# Taxing Corporations: Essays on the Implications of Productivity Differences and Risk Aversion

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*To my parents.*

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# Contents


**Preface** **1**

**1 Sorting into Outsourcing: Are Profits Taxed at a Gorilla's Arm's Length?** **6**

1.1 Introduction . . . . . 6

1.2 A Model of Optimal Organization . . . . . 11

1.2.1 Model Setup . . . . . 11

1.2.2 Benchmark Without Taxation . . . . . 15

1.2.3 Taxation . . . . . 18

1.3 A Model of Optimal Organization and Incomplete Contracts . . . . . 23

1.3.1 Model Setup . . . . . 23

1.3.2 Equilibrium . . . . . 27

1.3.3 Effective Tax Burden Under Arm's Length Taxation . . . . . 29

1.4 Extension to Transfer Price Manipulation and Discussion . . . . . 33

1.5 Conclusion . . . . . 37

**2 Should Tax Policy Favor High- or Low-Productivity Firms?** **39**

2.1 Introduction . . . . . 39

2.2 The Benchmark Model . . . . . 43

2.2.1 Consumers . . . . . 43

2.2.2 Producers . . . . . 44

2.2.3 Government . . . 45
2.3 Market Equilibria . . . 47
2.4 Optimal Policy . . . 50
2.4.1 Tax Competition and the Profit Tax Rate . . . 50
2.4.2 Optimally Differentiated Capital Input Taxes . . . 51
2.5 Discussion and Extensions . . . 56
2.6 Conclusion . . . 59

**3 Limiting Profit Shifting in a Model with Heterogeneous Firm Productivity 61**
3.1 Introduction . . . 61
3.2 Model . . . 64
3.3 Optimal Tax Policies . . . 70
3.3.1 Optimization of the Tax Haven . . . 70
3.3.2 Optimization of the Home Country . . . 71
3.4 Numerical Analysis . . . 73
3.4.1 Simulation of Proposition 3.1 . . . 73
3.4.2 Simulation of Proposition 3.2 . . . 74
3.5 Conclusion . . . 77

**4 Taxation and Corporate Risk-Taking 78**
4.1 Introduction . . . 78
4.2 Overview of Tax Loss Offset Rules . . . 82
4.3 A Model of Firm Risk-Taking . . . 84
4.3.1 Effect of Tax Loss Offset Rules ($\lambda$) on Firm Risk-Taking . . . 87
4.3.2 Effect of the Tax Rate (t) on Firm Risk-Taking . . . 88
4.4 Hypotheses . . . 90
4.5 Research Design & Sample Selection . . . 93
4.5.1 Research Design . . . 93

4.5.2 Sample Selection . . . . . . . . . . . . . . . . . . . . . . . . 95

4.6 Empirical Results . . . . . . . . . . . . . . . . . . . . . . . . . . 99

4.6.1 Loss Offset Provisions . . . . . . . . . . . . . . . . . . . . . . 99

4.6.2 Firm-Level Effects of Corporate Tax Rates . . . . . . . . . . . 104

4.7 Robustness and Discussion . . . . . . . . . . . . . . . . . . . . . 106

4.7.1 Firm Size . . . . . . . . . . . . . . . . . . . . . . . . . . . . 106

4.7.2 Robustness Tests . . . . . . . . . . . . . . . . . . . . . . . . 108

4.8 Conclusion . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 108

**Conclusion** **111**

**Appendices** **113**

A Appendix to Chapter 1 . . . . . . . . . . . . . . . . . . . . . . . 114

A.1 Proof of Proposition 1.1: Tax Burden of MNEs . . . . . . . . 114

A.2 Proof of Propositions 1.2 and 1.3: Composition and Mass of Active Firms and Price and Quantity Effects . . . . . . . . . 115

A.3 Heterogeneous Independent Suppliers . . . . . . . . . . . . . 115

A.4 Proof of Lemma 1.2: Optimal Organization with Incomplete Contracts . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 117

A.5 Proof of Proposition 1.4: Tax Burden of MNEs under Incomplete Contracts . . . . . . . . . . . . . . . . . . . . . . . . . 118

A.6 Alternative Specification of the Effective Tax Rate . . . . . . 119

A.7 Extension to Transfer Price Manipulation in the First Model . 120

A.8 Proof of Proposition 1.5: Implications of Transfer Price Manipulation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 121

B Appendix to Chapter 2 . . . . . . . . . . . . . . . . . . . . . . . 123

B.1 The Critical Cost Gap $\Delta$ . . . . . . . . . . . . . . . . . . . . . 123

B.2 A Regime With Complete Profit Shifting by MNEs . . . . . . 123

B.3 Bertrand Competition With Heterogeneous Goods . . . . . . 125

C Appendix to Chapter 3 . . . . . . . . . . . . . . . . . . . . . . . . 126
D Appendix to Chapter 4 . . . . . . . . . . . . . . . . . . . . . . . . 128

**Bibliography** **129**

# List of Figures

2.1 Optimal Input Taxes and Economic Integration . . . . . . . . . . . . 55
3.1 Aggregate Profits Shifted Abroad . . . . . . . . . . . . . . . . . . . . 74
3.2 Prohibiting Profit Shifting Given Different Market Characteristics . . 75
3.3 Prohibiting Profit Shifting Given Different Firm Characteristics . . . 76
C.1 3D-Plots of Simulated Welfare Levels . . . . . . . . . . . . . . . . . . 126

# List of Tables


4.1 Statutory Loss Carryback and Carryforward Periods . . . . . . . . . . 83

4.2 Sample Selection . . . . . . . . . . . . . . . . . . . . . . . . . . . 96

4.3 Descriptive Statistics . . . . . . . . . . . . . . . . . . . . . . . . . 98

4.4 Correlation Matrix . . . . . . . . . . . . . . . . . . . . . . . . . . 100

4.5 Relation Between Firm Risk and Loss Carrybacks & Carryforwards . 102

4.6 Relation Between Firm Risk and Tax Rate . . . . . . . . . . . . . . 105

4.7 Regression Results with Size Interaction . . . . . . . . . . . . . . . . 107

4.8 Relation Between Firm Risk and Tax Rate with 5-Year Risk Measure 109

C.1 Results of the Numerical Simulation . . . . . . . . . . . . . . . . . . 126

D.1 Variable Definitions and Data Sources . . . . . . . . . . . . . . . . . 128

# Preface

Few – but very large – enterprises shape the economy in developed countries. In the United States, the largest 0.01% of firms generated 48% of total sales in 2007, and employed 38% of the workforce (U. S. Census Bureau, 2007). Even in Germany, with its exceptionally broad base of medium sized companies (the *Mittelstand*), less than 0.1% of firms had 47% of the total sales in the economy in 2008 (Statistisches Bundesamt, 2010). These firms are not only the largest firms, but are also more productive than average firms (Leung et al., 2008). Most of them are also active internationally (Head and Ries, 2003; Helpman et al., 2004).

These large, productive, multinational firms generate a large share of aggregate profits. Potentially, they could thus contribute a large share of corporate tax revenues. Anecdotal evidence gives rise to doubts if that is the case. Making an estimated profit of a billion euro in Germany, Apple Inc. has been accused of paying only 5 million euro in taxes in Germany – a tax payment that corresponds to an effective tax rate below 1% (Süddeutsche Zeitung, 2013). Similar claims have been made about Amazon.com Inc. and Microsoft Corp. Empirical studies confirm that multinational firms' tax payments are small relative to their profits: Egger et al. (2010b) find that in European high-tax countries, subsidiaries of multinational corporations pay over 30% less tax than similar domestically-owned firms.

In some extreme cases, the low tax payments of multinational firms have led to strong public reactions – for example in the United Kingdom, where the coffee chain Starbucks Corp. could silence public criticism of its very low tax payments only by offering a voluntary additional payment of 20 million pounds sterling. The issue of appropriate tax payments of such large corporations has become more important recently as most governments are in search of cash in the aftermath of the global financial crisis.[1]

This thesis considers the taxation of these large, multinational enterprises. It explores not only why these firms pay relatively low taxes, but also the potential advantages and disadvantages of increasing their tax burden. In this analysis, a particular focus is put on the ways in which taxation affects large, productive multinational enterprises differently from small, domestic companies. A large part of the prior literature on corporate taxation did not consider that firms are inherently diverse, and thus had to rely on ad hoc assumptions to explain why some firms behave differently – e.g. become multinational enterprises. In contrast to this literature, this dissertation explains differing behavior among firms by inherent productivity differences.

Modelling such productivity differences has only recently become mainstream in the economic literature. An important contribution was Melitz (2003), who provided a tractable treatment of firm heterogeneity in the monopolistic competition framework that is often used in new trade theory. Helpman et al. (2004) and Antràs (2003) extended this framework to multinational firms' foreign direct investment (FDI) and outsourcing decisions. Davies and Eckel (2010), Baldwin and Okubo (2009), Krautheim and Schmidt-Eisenlohr (2011) and Bauer et al. (2011) have used similar frameworks in a public finance context, e.g. to model tax competition between states, taking into account that firms' incentives to relocate or shift profits vary with their productivity.

In this thesis, Chapters 1 to 3 contribute to this line of literature. In these chapters I show, for example, that productivity differences among firms offer an explanation of the low tax payments of large, multinational enterprises (relative to their high profits). Heterogeneous productivity also provides new insights into regulations which are supposed to limit profit shifting but may harm domestic activities of smaller firms. In a later chapter (Chapter 4), this dissertation focuses on large firms and empirically examines how the tax system affects the incentives to undertake risky investments. Besides these positive analyses describing how taxation influences firms, there is also a chapter taking a normative point of view, asking whether the tax law should favor large, multinational firms (Chapter 2).

[1]Since the start of the financial crisis in 2007, public debt has gone up enormously: From 1.6 trillion euro (or 65.2% of GDP) in 2007 to 2.2 trillion euro (81.9% of GDP) in 2012 in Germany, from 1.2 trillion (64.2% of GDP) to 1.8 trillion euro (90.2% of GDP) in France, and from 382 billion euro (36.3% of GDP) to 884 billion euro (84.2% of GDP) in Spain (Eurostat, 2012). Due to this development and negative economic outlooks, the rating agency Standard & Poors has downgraded the credit ratings of major countries (e.g. the United States in 2011 and France in 2012), thus making debt financing of government expenditure more difficult and more expensive. It is therefore understandable that governments increasingly look at taxation to finance their spending.

Each of these chapter considers the taxation of large, productive corporations in a particular context. In the following, I will give a brief overview of the lines of argument developed in each chapter.[2]

Chapter 1 analyzes profit taxation according to the arm's length principle. It shows that multinational firms are able to shift profits abroad even if they fully comply with the tax code. This is the case because transfer prices have to follow market values due to the arm's length principle. This principle is the prevalent standard worldwide to price transactions within multinational corporations. In this chapter, I present two separate models, which both show that – for different reasons – arm's length transfer prices systematically exceed multinationals' marginal cost. This mark-up reduces their tax payments compared to domestic firms. There are two reasons why transfer prices exceed marginal cost: The first model in this chapter shows that in equilibrium, intra-firm transactions occur in firms that are better than the market at input production. Additionally, as the second model points out, market input prices include a mark-up that arises from the bargaining between the firm and the independent supplier. Hence, the optimal organization of firms provides a new rationale for the empirically observed lower tax burden of multinational corporations. This chapter is based on joint work with Dr. Christian Bauer, University of Munich (Bauer and Langenmayr, 2011, 2013).

The second chapter asks if favoring more productive firms, for example via the arm's length principle (as described in Chapter 1), is the optimal policy from a welfare point of view. To answer this question, the model in this chapter studies the optimal choice of effective tax rates in an oligopolistic industry with heterogeneous firms. It shows that the optimal structure of tax differentiation depends critically on the feasible level of corporate profit taxes, which in turn depends on the degree of international tax competition. When tax competition is moderate and profit taxes are high, favoring high-productivity firms is indeed the optimal policy. When tax competition is aggressive and profit taxes are low, however, the optimal tax policy is reversed and low-productivity firms are tax-favored. This chapter is based on joint work with Prof. Dr. Andreas Haufler, University of Munich, and Dr. Christian Bauer, University of Munich (Langenmayr et al., 2012).

