate under SA:

$$t^*_{i,\alpha=0} = \frac{F(K_i) - G_i S - r b_i^I K_i + \Pi_d}{S\frac{\partial G_i}{\partial t_i} + r K_i \frac{\partial b_i^I}{\partial t_i} - (F_K(K_i) - r b_i^I)\frac{\partial K_i}{\partial t_i}} . \qquad (D.7)$$

Appendix E: Mathematical derivations to find unilateral incentives to deviate

In this appendix we totally differentiate the welfare function in order to examine whether a member of the tax union has an incentive to deviate from a pure sales-based FA or a pure SA taxation system after implementation of the optimal tax rate. Total differentiation of the welfare function (see equation D.1 in Appendix D) looks as follows:

$$dW_i = \frac{\partial W_i}{\partial t_i}dt_i + \frac{\partial W_i}{\partial \mathrm{K}_i}dK_i + \frac{\partial W_i}{\partial \mathrm{K}_j}dK_j + \frac{\partial W_i}{\partial \mathrm{G}_i}dG_i + \frac{\partial W_i}{\partial b_i^I}db_i^I + \frac{\partial W_i}{\partial \alpha}d\alpha \qquad with\ i = A, B$$

$$\Leftrightarrow \frac{dW_i}{d\alpha} = \frac{\partial W_i}{\partial t_i}\frac{dt_i}{d\alpha} + \frac{\partial W_i}{\partial \mathrm{K}_i}\frac{dK_i}{d\alpha} + \frac{\partial W_i}{\partial \mathrm{K}_j}\frac{dK_j}{d\alpha} + \frac{\partial W_i}{\partial \mathrm{G}_i}\frac{dG_i}{d\alpha} + \frac{\partial W_i}{\partial b_i^I}\frac{db_i^I}{d\alpha} + \frac{\partial W_i}{\partial \alpha} . \qquad (E.1)$$

The first term $\frac{\partial W_i}{\partial t_i}$ will be zero, because the initial tax rate is the optimal tax rate. This is an application of the envelope theorem; in the optimum a small change of the tax rate will not result in a change in welfare. After solving the other first derivates of the welfare function (see equation D.1 in Appendix D) for the different endogenous firm variables and substituting them in equation (E.1), we obtain the following expression:

$$\frac{dW_i}{d\alpha} = \left[\alpha t_i^*\left(F_K(K_i) - 2SX_{ij}\right) + (1-\alpha)t_i^*(F_K(\mathrm{K}_i) - rb_i^I)\right]\frac{dK_i}{d\alpha} + \left[\alpha t_i^* 2SX_{ji}\right]\frac{dK_j}{d\alpha}$$

$$-[(1-\alpha)t_i^* S]\frac{dG_i}{d\alpha} - [(1-\alpha)t_i^* rK_i]\frac{db_i^I}{d\alpha}$$

$$+t_i^*\left(F(K_i) - 2S\frac{F(K_i)}{F(K_i)+F\left(K_j\right)}\right) - t_i^*(F(\mathrm{K}_i) - G_i S - rb_i^I K_i). \qquad (E.2)$$

A. Sales-based formula apportionment ($\alpha = 1$)

In order to determine whether country *i* has an unilateral incentive to deviate in a sales-based FA union, we have to identify the sign of $\frac{dW_i}{d\alpha}$. After substituting α with 1 in equation (E.2), the following expression occurs:

$$\frac{dW_i}{d\alpha} = \left[t_{i,\alpha=1}^*\left(F_K(K_i) - 2SX_{ij}\right)\right]\frac{dK_i}{d\alpha} + \left[t_{i,\alpha=1}^* 2SX_{ji}\right]\frac{dK_j}{d\alpha}$$

$$+t_{i,\alpha=1}^*\left(F(K_i) - 2S\frac{F(K_i)}{F(K_i)+F\left(K_j\right)}\right) - t_{i,\alpha=1}^*(F(\mathrm{K}_i) - G_i S - rb_i^I K_i)\,. \qquad (E.3)$$

In a pure sales-based FA union and symmetric high-tax countries the following conditions hold in the optimum: $G_i = 1$, $b_i^I = 0$, $t_i^* = t_j^*$ and $F(K_i) = F\left(K_j\right)$. After implementing these conditions in equations (E.3), we obtain the following expression:

$$\frac{dW_i}{d\alpha} = \left[t_{i,\alpha=1}^*\left(F_K(K_i) - 2SX_{ij}\right)\right]\frac{dK_i}{d\alpha} + \left[t_{i,\alpha=1}^* 2SX_{ji}\right]\frac{dK_j}{d\alpha}$$

$$+t_{i,\alpha=1}^*(F(K_i) - S) - t_{i,\alpha=1}^*(F(\mathrm{K}_i) - S)$$

$$\Leftrightarrow \frac{dW_i}{d\alpha} = \left[t_{i,\alpha=1}^*\left(F_K(K_i) - 2SX_{ij}\right)\right]\frac{dK_i}{d\alpha} + \left[t_{i,\alpha=1}^* 2SX_{ji}\right]\frac{dK_j}{d\alpha}\,. \qquad (E.4)$$

B. Separate accounting ($\alpha = 0$)

In order to determine whether country *i* has an unilateral incentive to deviate in an SA union, we have to identify the sign of $\frac{dW_i}{d\alpha}$. After substituting α with 0 in equation (E.2), the following expression occurs:

$$\frac{dW_i}{d\alpha} = \left[t_{i,\alpha=0}^*(F_K(\mathrm{K}_i) - rb_i^I)\right]\frac{dK_i}{d\alpha} - \left[t_{i,\alpha=0}^* S\right]\frac{dG_i}{d\alpha} - \left[t_{i,\alpha=0}^* rK_i\right]\frac{db_i^I}{d\alpha}$$

$$+t^*_{i,\alpha=0}\left(F(K_i) - 2S\frac{F(K_i)}{F(K_i)+F(K_j)}\right) - t^*_{i,\alpha=0}(F(\mathrm{K}_i) - G_iS - rb^I_iK_i). \qquad (E.5)$$

In an SA union with symmetric high-tax countries, the following conditions hold in the optimum: $t^*_i = t^*_j$ and $F(K_i) = F(K_j)$. After implementing these conditions in equation (E.5), the expression looks as follows:

$$\frac{dW_i}{d\alpha} = \left[t^*_{i,\alpha=0}(F_K(\mathrm{K}_i) - rb^I_i)\right]\frac{dK_i}{d\alpha} - \left[t^*_{i,\alpha=0}S\right]\frac{dG_i}{d\alpha} - \left[t^*_{i,\alpha=0}rK_i\right]\frac{db^I_i}{d\alpha}$$

$$+t^*_{i,\alpha=0}(F(K_i) - S) - t^*_{i,\alpha=0}(F(\mathrm{K}_i) - G_iS - rb^I_iK_i)$$

$$\Leftrightarrow \frac{dW_i}{d\alpha} = \left[t^*_{i,\alpha=0}(F_K(\mathrm{K}_i) - rb^I_i)\right]\frac{dK_i}{d\alpha} - \left[t^*_{i,\alpha=0}S\right]\frac{dG_i}{d\alpha} - \left[t^*_{i,\alpha=0}rK_i\right]\frac{db^I_i}{d\alpha}$$

$$+ t^*_{i,\alpha=0}[(G_i - 1)S + rb^I_iK_i]\ . \qquad (E.6)$$