The third chapter analyzes measures that limit firms' profit shifting activities. Such measures, e.g. thin capitalization rules, have become increasingly widespread as gov-

[2] All chapters are based on stand-alone papers and can be read separately. Some chapters are based on co-authored papers. In these chapters, I have kept the pronoun "we" in the text (as it is used in the published and working paper versions) to clarify that their basis is joint work.

ernments have reacted to growing profit shifting activities of multinational companies. However, besides limiting profit shifting, such rules entail costs. As the regulations can only focus on the means to shift profits, not on profit shifting itself, they impose costs on all firms, no matter whether these firms shift profits abroad or not. In the model, these costs force some firms to exit the market. As this makes the remaining firms more profitable, regulations to limit profit shifting may even increase the aggregate amount of profits shifted abroad. From a welfare point of view, it may under certain circumstances be optimal not to limit profit shifting at all. Langenmayr (2011) is the basis of this chapter.

Chapter 4 considers that in a time of low growth and high public debt, many governments in the developed world look for ways to encourage growth without spending more. Risky investment by firms is one way to generate economic growth. This chapter explores if and in how far the tax system can give incentives to increase such corporate risk-taking. To do so this essay first derives a simple model to show that the effect of taxes on firm risk-taking depends on loss offset possibilities. The theoretical predictions are then confirmed empirically using a large international firm-level dataset. The empirical analysis shows that firm risk-taking is positively and significantly related to tax loss carryback and tax loss carryforward periods, and that this relation increases with the level of the tax rate. For firms that cannot expect to offset losses, higher tax rates inhibit risk-taking. If loss offset is probable, however, corporate tax rates have a significant and positive effect on risk-taking. This chapter is based on unpublished work carried out jointly with Rebecca Lester, Massachusetts Institute of Technology.

To derive the results in these four chapters, I use different methodologies and model frameworks. For example, in Chapters 1 and 3, I employ a monopolistic competition framework in which productivity follows a continuous distribution and the elasticity of substitution between goods is constant. This is the standard framework in the "new" new trade theory with heterogeneous firms. It has the advantage of offering a good description of an industry with many firms that differ in productivity, size and profits. As the varieties that the firms produce are slightly different, each firm has some ability to influence the price of its product (without loosing all demand as it would in a perfectly competitive environment). This is a realistic description of some industries, e.g. banking (Claessens and Laeven, 2004). It also keeps the analysis analytically tractable. But this framework also has some disadvantages: Prices are always mark-ups on marginal cost, and these mark-ups are identical for all firms. Therefore, changes in competition (for example due to a change in the number of active firms) do not influence prices. Welfare is crucially affected by the number of varieties available.[3]

Chapter 2 takes a different approach. It provides an analysis of welfare-maximizing taxation in the presence of firm heterogeneity. To focus on firm heterogeneity itself and not on consumption shares of different varieties, it uses an oligopoly framework with two firm types. The use of only two productivity levels renders more clear-cut results on the tax treatment of the different firm types possible. The oligopolistic setting lets firms choose their quantities strategically (depending on the competition they face) and thus makes it possible to consider the effect of taxes on this choice – showing, for example, under which circumstances the government will induce the more productive firms to increase production.

Chapter 4 differs methodologically from the preceding papers as its focus is empirical. First, however, it provides a simple model to clarify the effects that are tested in the empirical part. In contrast to the preceding chapters, the firm studied in this model has risk-averse characteristics – an important feature in this case, as the model focuses on firm risk-taking. Risky investments imply that firms' profits vary over time. Therefore, this chapter complements the preceding chapters, which focused on the variation of profits across firms. A look at the firm-level data used in the empirical analysis shows that firm profits vary strongly across both dimensions. The standard deviation of the return on assets is 0.26, a large value, given that the average return on asset is -0.1. There is also much heterogeneity across firms, even though the dataset includes only corporations with publicly traded shares – the very large firms which, as explained at the beginning of this preface, are responsible for a major share of economic activity. For example, total assets in this dataset vary between less than 1 000 U.S. dollars and over 800 million U.S. dollars, and the return on assets is between -4.6 and 0.5.

To sum up, firms' profits vary strongly both across firms and over time. The public finance literature has long dismissed this heterogeneity in its analysis of corporate taxation and instead assumed that all firms produce at the same cost and are neutral towards risk. These assumptions limited the possible effects of taxation. The essays in this dissertation make a contribution to fill these gaps in our knowledge of the influences of taxation on the behavior of corporations.

[3] In this framework, even when there are already very many varieties available, an additional variety increases welfare. This is not in all circumstances realistic. For example, behavioral economics has shown that in certain situations, e.g. grocery shopping or pension plans, individuals prefer less choice to more (Boatwright and Nunes, 2001; Iyengar et al., 2004).

# Chapter 1

# Sorting into Outsourcing: Are Profits Taxed at a Gorilla's Arm's Length?

## 1.1 Introduction

Multinational firm activity has become one of the most striking features of the global economy. Multinational enterprises (MNEs) now account for a major share of economic activity around the world. Some of these firms have an economic power similar to a middle-income country. General Electric, for example, which is active in over 100 countries, earned revenues of 182 billion US-Dollars in 2008, more than the GDP of a medium-sized economy like Chile.

Such enterprises are not only big, but also highly productive and profitable.[1] They are consequently very attractive for governments, as they not only provide jobs and investments, but their high profits also offer the opportunity to generate tax revenue. However, there are widespread concerns that MNEs' profits are especially hard to tax, as – due to their internationality – they can avoid taxation in high-tax countries. Anecdotal evidence supports this claim: In 2008, the car manufacturer BMW, who has split production among various facilities in and outside Europe, effectively paid

This chapter is based on joint work with Christian Bauer. It is the synthesis of Bauer and Langenmayr (2011) and Bauer and Langenmayr (2013).

[1] For empirical evidence on the superior productivity of MNEs see, among others, Head and Ries (2003) and Helpman et al. (2004).

6% tax on its income in Germany, where its headquarters are located. In the same year, on average, German corporations paid 30% of their earnings as profit taxes.[2]

Empirical evidence substantiates this phenomenon. Bartelsman and Beetsma (2003) show that multinational firms are able to shift income abroad and thus pay substantially less tax relative to their profits. Grubert et al. (1993) and Harris (1993) directly compare foreign-owned and domestically-owned firms, providing evidence for lower taxable profits of MNEs in the United States. Most recently, Egger et al. (2010b) have studied a large dataset of European firms using a matching approach. They find that an average subsidiary of a multinational corporation pays about 32% less tax in a high-tax country than a similar domestically-owned firm. In absolute terms, the tax payments of the foreign-owned firm are on average 1.3 million Euros lower than those of an otherwise identical domestic company.

This essay contributes to the literature that aims to explain lower tax payments of MNEs. This literature has established that MNEs are able to shift profits to low-tax locations by manipulating transfer prices and/or intra-firm debt. We provide a new and complementary explanation by showing that even a correct application of transfer prices under the ruling arm's length principle may imply profit shifting and lower taxes for MNEs if their optimal organizational choice and the bargaining process is taken into account.

We develop this results in two separate models. The first model focuses exclusively on the optimal organization of firms. In this model, firms source an input from a foreign country either by producing it in a fully-owned subsidiary or by purchasing it on the (foreign) market. Firms differ in their ability to produce the input in a subsidiary. In equilibrium, only the firms that are the most productive in input production engage in vertical foreign direct investment (FDI) and become a MNE. The remaining firms buy the input on the market at an exogenously given price. The second model considers more closely how input prices are determined. It assumes that firms and their suppliers operate in an environment of incomplete contracts. As in Antràs (2003) and Antràs and Helpman (2004), agreements prior to production are subject to ex-post renegotiation. The equilibrium input price thus depends on each side's bargaining power and outside options.

In each framework, we explore the implications of profit taxation. We explicitly model the determination of transfer prices according to the arm's length principle. This

[2] See the financial statements of BMW (2008, p. 11) and, for average tax payments in Germany, Deutsche Bundesbank (2011, p. 22).

principle, which is prevalent worldwide, implies that intra-firm transactions have to be valued at arm's length, i.e. as if the transaction had taken place between independent parties.[3] In practice, market prices of comparable transactions are used. However, integrated firms are able to obtain the input at significantly lower prices, as they are more productive and have a better bargaining position vis-à-vis their suppliers than firms that obtain the input from an external source. Therefore, the market (and transfer) price systematically exceeds the marginal cost of input production within the multinational firm. The arm's length at which intra-firm transactions are taxed exceeds the intended length – profits are taxed, metaphorically speaking, at a gorilla's, not a human's, arm's length.[4]

Taxation at this "gorilla's arm's length" has several implications for firm behavior. As the transfer price exceeds marginal cost, multinational firms can shift some profits abroad with each unit produced. This shows that some profit shifting of MNEs is a feature inherent in the tax system, and that even correct application of the arm's length principle implies that MNEs pay lower taxes than purely domestic firms.

Our argument is based on the widespread use of the arm's length principle in international taxation. This principle is the starting point of both Art. 7 of the OECD Model Double Tax Convention and Art. 9 of the UN Model Treaty, and has been implemented by almost all countries worldwide.[5] Its importance has also been confirmed recently by legal cases at high-level courts.[6]

As mentioned above, the guiding principle of the arm's length standard is to treat transactions within a multinational corporation as if they had taken place between independent enterprises. This proposes the use of a price that is not directly observable. In reality, it has to be approximated with the help of other transactions. In our model, we follow the "comparable uncontrolled price" (CUP) method, which uses a third

[3]For a detailed survey of transfer pricing and the arm's length principle see Wittendorff (2010).

[4]A gorilla's arms are about a foot (ca 30 cm) longer than the arms of a human, even though an average gorilla is shorter than an average man.

[5]In the US, the arm's length standard is codified in subchapter A of the treasury regulations, section 1.482-1(b). At the European level, it is endorsed in Art. 4 par. 1 of the Arbitration Convention of 1990 (see Schön (2013) for details on EU member states). The "Transfer Pricing Global Reference Guide" by Ernst & Young (2011) provides a worldwide overview.

[6]An example is the "SGI" case (C-311/08) at the European Court of Justice, in which the Société de Gestion Industrielle (SGI) took Belgium to court over her transfer pricing rules. SGI claimed that those rules violated the EU freedom of establishment. In its judgement on January 21st, 2010, the Court stressed the value of the arm's length standard to ensure a balanced allocation of tax bases and accepted the validity of legislation following the arm's length principle - even if it is potentially not in accordance with European law. For details, see Boone et al. (2010).

party price for an identical or similar input. If such a comparable uncontrolled price exists, both the legal literature (see Kobetsky, 2011, p. 332) and many local country transfer pricing regulations (see Bronson et al., 2010, p. 25-26) prefer this method to alternatives such as the cost-plus, the resale-minus or the comparable profit method.[7] All these methods have in common that they compare characteristics of transactions (e.g. mark-ups, list price discounts) or the division of profits with those of other, independent firms.

By modelling a realistic tax system, we thus offer a new rationale for the empirically observed lower tax burden of MNEs. As we show in an extension, it is complementary to the existing explanations, which focus on transfer price manipulation. So how important is the proposed effect of taxation at a "gorilla's arm's length" quantitatively? In our model, the magnitude of the effect depends on the productivity difference between MNEs and firms that engage in foreign outsourcing. Tomiura (2007) finds in a large dataset of Japanese firms that firms which engage in FDI are on average 18% more productive (as measured by value-added per worker) than firms who outsource input production. This suggests that there may be a substantive profit shifting effect due to productivity differences.

This chapter relates to several strands of literature. First, there is a vast literature on profit shifting by multinational firms. Early theoretical contributions include, for example, Janeba (1996) or Haufler and Schjelderup (2000). Huizinga and Laeven (2008) provide empirical evidence that there is substantial profit shifting between European countries.[8] Other empirical studies have focused on different methods of profit shifting. The use of intra-firm loans or adjustments of the capital structure to avoid taxation has been analyzed, among others, by Buettner et al. (2009) and Egger et al. (2010a). Furthermore, transfer prices, especially of intangible assets, have long been suspected to be manipulated for the purpose of profit shifting (see Dischinger and Riedel (2011) and Clausing (2003) for empirical evidence).

The theoretical literature on the tax implications of transfer pricing mostly focusses on situations where no arm's length price is observable. For example, Gresik and Osmundsen (2008) discuss how transfer prices are chosen in a vertically integrated

[7]The importance of CUP was confirmed by members of the transfer pricing team of one of the "Big Four" accountancy firms in private conversations. They assured us that CUP is used whenever it is possible to find similar/identical transactions, either between the same firm and an external supplier or between two external, comparable firms. Its use is especially common for financial transactions or standardized inputs.

[8]For a recent survey of the empirical literature see Devereux and Loretz (2012).

industry. Also in the absence of an arm's length price, Elitzur and Mintz (1996) study the choice of the transfer price in a setting where it affects both incentives of the subsidiary's manager as well as the tax burden. From a government point of view, Matsui (2012) studies optimal auditing standards of transfer prices in the absence of an observable arm's length price.

Keuschnigg and Devereux (2013) explicitly consider the arm's length principle and model its interaction with financial frictions. Similar to our work, they find that the arm's length principle provides a flawed benchmark for taxation. The mechanism underlying this result is however very different. In Keuschnigg and Devereux (2013), the distortion arises from financial constraints, which incentivize the headquarter to pay elevated transfer prices to provide the subsidiary with liquidity. Arm's length taxation penalizes this practice. In our model, in contrast, arm's length transfer pricing is advantageous for MNEs. This arises due to selection into FDI according to productivity, which is not captured by Keuschnigg and Devereux (2013). In their model, in which firms are homogeneous, the arm's length price would be correct in the absence of financial frictions. We show that this is not the case if firms differ in productivity.

By introducing and modeling explicitly the globally prevalent tax system in a framework of global sourcing, this essay also contributes to the literature on the FDI-vs.-outsourcing decision among heterogeneous firms (see Spencer (2005) for a survey). This chapter follows the bulk of this literature in taking an incomplete contracts approach to the theory of the firm.[9] The only other paper work that considers the interaction of taxes with the outsourcing decision is Egger and Seidel (2011). They show that the possibility to shift profits via transfer pricing constitutes a reason to do FDI instead of outsourcing. Disregarding the arm's length principle, they assume that transfer prices can be manipulated at a cost. These profit shifting opportunities are the only reason for integration in Egger and Seidel (2011) and are also the only reason for different tax burdens of integrated and outsourcing firms. In our model, in contrast, firm heterogeneity and profit opportunities drive the outsourcing decision, and transfer prices are set according to arm's length principle. Moreover, we explicitly determine transfer prices following the lead of Antràs and Helpman (2004), taking contracting frictions between headquarters and suppliers into account. Thus, even in the absence of transfer price manipulation, integration may be profitable and integrated

[9]See, among others, Grossman and Helpman (2002), Antràs (2003), Antràs and Helpman (2004), and Grossman and Helpman (2005).

firms are taxed less.[10] However, such profit shifting can additionally be incorporated in our analysis, as we show in an extension.

The remainder of this chapter is structured as follows. Section 1.2 presents the first model, which focusses on optimal firm organization, and derives a first set of results. Section 1.3 extends this framework and models explicitly how input prices are determined. Section 1.4 offers an extension to transfer price manipulation and discusses robustness with respect to some basic assumptions. Section 1.5 concludes.

## 1.2 A Model of Optimal Organization

In this section, we present the basic framework of our first model. We first describe the model framework, then solve the model for a world without taxes, and include taxes in a third step. The no-tax model serves as a benchmark.

### 1.2.1 Model Setup

Consider a static world economy with many countries which differ in their tax rates. There is a high-tax country, $H$, with tax rate $t_H$, and many low-tax countries with tax rates $t_L < t_H$. The tax rate differential can be rationalized in a simple setup in which the headquarter is immobile and tied to consumer markets in $H$ while suppliers are free to move between periphery countries. Competition among the latter will drive their tax rates down while $H$ is able to tax the rents arising from the immobility of the consumer good producers.[11] We focus on one periphery country, which we label $L$.

Each country is endowed with a fixed amount of inelastically supplied, internationally immobile labor, the only factor of production. The two countries produce and trade a homogeneous numeraire good $Y$. $H$ also produces a differentiated good $X$, for which firms source intermediate inputs from $L$. The $X$-sector is monopolistically competitive, while the $Y$-sector is perfectly competitive. There is free entry into

[10] Egger and Seidel (2011) also provide empirical evidence for their findings, showing that a higher tax rate differential is associated with more intra-firm imports. This finding is also consistent with our model.

[11] For a similar set-up where headquarters are located in the core and suppliers in the periphery see Fujita and Thisse (2006). The high mobility of suppliers is in line with casual observation: the mobile phone maker Nokia, for example, moved its production from Germany to Romania (in 2007) and from there to China (in 2012), while remaining headquartered in Finland.

product markets and free trade between $H$ and $L$ in inputs and in the $Y$ good.[12] Firms in the $Y$-sector are homogeneous, and thus earn zero profits. Choosing units so that one unit of the numeraire is produced from one unit of labor, wages are equal to unity in both countries.[13]

In more detail, firms in the $X$ sector each produce a differentiated consumer good from a specific variety of a generic intermediate input and fixed overhead labor. Firms endogenously decide about the organization of production, choosing to either outsource or produce the input in a subsidiary. In the first case, they obtain a generic variant of the input on the foreign market and customize it within the firm. Alternatively, firms can produce a customized input in a fully-owned foreign subsidiary (FDI).[14] The differentiated goods producers differ with respect to the quality of their FDI opportunities (i.e. their variable costs of input production in the subsidiary), which are exogenously assigned to them. This heterogeneity can be interpreted as being implied by the quality of the blueprint that a firm possesses, or as differences in the ability to implant these blueprints efficiently in a foreign subsidiary.

The sequence of events is the following. First, firms decide whether to enter into the product market based on their anticipated future profits. Second, $X$ sector firms organize optimally. Third, production and consumption occurs, and profits are realized.

Consumers in $H$ are homogeneous and value the two (private) goods $X$ and $Y$. The preferences of a representative consumer are given by a log-linear utility function[15] of

[12] Allowing for trade in $X$ is also possible, but not necessary, and is therefore omitted for simplicity.

[13] Therefore, as there are no wage differentials, our model is one of FDI between similar (developed) countries. This is indeed one of the most common forms of FDI. Note that wage differentials would have no consequences for our main proposition, as the arm's length principle uses input prices paid to independent suppliers that are located in the *same* country as a benchmark for integrated suppliers.

[14] Input production in a subsidiary in $H$ is also possible, but, as becomes clear below, yields no substantial insights in the benchmark model due to factor price equalization. This is because we design the model so that integrated firms are indifferent between producing in $H$ and $L$ when tax rates are identical across countries. When tax rates differ, however, they will strictly prefer the low-tax country, $L$, justifying the environment described above.

[15] The choice of a quasi-linear utility function is innocuous, as income effects would not affect our main results: As will be shown later, effective tax rates depend only on parameters and on prices, which are always mark-ups on effective input costs. As the implicit subsidy of arm's length taxation would not be affected by income effects, effective tax rates remain unaffected by changes in profit income. Thus, as income effects are not relevant to our argument, we use quasi-linear preferences for simplicity, as has become standard in the applied literature (see, for example, Chor, 2009; Baldwin and Okubo, 2009; Cole and Davies, 2011; Krautheim and Schmidt-Eisenlohr, 2011).

the form

$$U = \mu \ln X + Y^D,\ X = \left[\int_{i\in\Omega} x_i^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}}, \tag{1.1}$$

where $Y^D$ is the quantity consumed of the numeraire good and $\Omega$ represents the set of available varieties in the monopolistically competitive sector. Varieties are consumed in quantities $x_i$, where $i$ is the index for the variety and its seller. Varieties are substitutes and the elasticity of substitution between any pair of varieties is $\sigma$, with $1 < \sigma\,(< \infty)$. The parameter $\mu$ weighs the relative importance of the two goods. As in Dixit and Stiglitz (1977), demand for each variety is isoelastic and given by

$$x_i = \frac{\mu}{p_i^\sigma} P^{\sigma-1}, \tag{1.2}$$

where $p_i$ is the price of variety $i$ and $P = \left[\int_{i\in\Omega} p_i^{-(\sigma-1)} di\right]^{-\frac{1}{\sigma-1}}$ is the price index for good $X$. Due to the quasi-linearity of preferences, expenditures for $X$ are determined by the constant $\mu$: $\mu = PX$. Denoting total income by $I$, the residual income is spent on the numeraire good, so that $Y^D = I - \mu$.

Next, consider the corporate sector. There is a large pool of potential entrants into the $X$ sector. We normalize its mass to 1.[16] Anticipating market conditions, each potential entrant chooses its optimal organizational structure ("make or buy") and, given this structure and the ensuing optimal output choice, decides whether to enter.

In the following, we characterize firms' objectives and their optimal decisions under each of the two alternative organizational forms, FDI and outsourcing.

**FDI.** Each firm has the option to become a MNE by acquiring or setting up a fully-owned foreign subsidiary. Operating this foreign plant requires a fixed cost $f > 0$. Input production takes place at a firm-specific constant marginal cost $a_i$. These input coefficients are drawn from a distribution $G(a)$, $a \in [\underline{a}, \overline{a}]$. They are exogenously assigned to each firm and known at the time of market entry.[17] The final assembly of the consumer good occurs at the headquarter in $H$; this requires the headquarter to

[16] Assuming a given mass of potential entrants as part of the economy's endowment is common in the applied literature on heterogenous firms, see Baldwin and Okubo (2009) and Krautheim and Schmidt-Eisenlohr (2011), among others.

[17] If we think of $a_i$ representing the technological knowledge of firm $i$, the implicit assumption is that this knowledge can be transferred completely and costlessly to the subsidiary. Alternatively, we may presume a matching process that pairs firms and potential foreign subsidiaries and think of $a_i$ as the match-specific unit production cost. For a more elaborate environment similar in spirit see Grossman et al. (2006).

incur fixed costs $c > 0$.

Profit maximization given demand (eq. 1.2) results in standard mark-up pricing:

$$p_i = \frac{\sigma}{\sigma - 1} a_i. \tag{1.3}$$

Maximized profits are equal to

$$\pi_i = [p_i - a_i]\, x_i - c - f = \left[\frac{\sigma - 1}{\sigma} \frac{P}{a_i}\right]^{\sigma - 1} \frac{\mu}{\sigma} - c - f. \tag{1.4}$$

More productive MNEs charge lower prices, thus sell larger quantities, and earn higher profits.

**Outsourcing.** Under outsourcing, the firm buys a non-specific variant of the input from a competitive stand-alone supplier in $L$ at an exogenous price $r$.[18] This assumption introduces a unique market price for comparable transactions, which is the ideal world for the application of the arm's length principle below, where one market price determines the transfer price for all MNEs.

Outsourcing avoids the added fixed costs for operating a subsidiary, but the generic variant of the input needs to be customized to fit the differentiated good firm's specific requirements.[19] To model these costs in a simple way, we assume that the firm has to buy $1 + \tau$ units of the input in order to use one unit in production.

Since the market price for the input and customization costs are the same for all outsourcing firms, these firms charge identical profit-maximizing prices:

$$p_o = \frac{\sigma}{\sigma - 1} (1 + \tau)\, r. \tag{1.5}$$

It follows that all outsourcing firms also sell the same quantities $x_o$ and earn the same profits $\pi_o$. Taking fixed costs $c$ in the headquarter into account, profits in the optimum

[18] We take the existence and productivity of the intermediate input supplier as given and assume that demand of outsourcing firms in $H$ does not affect the world market price of the input. Furthermore, we make the implicit assumption that the subsidiary of the most productive firm does not sell to other final good producers, for example because its advantage lies only in producing the customized input.

[19] For a similar approach where a standardized, market-bought input is less suited for the producer's specific purposes see, among others, Lorz and Wrede (2008).

are given by

$$\pi_o = [p_o - (1+\tau)\, r]\, x_o - c = \left[\frac{\sigma-1}{\sigma}\frac{P}{(1+\tau)\, r}\right]^{\sigma-1}\frac{\mu}{\sigma} - c. \tag{1.6}$$

From the point of view of an outside observer, all outsourcing firms behave identically, even though they are intrinsically heterogenous because their organizational outside options differ.[20]

It follows immediately from the presence of fixed costs that, for firms to optimally choose FDI over foreign outsourcing, variable costs of MNEs must fall short of variable costs of outsourcing, $(1+\tau)\, r$. This is the simple intuition behind our claim that MNEs pay relatively less tax than firms without foreign affiliates due to the use of market prices for the determination of transfer prices.

In principle, the presence of customization costs may imply that not *all* integrated firms exhibit variable costs below the market price of the input, $r$. Such firms (the smallest integrated firms) would optimally choose domestic integration, not FDI, as profit taxation would impose variable costs in excess of their true economic costs. To avoid the inconvenience of a case distinction between domestic and foreign integration, we focus on an industry where

$$\tau \leq \left(\frac{c+f}{c}\right)^{\frac{1}{\sigma-1}} - 1. \tag{1.7}$$

This set of parameters simplifies the exposition because, in equilibrium, all integrated firms are MNEs. Dropping this restriction would complicate the model without changing the implications of optimal organization for profit taxation at arms' length prices: that MNEs are able to shift profits abroad even if they adhere perfectly to the tax code.

### 1.2.2 Benchmark Without Taxation

In equilibrium, sufficiently productive firms incur the added fixed cost of organizing a foreign affiliate and become MNEs. Less productive firms may always enter and realize $\pi_o$ by sourcing the input from the market. Since $\pi_o$ is decreasing in the mass of active firms, entry will drive the profits of outsourcing firms to zero. Combining (1.6)

[20] Since outsourcing firms have homogenous unit production costs and MNEs have heterogenous unit production costs, one can view our model as a hybrid of the Krugman (1980) model and the Melitz (2003) model.

and $\pi_o = 0$, this implies:

$$P^* = \left(\frac{\sigma c}{\mu}\right)^{\frac{1}{\sigma-1}} (1+\tau)\, r \frac{\sigma}{\sigma - 1}. \tag{1.8}$$

The price index of the $X$ sector is fully determined by free entry into outsourcing, and thus independent of the distribution of productivities $G(a)$.[21] The price index is increasing in overhead costs because they reduce the mass of active firms; it is lower in larger markets (as measured by $\mu$), since a larger market induces additional firm entry.[22] Moreover, if customization is more costly or input suppliers become less productive (an increase in $\tau$ or $r$), the price level rises, as varieties produced by outsourcing firms become more expensive.

Firms choose their mode of organization by comparing profits under outsourcing (eq. 1.6) and vertical integration (eq. 1.4). Since profits of MNEs are strictly decreasing in their own unit production costs, while profits are independent of these costs under outsourcing, only firms with $a_i \leq a^*$ profitably choose to become MNEs. The cutoff $a^*$ is thus uniquely determined by $\pi(a^*) = \pi_o$. In equilibrium, using (1.8), it is given by:

$$a^* = \left(\frac{c}{c+f}\right)^{\frac{1}{\sigma-1}} (1+\tau)\, r. \tag{1.9}$$

We summarize the properties of optimal organizational form in:

**Lemma 1.1 (Optimal organization)** *Firms with $a_i < a^*$ become MNEs while firms with $a_i \geq a^*$ source the input from the market. The cost cutoff $a^*$ for FDI is increasing in the cost level of input suppliers on the market ($r$), in the necessary degree of customization ($\tau$), and in the relative fixed cost of outsourcing vs. integration ($c/(c+f)$).*

These properties are immediately intuitive. As the fixed costs of integration $(c+f)$ rise relative to those of an outsourcing firm $(c)$, outsourcing becomes more attractive.

[21] How does the zero-profit condition of outsourcing firms determine the price index? Suppose some shock induces an additional MNE to enter the market. The added demand for overhead labor bids up the real wage $(1/P)$ and, other things equal, reduces profits of all active firms. This causes some outsourcing firms to exit the market, so that the price index raises again. It does so up to its starting value, the only level compatible with zero profits of outsourcing firms.

[22] The C.E.S. price index can be interpreted as the price index of the optimized consumption bundle. As additional varieties increase consumers's options and thereby utility, more varieties imply a lower price index.

More firms are integrated if profits under outsourcing are lower, which is the case if the customization costs ($\tau$) or the market price ($r$) are higher.

Moreover, we conclude that the organizational form is robust to changes in the underlying productivity distribution of firms' production abilities. Innovations in the production technology, measured e.g. by a shift in the mean of $G(a)$, thus leave the cutoff for outsourcing unaffected. This is because, in our model, such changes are perfectly accommodated by entry into outsourcing. This feature, which comes without loss of generality for the general point that firms sort into FDI, allows for a particularly tractable solution.

We now turn to the variety of available products. The mass of varieties produced by MNEs is given by $1 \times G(a^*)$. We solve for the mass of outsourcing-firms $n_o^*$ as a function of the cutoff $a^*$ by combining the equilibrium price index, firms' pricing rules, and, after substituting for firm indices with their cost coefficients, the definition of the price index:[23]

$$n_o{}^* = \frac{\mu}{\sigma c} - \left[\frac{(1+\tau)\,r}{\tilde{a}\,(a^*)}\right]^{\sigma-1}, \tag{1.10}$$

where we defined a harmonic mean of input coefficients of MNEs,

$$\tilde{a}\,(a^*) \equiv \left[\int_{\underline{a}}^{a^*} a^{-(\sigma-1)} dG\,(a)\right]^{-\frac{1}{\sigma-1}}. \tag{1.11}$$

The number of outsourcing firms increases in the size of the $X$ sector (as measured by $\mu$) and decreases in the organization cutoff $a^*$, which is endogenous and given in (1.9). Following an increase in fixed costs $c$, the number of outsourcing firms active in the market falls, so that equilibrium profits are again consistent with free market entry.

To complete the characterization of equilibrium, we now solve for the outcome in the $Y$ sector. As noted above, due to the quasi-linear preference structure, demand for $Y$ is given by $Y^D = I - \mu$.[24] Income $I$ consists of labor income $l$ and profits, i.e. $I = l + \int_{\underline{a}}^{a^*} [p_i x_i - a_i x_i - c - f]\, dG\,(a)$. Thus, $Y^D$ is given by

$$Y^D = \left[\frac{(1+\tau)\,r}{\tilde{a}\,(a^*)}\right]^{\sigma-1} c - (c+f)\,G\,(a^*) + l - \mu. \tag{1.12}$$

[23] Substituting for firms $i$ with input coefficients $a$, the price index in the economy is given by $P = \left[n_o\,(p_o)^{-(\sigma-1)} + \int_{\underline{a}}^{a^*} p(a)^{-(\sigma-1)} dG\,(a)\right]^{-\frac{1}{\sigma-1}}$.

[24] Note that $Y^D$ is not equal to the amount of $Y$ produced in the country ($Y^S$), as some of the $Y$-goods must be exported in order to balance trade (inputs are imported from the other country).

A change in the organizational structure of the $X$ sector affects $Y^D$ via profit income. If the cutoff $a^*$ increases, there is a larger number of profitable MNEs, which implies a higher aggregate income, thus raising demand for $Y$. This effect is dampened by the additional fixed costs incurred by MNEs.

This completes the description of the benchmark case without taxes.

### 1.2.3 Taxation

We now introduce profit taxation into the model to address the stylized fact proposed in the introduction: that multinational firms pay systematically less tax (relative to their profits) than firms without foreign affiliates. The common explanation is that firms strategically misprice cross-border transactions (i.e. manipulate transfer prices or intra-firm debt) to shift profits into low-tax jurisdictions.

To policy makers and much of the academic literature, the ideal method to prevent these manipulation activities is the arm's length principle.[25] As described in the introduction, this principle states that intra-firm transactions should be valued as if they had taken place between independent parties. It has been supposed that, if firms adhered perfectly to this principle, no profit shifting would take place. The low tax burden of MNEs would then originate from the ability of MNEs to circumvent the rules imposed by the arm's length principle.

In the following, we offer an alternative explanation. We show that, due to sorting into outsourcing, MNEs are able to shift some profits abroad even if the arm's length principle is fully enforced.

To approximate the arm's length price it is common practice to identify comparable market transactions and impose the associated price for the valuation of transactions within the multinational corporation (the "comparable uncontrolled price" (CUP) method described in the introduction). The relevant price for taxation within a MNE is thus equal to the price that the firm would have had to pay to an unrelated party on the market.

We implement this practice in the model by setting the transfer price for taxation equal to the market price of the input, $r$.[26] The after-tax profit of a multinational firm

[25] See, however, Keuschnigg and Devereux (2013).

[26] We use $r$, not $(1 + \tau)\, r$, as the customization costs $\tau$ arise in the production of the final consumer good. Setting the transfer price equal to $(1 + \tau)\, r$ would strengthen the effects shown in the following section.

is given by

$$\pi_i^t = (1 - t_H)\left(p_i^t - r\right)x_i^t + (1 - t_L)(r - a_i)\, x_i^t - c - f, \tag{1.13}$$

where $t_H$ and $t_L$ ($< t_H$) are the domestic and the foreign profit tax rate, respectively, and foreign profits can be repatriated without additional cost and are exempt from taxation in the home country.[27] For simplicity, we assume that fixed costs are not deductible.[28] Substituting (1.2) into (1.13) and optimizing yields profit maximizing prices for each multinational:[29]

$$p_i^t = \frac{\sigma}{\sigma - 1}\left(\frac{1 - t_L}{1 - t_H}a_i - \frac{t_H - t_L}{1 - t_H}r\right). \tag{1.14}$$

Arm's length taxation distorts MNEs' behavior as a combined result of the tax rate differential and firm heterogeneity.

Turning to outsourcing firms, their profit function is now given by:

$$\pi_o^t = (1 - t_H)\left[p_o^t - (1 + \tau)\, r\right]x_o^t - c. \tag{1.15}$$

Facing a pure tax on operating profits, the profit maximizing price is again given by its no-tax value in eq. (1.5) and equal for all outsourcing firms. Note, however, that since profit taxation impacts the prices of MNEs, it affects demand conditions of all active firms via the industry price level.

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[27]We thus assume that profits are taxed under the exemption method, which is the predominant method in the OECD. It has traditionally been applied by most continental European countries and more recently also by the UK and Japan. The alternative is the tax credit method, under which *worldwide* income is taxed at the home country's tax rate (and foreign tax payments are credited). If the high-tax country uses the tax credit method, in principle only its tax rate matters and transfer prices are irrelevant. It is thus consistent with our treatment that empirical evidence suggest that the effects highlighted in this chapter arise only under the exemption method, and not necessarily under the tax credit system. For firms in the US (where the tax credit system is used), Desai et al. (2006) do not find a positive effect of the average tax rate of a firm in non tax haven countries on the probability to invest in a tax haven. For Germany, where profits are taxed according to the exemption method, Gumpert et al. (2011) however find a positive effect.

[28]This assumption is common in the literature, see e.g. Krautheim and Schmidt-Eisenlohr (2011). Imagine, for example, that these are the costs for landholdings, or language barriers in the case of the additional fixed cost of international integration. Our main results continue to hold if fixed costs are deductible, but assuming non-deductable fixed costs cuts out analytical complexity. The only qualitative difference of making fixed costs deductable is with respect to the price index, which then becomes independent of taxation.

[29]To guarantee positive prices, we make the following technical assumption on the lower bound of the support of $G(a)$: $\underline{a} > \frac{t_H - t_L}{1 - t_L} r$. This permits standard distributions like the bounded Pareto, uniform, and others.

Finally, we assume that tax revenues are redistributed as a lump sum to the consumers. Note that this transfer does not affect aggregate demand in the $X$ sector, which is optimally equal to $\mu$ due to the quasi-linear preferences.

Firms' optimal behavior depends on the industry price level, which is endogenous. The equilibrium condition that determines the price index is the zero-profit condition for outsourcing firms. From $\pi_o^t = 0$, we solve for[30]

$$P_t^* = \frac{\sigma}{\sigma-1}\left(\frac{1}{1-t_H}\frac{\sigma c}{\mu}\right)^{\frac{1}{\sigma-1}}(1+\tau)\,r = \left(\frac{1}{1-t_H}\right)^{\frac{1}{\sigma-1}} P^*. \tag{1.16}$$

Despite lower prices set by MNEs, the price index is higher than its no-tax benchmark value due to market exit.[31] Using (1.16) allows us again to solve for the unique cost cutoff that determines the firm's optimal mode of production. Comparing after-tax profits under both organizational forms, firms choose to become multinationals if and only if $a_i \leq a_t^*$, where

$$a_t^* = \frac{1-t_H}{1-t_L}(1+\tau)\,r\left(\frac{c}{c+f}\right)^{\frac{1}{\sigma-1}} + \frac{t_H-t_L}{1-t_L}r. \tag{1.17}$$

With this, we are in the position to prove our main result, which is that MNEs in equilibrium may shift profits abroad even when they perfectly comply with the tax rules that are widely perceived to prevent profit shifting.

To this end, we compare effective tax rates, which are defined as tax payment per unit of the tax base. For MNEs, the effective tax rate is given by

$$t_i^{eff} = \frac{t_H(p_i^t - r)x_i^t + t_L(r-a_i)x_i^t}{(p_i^t - a_i)x_i^t}. \tag{1.18}$$

The effective tax rate of outsourcing firms, $t_o^{eff}$, is equal to $t_H$, as these firms have no opportunity to shift profits. The empirically low tax burden of MNEs, by which we motivated this chapter, thus follows naturally from the sorting decision of MNEs:

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[30] To avoid double superscripts, we indicate equilibrium values of aggregates in the case with taxation with subscript $t$.

[31] As MNEs set lower prices, demand shifts from outsourcing firms to MNEs. Additionally, as fixed costs are not tax deductible, higher sales are necessary for outsourcing firms to break even. Taken together, some outsourcing firms exit the market, raising demand for the remaining firms. Eq. (1.16) shows that the associated loss of varieties overcompensates the decline in prices charged by MNEs.

**Proposition 1.1 (Tax burden of MNEs)** *If profits are taxed at arm's length under an exemption system, MNEs face a lower tax burden relative to their profits than outsourcing firms, as is shown by the comparison of their effective tax rates:* $t_i^{eff} < t_o^{eff} = t_H$. *The most productive firms face the lowest effective tax rate* $\left(\frac{\partial t_i^{eff}}{\partial a_i} > 0\right)$.

**Proof.** See Appendix A.1. ■

In an industry with heterogeneous firms, application of the arm's length principle implies a systematic misvaluation of transfer prices for MNEs. This is a consequence of firms' endogenous decisions about their organizational form. The potential for profit shifting is largest for the most productive firms, who benefit from the most pronounced difference between actual costs and the market-determined transfer price.

The opportunity to shift profits abroad (where they are taxed at a lower rate) induces additional integration at the margin, raising the mass of multinational firms beyond its no-tax benchmark. Formally, the mass of MNEs is given by $G(a_t^*)$, and $a_t^* \geq a^*$ (proof in Appendix A.2).

As can be verified from eq. (1.17), the additional incentive to become a MNE is more pronounced when a high market price of the input allows for substantial profit shifting, or when a low foreign tax rate implies large gains from being partly taxed abroad. The latter effect is larger in magnitude if the domestic tax rate is already high to begin with. Similarly, gains from integration rise with the domestic tax rate; and this effect is stronger if the potential for profit shifting is high ($r$ is large) or the associated gains are large ($t_L$ is low).

While taxation induces additional firms to integrate, at the same time it reduces the total number of outsourcing firms. Formally, by solving the definition of the price index for $n_o^t$, the equilibrium number of domestic firms is now given by

$$n_o^t = \frac{\mu}{\sigma c}\left(1 - t_H\right) - \left[\frac{\left(1+\tau\right) r}{\tilde{a}^t\left(a_t^*\right)}\right]^{\sigma-1}. \tag{1.19}$$

Here, $\tilde{a}^t$ defines a weighted average effective input coefficient under taxation; i.e., a measure of the average marginal cost when taking the distortion caused by the arm's length principle into account:

$$\tilde{a}^t\left(a_t^*\right) \equiv \left[\int_0^{a_t^*} \left[\frac{1-t_L}{1-t_H} a_i - \frac{t_H - t_L}{1-t_H} r\right]^{-(\sigma-1)} dG\left(a\right)\right]^{-\frac{1}{\sigma-1}}. \tag{1.20}$$

Comparing equations (1.10) and (1.19), and noting that $\tilde{a}^t(a_t^*) \leq \tilde{a}(a^*)$, we find that $n_o^t < n_o$. Intuitively, the number of outsourcing firms falls for two reasons. First, some firms integrate that would buy the input on the market in the absence of taxes. In addition, some outsourcing firms exit the market because demand is shifted away from their varieties to products manufactured by multinationals who are induced to set lower prices by the taxation at arm's length.

The increase in the mass of MNEs cannot compensate the market exit by outsourcing firms. The change in the overall mass of firms can be seen in the change of the price index, which is a decreasing function of the total mass of active firms. As prices either do not change (outsourcing firms) or decrease (MNEs) due to taxation, the fact that $P_t > P$ (see eq. 1.16) thus implies that the overall mass of firms falls. We summarize these findings in the following proposition:

**Proposition 1.2 (Composition and mass of active firms)** *Compared to a world without taxes, arm's length taxation under an exemption system leads to more multinationals and fewer outsourcing firms. Overall, the mass of firms (of available consumer products) falls.*

**Proof.** See Appendix A.2. ■

Next, we delve deeper into the effects of profit taxation on equilibrium prices and quantities, which we gather in the following proposition:

**Proposition 1.3 (Price and quantity effects of arm's length taxation)** *Relative to the no-tax benchmark, arm's length taxation under an exemption system raises the equilibrium output/size of multinational and outsourcing firms, reduces the prices charged by MNEs, and leaves the prices charged by outsourcing firms unaffected. The price reduction by MNEs is more pronounced if the tax rate differential, the arm's length price, or the productivity of the MNE's subsidiary is higher.*

**Proof.** See Appendix A.2. ■

MNEs reduce consumer prices in response to taxation because of an additional effect in their profit maximization. Besides its impact on quantities, the pricing decision now also affects the firm's effective tax rate. This is because the share of profits taxed in the high-tax country is determined by the difference between the consumer price and the transfer price. Other things being equal, by lowering consumer prices, the MNE is able to shift a higher fraction of profits abroad and thus to raise after-tax profits.

The effect on prices is increasing in the tax rate differential ($t_H - t_L$), which acts as a measure of the potential gains from profit shifting. Similarly, a high transfer price $r$ or – from a firm's perspective – possessing a low $a_i$ implies more opportunities to avoid profit taxes and thus leads to lower prices. These channels reinforce each other: the effect of a rise in $t_H$ (a fall in $t_L$) is larger if $t_L$ is low ($t_H$ is high), or if $r$ is large.

Besides the change in prices, sales are affected by an equilibrium change in demand, as captured by the price index (see eq. 1.16). The increase in the price level reinforces the direct effect of taxation, leading to higher sales of all surviving firms. Sales of MNEs increase by more than those of outsourcing firms, as the former actively set lower prices in order to benefit from the profit shifting possibilities which arise due to the arm's length principle. As sales of MNEs increase, and some outsourcing firms become MNEs, the tax system contributes to the rising importance of MNEs.

This section has explained lower input prices paid by MNEs with their superior productivity. In the next section, we will introduce an additional channel, namely that MNEs have a better bargaining position vis-à-vis their suppliers than outsourcing firms.

## 1.3 A Model of Optimal Organization and Incomplete Contracts

In this section, we present the second model, which no longer takes input prices as exogenous but derives them endogenously in a framework of incomplete contracts.

### 1.3.1 Model Setup

The general setup of the model is identical to the one presented above. However, we now consider production in an environment of incomplete contracts where agreements prior to production are subject to ex-post renegotiation. This implies that headquarters and suppliers cannot sign ex-ante enforceable contracts that specify the price of the inputs, similar to Antràs (2003) and Antràs and Helpman (2004). The input price is renegotiated upon production in a Nash-bargain, where the outside options depend on the organizational mode as in Grossman and Hart (1986).

We again implement the arm's length principle by the CUP method. In our model the CUP price equals the price that an outsourcing firm has to pay for the input. We first treat the transfer price as a parameter, but later explore its determination fully in Section 1.3.3.

We consider a one-shot game, where the sequence of events is the following. First, firms decide whether to enter into the product market based on their anticipated future profits. Second, $X$-sector firms choose their organizational form, and all active suppliers produce. Third, $X$-sector firms and their individual suppliers renegotiate input prices. Upon agreement, the produced inputs are released, final production and consumption occur, and profits are realized.

Consumers are modeled as described above in Section 1.2. As there are some changes to the production structure of firms, we characterize again firms' behavior under each of the two alternative organizational forms.

**FDI.** The headquarter produces one unit of the final consumer good from each unit of input. Moreover it incurs a fixed cost, $c > 0$.[32] If the firm decides to become a MNE, it has to establish a foreign subsidiary for input production, which causes an additional fixed cost, $f > 0$. The subsidiary is located in $L$ and produces one unit of the input, $m_i$, with $a_i$ units of labor. The firm-specific input coefficients $a_i$ are distributed according to the distribution function $G(a)$. They are exogenously assigned to each firm and known at the time of market entry.

While the headquarter formally has legal control over its subsidiary, it suffers from the incompleteness of contracts. The payment to the foreign supplier is subject to renegotiation once the input has been produced. Following Antràs and Helpman (2004), we model this as a generalized Nash bargaining with outside options that reflect the specificity of the input and the firm's property rights. We assume an outside option of zero for the supplier, as the input cannot be used by a different firm. The headquarter may seize a fraction $\delta$ [$\in (0, 1)$] of the produced inputs, as it has property rights over it. We assume that, due to the specificity of the input, the headquarter is tied to its supplier and thus cannot resort to a different (outsourcing) supplier.

Denoting an integrated firm's revenues by $R_I$, the per-unit payment to the supplier by $r_I$, and the transfer price for taxation by $\rho$, the firm's surplus for the Nash bargain is

[32] Relative to Antràs and Helpman (2004) we abstract from a variable headquarter input, which is not necessary to show our point.

given by[33]

$$\begin{aligned} S_I^{HQ} &= R_I - r_I m_I - c - f - t_H\left(R_I - \rho m_I\right) - t_L\left(\rho m_I - a_i m_I\right) \\ &\quad - \left[\delta^{\frac{\sigma-1}{\sigma}} R_I - c - f - t_H\left(\delta^{\frac{\sigma-1}{\sigma}} R_I - \rho\delta m_I\right) - t_L\left(\rho\delta m_I - a_i m_I\right)\right] \\ &= \left(1 - t_H\right)\left(1 - \delta^{\frac{\sigma-1}{\sigma}}\right) R_I - r_I m_I + \left(t_H - t_L\right)\left(1 - \delta\right)\rho m_I, \end{aligned} \qquad (1.21)$$

where, from eq. (1.2), revenues are

$$R_I = \mu\left(\frac{m_I}{X}\right)^{\frac{\sigma-1}{\sigma}}. \qquad (1.22)$$

The first line of eq. (1.21) represents the headquarter's profits if it reaches an agreement with the supplier. In the second line, the outcome if negotiations break down is deducted. Profits are taxed according to the exemption system: Foreign profits $(\rho m_I - a_i m_I)$ are taxed in $L$ and exempt from taxation in $H$.[34] The headquarter, as the legal counterparty of the tax authority, is liable for the entire group's tax payments. For simplicity, we again assume that fixed costs are not deductible.

When negotiations break down, the headquarter seizes a fraction $\delta$ of the inputs. Given our demand specification, this implies that the firm's revenues diminish to a fraction $\delta^{\frac{\sigma-1}{\sigma}}$ of equilibrium revenues. Hence, under the outside option, the tax base in $H$ shrinks to $\delta^{\frac{\sigma-1}{\sigma}} R_I - \rho\delta m_I$.

The supplier is unable to sell the inputs to a third party after production, as they are firm-specific. Her surplus is thus given by

$$S_I^S = r_I m_I - a_i m_I - \left[-a_i m_I\right] = r_I m_I. \qquad (1.23)$$

Given the surpluses, the payment to the supplier, $r_I m_I$ is determined by a generalized

[33]The subscript $I$ $(O)$ denotes variables under integration (outsourcing). To simplify the notation, the variety subscript $i$ is dropped except for the firm-specific input cost coefficient $a_i$.

[34]Throughout this chapter, we only look at firms for which $p_I\left(a_i\right) \geq \rho$ holds, thus guaranteeing a non-negative tax base. If the tax base were to become negative for some firms, the tax payments of these firms would be zero, as tax authorities generally do not pay out negative taxes. Alternatively, one could argue that the tax authorities observe the consumer price $p_I$ and would veto any transfer price $\rho$ in excess of $p_I$. Such assumptions are common in the literature, see, for example, Matsui (2012). Here, it spares us the cumbersome case distinction for firms that do not pay any taxes in the high-tax country and focusses attention on the more interesting case of positive tax payments in both countries. As the most productive firms set the lowest prices and are therefore the most likely to have prices below $\rho$, all our results would go through with the case distinction as well.

Nash-bargain, where the headquarter's bargaining weight is given by $\beta$ [$\in (0,1)$]. Maximizing the Nash product $\left(S_I^{HQ}\right)^{\beta} \cdot \left(S_I^S\right)^{1-\beta}$ yields the input price paid to the integrated supplier,

$$r_I = (1-\beta)\left[\left(1-\delta^{\frac{\sigma-1}{\sigma}}\right)(1-t_H)\frac{R(m_I)}{m_I} + (1-\delta)(t_H - t_L)\rho\right]. \tag{1.24}$$

Taxation influences the bargaining outcome twofold. First, it reduces the available surplus. Second, the supplier participates in the firm's gains from a positive cross-country tax differential due to the arm's length principle.

**Outsourcing.** Under outsourcing, the firm sources the input from an independent (stand-alone) supplier in $L$. For simplicity, we assume that competition or imperfect protection of property rights has aligned the production technologies of independent suppliers so that outsourcing firms are homogeneous. Appendix A.3 shows that our main result equivalently applies when we further add heterogeneity in the production technologies of non-integrated suppliers. The foreign supplier obtains one unit of $m_i$ from one unit of labor. As with FDI, the headquarter produces one unit of the final variety with one unit of input after paying the headquarter fixed cost $c$. As the headquarter and the supplier are now separate legal entities, the headquarter pays taxes only in $H$.

The outsourcing firm's surplus in the Nash bargain is

$$S_O^{HQ} = (1-t_H)(R_O - r_O m_O) - c - [-c] = (1-t_H)(R_O - r_O m_O), \tag{1.25}$$

where $R_O = \mu\left(\frac{m_O}{X}\right)^{\frac{\sigma-1}{\sigma}}$ denotes revenues under outsourcing. The headquarter pays $r_O$ to the supplier for each unit of the input. As headquarter and supplier are separate, the headquarter cannot secure any inputs if negotiations break down. In that case, it is left with the sunk fixed cost $c$.

The surplus of the supplier under outsourcing is homogeneous and given by

$$S_O^S = (1-t_L)(r_O m_O - m_O) - [-(1-t_L)m_O] = (1-t_L) r_O m_O. \tag{1.26}$$

As an independent entity, the supplier has to pay the tax in $L$. If negotiations break down, she is unable to sell the input to a different firm due to its specificity. We assume that the production costs are tax deductible, e.g. because they can be offset against other revenues.

Maximizing the Nash product shows that an independent supplier receives a share $(1-\beta)$ of the firm's revenues.

$$r_O = (1-\beta)\frac{R(m_O)}{m_O}. \tag{1.27}$$

Tax payments do not influence this outcome as they are – in the absence of intra-firm trade – proportional to the surpluses.

### 1.3.2 Equilibrium

We solve for the equilibrium by backward induction, starting with the optimal production choices in each organizational form.

**Input production and equilibrium quantities.** Each input supplier produces the quantity of the input that maximizes her profits, anticipating the result of the bargaining game. The respective optimal quantities under outsourcing ($m_O$) and integration ($m_I$) are[35]

$$m_O = \left[(1-\beta)\,\mu\frac{\sigma-1}{\sigma}\right]^{\sigma} X^{-(\sigma-1)}. \tag{1.28}$$

$$m_I = \left[\frac{(1-\beta)\left(1-\delta^{\frac{\sigma-1}{\sigma}}\right)(1-t_H)\,\mu}{a_i-(1-\beta)(1-\delta)(t_H-t_L)\,\rho}\frac{\sigma-1}{\sigma}\right]^{\sigma} X^{-(\sigma-1)}. \tag{1.29}$$

Input quantities are high when the supplier has a high bargaining power (low $\beta$, and, for integrated firms, low $\delta$) or the market is large (high $\mu$). Taxation only affects the production decision of the integrated supplier. A high foreign tax rate induces the integrated suppliers to produce less, as it decreases the tax advantage inherent in using a transfer price above marginal cost (as will be shown in Section 1.3.3). A high transfer price $\rho$ raises the quantity of the input. The effect of changing the home tax rate is ambiguous: while an increase in $t_H$ lowers the available surplus, it also amplifies the tax advantage of using a transfer price above marginal cost. As this tax advantage depends on quantities sold, it constitutes an incentive to increase the production of the input.

[35] To guarantee positive quantities and prices, we make the following technical assumption on the lower bound of the support of $G(a)$: $a > (1-\beta)(t_H-t_L)(1-\delta)\frac{\sigma}{\sigma-1} \equiv \underline{a}$.

Using eq. (1.2), these input quantities immediately translate into consumer prices.

$$p_O = \frac{\sigma}{\sigma - 1} \frac{1}{(1-\beta)}. \tag{1.30}$$

The prices charged by outsourcing firms do not depend on the level of taxes, as is to be expected with a profit tax that applies equivalently to a firm's revenues and costs.

For integrated firms, however, taxation distorts the pricing decision.

$$p_I = \frac{\sigma}{\sigma - 1} \frac{a_i - (1-\beta)(1-\delta)(t_H - t_L)\rho}{(1-\beta)(1-\delta^{\frac{\sigma-1}{\sigma}})(1-t_H)}. \tag{1.31}$$

Again, two effects are at work. The tax term in the numerator captures the incentive to sell more: This lowers the effective tax rate as the transfer price $\rho$ is larger than marginal cost. At the same time, taxation in the home country without full deductability lowers the surplus and thus the incentive to sell, as can be seen in the denominator. More productive MNEs (small $a_i$) set lower prices than less productive firms. An increase in either $\beta$ or $\delta$, which improves the HQ's bargaining position and thus discourages input production by the supplier, reduces quantities and raises consumer prices among MNEs. Improving the deductibility of expenses by raising the transfer price, $\rho$, acts like a per unit production subsidy, whose power is increasing in the tax rate differential.

**Optimal organizational choice and entry.** Anticipating market conditions, each potential entrant chooses its optimal organizational structure ("make or buy") and, foreseeing the suppliers' input production and ensuing profits, decides whether to enter. Only sufficiently productive firms incur the added fixed cost of integration with the supplier to become MNEs. Denoting the cutoff productivity by $a^*$, firms with $a_i \leq a^*$ will integrate whereas firms with higher input coefficients will outsource.[36]

Before considering the cut-off $a^*$, note that, from the point of view of an outside observer, all outsourcing firms behave identically. Therefore, these firms may always enter and realize the corresponding after-tax profit. Since any firm's profits are decreasing in the mass of active firms, entry will drive the profits of outsourcing firms to

[36] We focus on an industry in which fixed costs are such that both outsourcing and integration take place in equilibrium. Denoting after-tax operating profits as $\tilde{\pi}$, this implies that fixed costs $f$ are such that $\tilde{\pi}_I(a^*) - c < f < \tilde{\pi}_I(\underline{a}) - c$. The first half of this condition states that integration may not be profitable for all firms in the market. The second half implies that fixed costs are such that the most productive firms in the market realize strictly positive profits when integrated. If this condition is not met, the arm's length principle is not applicable as there are either no intra-firm transactions, or no comparable market transactions which can be used as a benchmark.

zero. In equilibrium, using the bargaining outcome in (1.27) together with eq. (1.28), we obtain the aggregate industry quantity $X$ from $\pi_O^{HQ} = (1-t_H)(R_O - r_O m_O) - c = 0$:

$$X = \frac{\sigma - 1}{\sigma} \left( \frac{(1 - t_H)\,\beta}{c} \right)^{\frac{1}{\sigma - 1}} (1 - \beta)\, \mu^{\frac{\sigma}{\sigma - 1}}. \tag{1.32}$$

As $\mu = PX$, both the aggregate industry quantity and the price index are fully determined by free entry into outsourcing - and thus independent of the distribution of productivities $G(a)$ and of the transfer price $\rho$. The price index is increasing in overhead costs $c$ because they reduce the mass of active firms. It is lower in larger markets (as measured by $\mu$), as they induce additional firm entry.

While all outsourcing firms realize zero profits, MNEs are able to realize positive profits as they can produce the input more efficiently in an integrated subsidiary. Thus, headquarters choose to integrate when they are sufficiently productive to pay the additional fixed cost of integration. Hence, the cut-off for integration is implicity defined by $\pi_I^{HQ}(a^*) = \pi_O^{HQ} = 0$. The optimal organizational form is characterized in

**Lemma 1.2 (Optimal organization with endogenous input prices)** *Firms with $a_i < a^*$ become MNEs while firms with $a_i \geq a^*$ source the input from the market. The cost cutoff $a^*$ rises in the transfer price, $\rho$, and falls in the added fixed cost of integration ($f$).*

**Proof.** See Appendix A.4. ■

These properties are immediately intuitive: As the elevated transfer price $\rho$ has effects similar to those of a production subsidy, it forms an additional incentive to become a MNE. If the fixed costs of integration $f$ rise, outsourcing becomes more attractive.

The organizational form is robust to changes in the underlying productivity distribution. Innovations in the production technology, measured e.g. by a shift in the mean of $G(a)$, thus leave the cutoff for outsourcing unaffected. This is because, in our model, such changes are perfectly accommodated by entry into outsourcing.

### 1.3.3 Effective Tax Burden Under Arm's Length Taxation

In this section, we analyze firms' tax burdens to address the stylized fact proposed in the introduction: that multinational firms pay systematically less tax (relative to their profits) than firms without foreign affiliates. We determine the transfer price $\rho$

endogenously and use it to compare effective tax rates between outsourcing firms and MNEs.

Effective tax rates are given by a firm's tax payments per unit of operating profits. For an outsourcing firm, which pays taxes only in the high-tax country $H$, the effective tax rate is given by

$$t_O^{eff} = \frac{t_H \left(R_O - r_O m_O\right)}{R_O - r_O m_O} = t_H. \tag{1.33}$$

In contrast, the effective tax rate of an integrated firm is (using $R_I = p_I m_I$)

$$t_I^{eff} = \frac{t_H \left(R_I - \rho m_I\right) + t_L \left(\rho m_I - a_i m_I\right)}{R_I - a_i m_I} = t_H - \left(t_H - t_L\right) \frac{\rho - a_i}{p_I - a_i}. \tag{1.34}$$

The tax burden of MNEs depends on the tax rate differential and on the transfer price, $\rho$.[37] As explained in the introduction, the arm's length price is used as transfer price, as governments cannot observe the true cost of the input.[38] This is the price that would have been paid to the supplier if the two parties were not related. We first consider taxation if such a firm-specific, "ideal" transfer price could be utilized. In a second step we look at the distortions caused by implementing the arm's length transfer price with the CUP method.

In our model, the "ideal" arm's length price is the price a headquarter would have paid an independent supplier with the "integrated" input cost $a_i$. Using eqs. (1.22) and (1.28) in (1.27) and setting the input cost to $a_i$, this "ideal" arm's length price is

$$\rho_i^{IDEAL} = \frac{R\left(a_i\right)\left(1 - \beta\right)}{m_O\left(a_i\right)} = \frac{\sigma}{\sigma - 1} a_i. \tag{1.35}$$

Hence, in principle, the arm's length price is a firm-specific price. In this idealized case, it fully accounts for productivity difference among firms. Note that the arm's length transfer price $\rho$ is always higher in industries with a lower elasticity of substitution, as the imperfect competition increases the revenues that are shared between headquarter

[37]If the two countries start coordinating their tax policies so that the tax rate differential decreases, tax burdens of MNEs and outsourcing firms converge.

[38]In theory, input cost could be inferred from observed consumer prices. To avoid this, we assume that $\beta$ is not accurately observed by the tax authority. Alternatively, we could impose that tax authorities only observe prices with noise, and cannot distinguish between marginal cost and demand shocks; or, in the extension with transfer price manipulation below (Section 1.4), that the innate costs of undertaking tax evasion are private information. We thank an anonymous referee for stressing this prerequisite.

and supplier.[39] Even with this "ideal" arm's length price, MNEs are taxed at a lower rate than outsourcing firms:

$$t_I^{eff}(\rho_i^{IDEAL}) = t_H - (t_H - t_L)\frac{\frac{1}{\sigma-1}a_i}{p_I(\rho_i^{IDEAL}) - a_i} \quad < t_H = t_O^{eff}. \tag{1.36}$$

The lower tax burden of MNEs arises because the transfer price is higher than the marginal cost of input production. To incentivize the supplier, the outsourcing firm has to pay her an input price above marginal cost. This mark-up translates into an elevated transfer price due to the arm's length principle. Thus, the headquarter will, in equilibrium, shift some profits to the low-tax country. This tax advantage depends on the amount of the good that is produced. Therefore, even with this "ideal" transfer price, more productive firms gain more from the arm's length principle, as they have higher sales.

The profit shifting opportunities of most MNEs are even more enlarged when we consider that, in reality, the "ideal" arm's length price cannot be observed and thus has to be approximated by other values. As detailed in the introduction, it is common to use market prices for the same input (the CUP method of implementing arm's length prices). In this model, the CUP transfer price is the price that any outsourcing firm in the market pays its supplier, i.e.

$$\rho^{CUP} = r_O = \frac{\sigma}{\sigma - 1}. \tag{1.37}$$

The implementation of the arm's length principle via the CUP method introduces an additional distortion as it ignores the productivity differences among firms. If an integrated supplier has lower production cost than a stand-alone supplier, the CUP transfer price for this firm is higher than the "ideal" arm's length price would be. Using $\rho^{CUP}$, the effective tax rate of MNEs is

$$t_I^{eff}(\rho^{CUP}) = t_H - (t_H - t_L)\frac{\left(\frac{\sigma}{\sigma-1} - a_i\right)}{p_I(\rho^{CUP}) - a_i} \quad < t_I^{eff}\left(\rho_i^{IDEAL}\right) \text{ if } a_i < 1. \tag{1.38}$$

If $a_i < 1$, $\frac{\sigma}{\sigma-1} - a_i > \frac{1}{\sigma-1}a_i$ and, as $\rho^{IDEAL} < \rho^{CUP}$, $p_I^{CUP} < p_I^{IDEAL}$. Therefore, all MNEs with a true cost advantage (i.e. $a_i < 1$) face an even lower effective tax rate when the transfer price is approximated via CUP.

[39] In his analysis of a welfare-maximizing transfer price, Matsui (2012) finds that tax authorities should relax the price standards if the elasticity of substitution decreases. Our analysis shows that this characteristic is inherent in the arm's length standard.

As the CUP transfer price is based on observed transactions in the market, it ignores systematic productivity differences between MNEs and firms that decided against integration. Consider an industry with sufficiently high fixed costs of integration so that all MNEs are more productive than the market (i.e. so that $a^* \leq 1$ holds).[40] Then, the implementation of the arm's length principle via the CUP method leads to an even lower tax burden of MNEs. It is caused by the difference between the input production cost of an independent supplier, on which the transfer price is based, and the lower input cost of the more productive integrated supplier. This tax advantage of MNEs inherent in the higher productivity of these firms is largest for the most productive firms. Thus, the well-established observation that very productive firms become multinationals directly implies that they face a lower effective tax rate.

We summarize the results on MNEs' tax burden in the following proposition:

**Proposition 1.4 (Tax burden of MNEs)**

*(i) Under an exemption system, MNEs face a lower tax burden relative to their profits than outsourcing firms if the "ideal" arm's length price is used as transfer price.*

*(ii) An approximation of the arm's length transfer price via the CUP method reinforces this effect for MNEs with $a_i < 1$.*

*(iii) More productive firms face a lower effective tax rate under both the "ideal" and the CUP transfer price.*

**Proof.** See Appendix A.5. ■

The lower tax burden of MNEs results as the transfer price is higher than the marginal cost of input production. The mark-up inherent in the transfer price arises because the arm's length principle ignores fundamental differences between multinational and domestic firms. These disparities may arise from the bargaining, or from productivity advantages, or both. The result of a lower tax burden for MNEs generally holds also if only one of the two sources of elevated arm's length prices is present. For the optimal

[40] Note that in general, not necessarily *all* MNEs are more productive than outsourcing firms. Integration not only allows firms to produce with their inherent productivity $1/a_i$, but also brings the advantage of a better bargaining position and lower tax payments. It therefore depends on the additional fixed cost of integration, $f$, whether all integrated firms have a true productivity advantage (i.e. $a^* \leq 1$). This ambiguity does not arise in the alternative specification in Appendix A.3, in which all suppliers are heterogeneous.

organization this has been already shown in the first model (Section 1.2). It is also robust to a different specification of the effective tax rate.[41]

Our model thus provides a new explanation for well-known empirical observation of lower tax payments of multinational firms. Previously, the common explanation was that firms strategically misprice cross-border transactions (i.e. manipulate transfer prices or intra-firm debt) to shift profits into low-tax jurisdictions.[42] While our model offers a different explanation, this does not imply that no tax evasion takes place.

A major possibility for MNEs to actively reduce tax payments is by manipulating transfer prices. Explanations based on such activities are complementary to the implicit profit shifting that results from the optimal organization of production, as the next section shows.

## 1.4 Extension to Transfer Price Manipulation and Discussion

In this section, we provide a link to the literature on transfer price manipulation by including this practice in our model and discuss some of our key assumptions. The consequences of transfer price manipulation are similar in the two models presented in this chapter. Therefore, the following uses the second model (Section 1.3); the corresponding analysis in the first model framework is provided in Appendix A.7.

Allowing for transfer price manipulation, the profit function of a MNE is

$$\hat{\pi}_i = \hat{R}_I - \hat{r}_I \hat{m}_I - c - f - t_H \left[\hat{R}_I - (1+\alpha)\,\rho \hat{m}_I\right] - t_L \left[(1+\alpha)\,\rho \hat{m}_I - a_i \hat{m}_I\right] - \alpha^2 \gamma \hat{m}_I, \tag{1.39}$$

where $\alpha$ measures the extent of transfer price manipulation and $\gamma$ is a factor that scales the cost of tax evasion. Manipulating the transfer price comes at a convex cost, which we presume, for simplicity, to have quadratic form.[43] Our analysis in the previous section can thus be seen as the limiting case where $\gamma \to \infty$. We assume that the

[41] Instead of looking at the whole MNE's profit and tax payment, it is also possible to focus on its activities in $H$ and consider its tax payments in $H$ relative to the headquarter's profit. Appendix A.6 shows that this does not change the results and points out that not only marginal cost, but also the bargained input price is lower than the transfer price (due to the better outside option of MNEs).

[42] See e.g. Haufler and Schjelderup (2000) or Egger and Seidel (2011).

[43] This way of modeling transfer price manipulation follows Egger and Seidel (2011) and others.

amount of transfer price manipulation is decided after the headquarter has obtained the input, and that the headquarter is unable to credibly commit to a different level of transfer price manipulation in the bargaining.

Since transfer price manipulation requires intra-firm transactions, the profits of an outsourcing firm are as before. Therefore, as the decision variables of outsourcing firms are as in the main model, we focus on integrated firms in the following. Solving backwards we first determine the optimal degree of transfer price manipulation by the MNE before considering the bargaining. Given our assumption on manipulation costs, it is always optimal to artificially increase transfer prices at the margin ($\alpha > 0$), as this lowers the effective tax burden:

$$\alpha^* = \frac{1}{2\gamma} \left(t_H - t_L\right) \rho. \tag{1.40}$$

The optimal degree of transfer price manipulation equates the marginal cost of transfer price manipulation, $2\alpha\gamma$, with its benefits, $\left(t_H - t_L\right) \rho$, which are increasing in the tax rate differential and the transfer price recognized in the absence of manipulation effort. Thus, $\alpha$ and $\rho$ are complementary.

The price for the input, $\hat{r}_I$, is again determined by Nash bargaining. The only difference in the bargaining is that the headquarter's surplus now depends on the costs and benefits of credibly claiming a manipulated transfer price recognized by the tax authority. The supplier anticipates this transfer price manipulation. Maximizing the Nash product, the internal transfer price is given by

$$\hat{r}_I = (1-\beta) \left[ \left(1 - \delta^{\frac{\sigma-1}{\sigma}}\right) (1 - t_H) \frac{\hat{R}\left(\hat{m}_I\right)}{\hat{m}_I} + (1-\delta)(1+\alpha)\left(t_H - t_L\right) \rho - (1-\delta)\, \alpha^2 \gamma \right]. \tag{1.41}$$

Eq. (1.41) reflects the rise in the surplus brought about by additional profit shifting, which lowers the MNE's tax burden, and the surplus-reducing manipulation costs. As $\alpha$ is chosen after the supplier's remuneration is determined, the supplier participates in both costs and benefits, with a share given by its bargaining weight $(1-\beta)$. In equilibrium, with the headquarter trading off costs and benefits of transfer price manipulation, transfer price manipulation lowers the per-unit payment to the supplier ($\hat{r}_I \leq r_I$), as the supplier herself chooses to increase quantities in response to the higher overall after-tax surplus.[44]

[44] For a formal proof of this and the following statements on transfer price manipulation, see Appendix A.8.

The net benefit of tax evasion incentivizes the supplier to optimally increase the supplied quantity of the input to

$$\hat{m_I} = \left[ \frac{(1-\beta)\left(1-\delta^{\frac{\sigma-1}{\sigma}}\right)(1-t_H)\,\mu}{a_i - (1-\beta)(1-\delta)(1+\alpha)(t_H - t_L)\rho + (1-\beta)(1-\delta)\alpha^2\gamma} \frac{\sigma-1}{\sigma} \right]^{\sigma} (X)^{-(\sigma-1)}. \tag{1.42}$$

To see that $\hat{m_I} \geq m_I$, note that $X$ is exclusively determined by outsourcing firms and that the supplier participates proportionally in both the cost and benefits of transfer price manipulation.

Furthermore, as can be verified from eqs. (1.42) and (1.2), positive transfer price manipulation reduces consumer prices charged by MNEs, since the amount of tax they can evade increases with each unit sold. This effect is stronger when the cost of transfer price manipulation $\gamma$ is low, or the statutory transfer price $\rho$ is high.

It is now straightforward to see that manipulation of transfer prices decreases the effective tax rate of multinationals to

$$\hat{t}_I^{eff} = t_H - (t_H - t_L)\frac{(1+\alpha)\rho - a_i}{\hat{p}_I - a_i}. \tag{1.43}$$

By providing an additional possibility to raise the transfer price, transfer price manipulation thus multiplies the tax-reducing impact of taxation at arm's length. This larger tax advantage also makes it more attractive to organize as a MNE (i.e. $\hat{a}^* \geq a^*$).

We summarize the added implications of transfer price manipulation in the following proposition:

**Proposition 1.5 (Implications of transfer price manipulation)** *If MNEs can manipulate transfer prices, their effective tax rates fall. There are more integrated firms, which set lower consumer prices and produce larger quantities than in the benchmark without manipulation. The behavior of outsourcing firms is unaffected.*

**Proof.** See Appendix A.8. ■

The empirical evidence of lower tax payments of MNEs (relative to purely domestic firms) is compatible with both the manipulation of transfer prices and the effect of taxation at a gorilla's arm's length, as they are complementary. However, policy conclusions differ. Importantly, we find that tightening transfer price regulations (increasing $\gamma$) may help to reduce tax evasion, but cannot be expected to even out the tax burden between domestic and multinational firms.

We conclude our analysis by briefly discussing the robustness of our main results with respect to some basic assumptions. First, we have employed a highly simplified production structure, where final good production at a MNE's headquarter is modeled exclusively via fixed costs ($c$). This, however, is innocuous: Under a more elaborate production structure, including a potentially firm-specific production function, the effect of taxation at a gorilla's arm's length remains present as long as the MNE has a cost advantage of some sort in the procurement of the input from abroad.

Second, we have focussed on MNEs whose headquarters are located in the high-tax country. But what about final good producers located in the low-tax country? Consider their alternatives for procuring the input: They can either buy it from the market, or produce it in a subsidiary either at home or abroad. However, given that the other country offers the same wage (i.e. identical production cost) but has a higher tax rate, firms in the low-tax country have no incentive to become a MNE, but will instead produce the input in a subsidiary at home. The case analyzed in our model – with MNEs being headquartered in high-tax countries in Europe or in Japan – is also empirically the most relevant, see Voget (2011).

Lastly, our underlying argument continues to hold if the arm's length price is implemented in a different manner. For example, consider the "comparable profit method", which is discussed in the literature e.g. in Schjelderup and Weichenrieder (1999). It allows tax authorities to tax a MNE's subsidiary on a deemed profit of e.g. 75% of a domestic firm's profit in the same industry. However, given that MNEs are more productive, they realize higher profits than comparable domestic firms. Thus, also this method of implementing the arm's length principle implies an inherently lower tax burden of MNEs.

In all these different specifications, the common reason for the lower tax payments by MNEs is that the arm's length principle ignores the underlying reasons why some firms choose to organize as MNEs while others do not. It follows immediately from the presence of fixed costs that, for firms to optimally choose FDI over foreign outsourcing, variable costs of MNEs usually fall short of variable costs of outsourcing. This is the essence of sorting, which has systematically been shown in the new international trade literature (see Antràs and Helpman (2004) and Helpman et al. (2004), among others). Moreover, integration itself causes MNEs to behave differently, as it gives them more bargaining power. This, too, is disregarded by the arm's length principle.

Thus, Propositions 1.1 and 1.4 hold in a wide range of possible specifications of heterogeneity in production or the quality of the consumer product, as well as for different specifications for the behavior of tax authorities off equilibrium where renegotiations break down.

## 1.5 Conclusion

We hope to contribute to explaining why MNEs pay systematically less tax than domestic firms. Focussing on the endogenous organizational choice of international enterprises, our model complements existing mechanisms for profit shifting, which usually build on the notion that MNEs are able to manipulate transfer prices. In our framework, profit shifting occurs even when MNEs perfectly comply with the tax code. The fact that transfer price regulation has tightened substantially over the last decades, while tax burden differentials between MNEs and domestic firms appear to remain substantial, seems to support this view.

The focus of this chapter is on positive economic analysis, as it provides a new explanation for a well-known empirical observation. However, it is also worthwhile to see which normative inferences can be drawn from our model. It cautions against the use of costly policies to hamper transfer price manipulations, as it is not clear to what extent the comparatively low tax payments by MNEs are due to such manipulations. Cost-benefit analysis of anti-avoidance measures has to take into account that only one part of empirically observed profit shifting can be addressed by these policies. As such measures usually imply efficiency or monetary losses for the firms, they should be employed cautiously as tax payments are likely to remain low even if MNEs perfectly adhere to the tax code.

A second normative question that arises from this chapter is the desirability of the arm's length principle for taxation in general. The next chapter considers one aspect of this question in more detail. It asks whether it can be justified from a welfare perspective to tax highly productive firms less. The answer depends on the extent of international tax competition: If tax competition is moderate, i.e. profits can be taxed relatively highly, it is indeed optimal to favor highly productive firms.

However, if one comes to the conclusion that the favorable treatment of highly productive firms is undesirable (for welfare or perhaps political reasons), it remains to discuss alternatives to the arm's length principle for the taxation of multinational firms. In a tax system based on separate accounting, there is no clear alternative. Using firm's marginal cost or internal input prices does not seem feasible, as such unobservable values would be overstated by MNEs to lower their tax payments. Therefore, the inherent limitations of the arm's length principle provide an argument against separate accounting in general. The alternative is a tax system based on formula apportionment, where the profit of the MNE as a whole is calculated and then split between countries depending on the location of the firm's capital, labor and sales. Under formula apportionment, transfer pricing rules are thus no longer necessary. Such a proposal has been made for the European Union (see European Commision, 2011). The distortions inherent in arm's length transfer pricing, as shown in this article, provide a further argument to pursue this alternative approach to the taxation of MNEs.

# Chapter 2

# Should Tax Policy Favor High- or Low-Productivity Firms?

## 2.1 Introduction

Corporate taxes do not fall equally on all firms, but affect firms of varying size and productivity in different ways. Such asymmetries arise for several reasons. An example is the unequal treatment of profits and losses in the tax law. It discriminates against small firms, as they can only offset losses against uncertain future income, whereas large firms can offset losses in some product lines against profits in others (Mirrlees et al., 2011).[1] Furthermore, corporate tax noncompliance rises with firm size (Hanlon et al., 2007). This also implies lower effective tax rates for larger firms. Moreover, large, productive firms are more likely active internationally (Helpman et al., 2004) and thus able to shift profits to exploit international tax differences in a tax-minimizing way.[2]

All these features of tax systems suggest that large firms pay lower effective tax rates than small firms. A possible rationale for this discrimination in tax policy is that larger firm size is empirically correlated with higher productivity and higher wages (Oi

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This chapter is based on joint work with Andreas Haufler and Christian Bauer (Langenmayr et al., 2012).

[1]Auerbach (2007, Table 4) documents the quantitative importance of this effect for the United States. Corporations reported annual losses of 350-400 billion USD in aggregate in each of the years 2001-2003, representing roughly two thirds of positive corporate profits in the same years.

[2]See e.g. Huizinga and Laeven (2008) for a recent and detailed analysis of profit shifting. Relevant channels for profit shifting include, for example, international debt shifting (Desai et al., 2004), and the allocation of patents (Dischinger and Riedel, 2011).

and Idson, 1999).[3] Thus, firm heterogeneity raises the question of whether countries should pursue 'pick-the-winner' strategies, that is, tax-discriminate in favor of large, productive businesses as a means to divert production towards the most productive firms.

This essay addresses this issue. We derive the optimal pattern of capital taxes when effective tax rates can vary for firms with different productivities and profit taxation is limited by international tax competition. In this setting we show that offering tax preferences to more productive firms may indeed be optimal, but the case for such tax preferences is systematically reduced as economic integration proceeds and tax competition becomes more aggressive.

We derive this argument in a small open economy model where firms in an oligopolistic sector produce at two different cost or productivity levels. The government may differentiate the tax base according to the different cost levels, so that the resulting effective tax rates can differ between low-cost and high-cost firms. In addition to the tax bases, the small country chooses a uniform profit tax rate, but it is constrained in this choice by international tax competition. We incorporate tax competition in a simple way, replicating the well-known result that economic integration reduces the equilibrium level of the corporate profit tax. In this set-up the optimally differentiated tax policy results from the trade-off between raising the aggregate productivity by shifting production to the low-cost firms, and the incentive to indirectly tax foreign-owned profits via a broader tax base, which raises more revenue when applied to the low-cost firms.

Our main result is that the optimal solution to this trade-off depends critically on the rate of profit taxation that is feasible in the presence of tax competition with an outside tax haven. Granting tax advantages to the low-cost, multinational firms turns out to be the optimal policy when tax competition is moderate and the possibility to tax the resulting profits is accordingly high. In contrast, when tax competition from the tax haven is aggressive and the feasible rate of profit taxation is low, the pattern of discrimination is reversed and a broader tax base is applied to high-productivity firms. These results are shown to hold for both quantity and price competition among firms, and for different assumptions about firm ownership.

[3] Productivity differences between firms have been at the core of recent empirical and theoretical research in international trade. This research stresses that more productive firms self-select either into the export market (Melitz, 2003), or into foreign direct investment (Helpman et al., 2004), and that they are larger in equilibrium than less productive firms.

In sum, our analysis thus predicts a fall in the tax advantages of large, productive multinational enterprises (MNEs) as a result of economic integration and tighter corporate tax competition. And indeed, recent developments in tax policy seem to point in this direction. One well-noted trend is the substantial fall in statutory corporate tax rates: Among the OECD members corporate tax rates averaged around 50% in the early 1980s, but this average has fallen to 30-35% by 2010 (OECD, 2012b). A similar trend can also be observed in less-developed parts of the world (Klemm and van Parys, 2012). There is a widespread consensus in the literature that one of the key factors in explaining this development is the international competition for mobile capital, firms and profits.[4]

At the same time, many countries have recently undertaken unilateral measures aimed at limiting the tax advantages of multinational firms. A first example is the proliferation of thin capitalization rules, which restrict the ability of MNEs to engage in international debt shifting. In the mid-1990s less than one half of all OECD members had adopted thin capitalization rules, but this share has risen to roughly two thirds in 2005 (Buettner et al., 2012, Table 1).[5] A second example is the number of large-scale state investment subsidies offered to multinational firms in Europe, which has peaked in the early 2000s and has dropped significantly since then (Haufler and Mittermaier, 2011, Table 1). A third example comes from less-developed countries, where tax holidays – periods of reduced or no profit taxation – are a major policy measure to attract FDI. In a broad sample of countries, the average length of tax holidays has fallen from more than four years in the late 1980s to around 2.5 years in 2005 (Klemm and van Parys, 2012, Fig. 1).

The coexistence of these seemingly opposing trends is particularly noteworthy, because one would expect that increasing competition for mobile, multinationals firms would lead to *more*, not fewer, tax advantages for MNEs. The existing literature on discriminatory tax competition has indeed argued that governments will discriminate in favor of those tax bases that display the highest degree of international mobility. In contrast, this chapter shows that reduced tax advantages for profitable multinationals can be the optimal policy response to economic integration when tax discrimination

[4]See Devereux et al. (2008) for econometric evidence and Auerbach et al. (2010) for a recent survey.

[5]The German corporate tax reform of 2008 is a prominent example for a reform explicitly aimed at limiting the tax advantages of MNEs. It reduced the German corporate tax rate and simultaneously introduced a rigorous ceiling on the tax-deductibility of interest payments, which was tailored so as to apply exclusively to highly profitable, multinational firms.

is instead based on productivity differences between firms. Our analysis thus offers a rationale for the above-mentioned recent trends in corporate tax policy, which cannot be explained by existing paradigms.[6]

Our analysis is related to several strands of previous research. A first strand is the literature on preferential tax regimes. Janeba and Peters (1999) and Keen (2001) compare discriminatory and non-discriminatory tax competition in a setting with two tax bases that differ in their degree of international mobility. Peralta et al. (2006) ask under which conditions countries may have an incentive to tax-discriminate in favor of MNEs by not monitoring international profit shifting. More recently, several papers have analyzed - with diverging conclusions - the role of tax havens, which allow countries to tax-discriminate in favor of internationally mobile firms (Slemrod and Wilson, 2009; Hong and Smart, 2010). In all these papers, equilibrium patterns of tax differentiation arise from differences in the international mobility of tax bases, whereas productivity differences between firms are ruled out.

A second related literature strand considers tax and subsidy competition in settings with heterogeneous firm productivity. Some articles in this area model the competition for internationally mobile firms (e.g. Davies and Eckel, 2010; Haufler and Stähler, 2013), whereas others focus on profit shifting (Krautheim and Schmidt-Eisenlohr, 2011) or entry subsidies (Pflüger and Suedekum, 2013). None of these papers, however, allows for taxes or subsidies that differ between the heterogeneous firms.

Also relevant to our setting is the recent literature on industrial policy. Aghion et al. (2012), for example, show that subsidies to sectors with intense competition foster productivity and innovation. In their model, however, the differentiation of policies depends on the market structure in different sectors, not on the productivity of individual firms. Finally, Gersovitz (2006) derives the optimal pattern of income and consumption taxes when both have differential effects on firms with varying productivity. He does not tie his results to the effects of tax competition, however, and many of his findings have to rely on simulation results.

The plan of this chapter is as follows. Section 2.2 lays out our benchmark model in which heterogeneous firms are taxed by a general corporate profit tax which is applied to differentiated tax bases. Section 2.3 derives the market equilibrium. Section 2.4

[6]We do not claim, of course, that mobility-based approaches to discriminatory tax competition are unimportant. For example, a recent development in several EU countries, including the United Kingdom and the Benelux countries, is to offer significantly reduced tax rates for knowledge-intensive firms. This preferential tax treatment is clearly driven by the high international mobility of intellectual capital. For an analysis of these so-called 'patent boxes', see Griffith et al. (2012).

analyzes the optimal structure of capital taxes and relates this pattern to the degree of economic integration. Section 2.5 discusses the robustness of our results. Section 2.6 concludes.

## 2.2 The Benchmark Model

We study a small open economy that produces and consumes two homogenous goods, $X$ and $Y$. Firms in the $Y$ industry (the numeraire sector) are homogenous and operate under perfect competition. The $X$ sector has an oligopolistic market structure and the firms producing in this sector differ with respect to their unit cost. Consumers in the small economy hold a total endowment of $K$ units of capital, which is the only variable input in the production of both goods. Producing one unit of $Y$ requires $1/r$ units of capital. Capital and the numeraire $Y$ can be freely traded internationally at the fixed world interest rate $r$.[7]

The focus of our analysis lies on the corporate tax structure that the small country's government applies to the heterogeneous firms in the $X$ sector. To keep the model as simple as possible, we assume that good $X$ is a non-traded good. This assumption ensures that corporate tax policy directly affects the domestic market equilibrium, without incorporating the attenuating effects arising from import and export markets. It is well-known from the literature that the effects of domestic tax policies are qualitatively similar when costly international trade is permitted.[8]

### 2.2.1 Consumers

Consumers are homogeneous. A quasilinear utility function represents their preferences over the two private goods $X$ and $Y$:

$$U = aX - \frac{1}{2}\, bX^2 + Y^D, \tag{2.1}$$

where $Y^D$ is the quantity demanded of the numeraire, and $a, b > 0$ are parameters.

[7] Free trade in both $Y$ and $K$ implies that the model does not specify where the numeraire good is produced. This, however, is immaterial for all our results.

[8] As a result of transport costs, foreign-produced goods remain more expensive than domestically produced goods. Thus a setting with costly international trade maintains the motive for tax policy to expand domestic production in an imperfectly competitive market and to increase domestic consumer surplus (see e.g. Haufler and Wooton, 2010).

Utility maximization is subject to the budget constraint $Y^D + pX \leq I$, where $p$ is the price of good $X$ in the small country. To determine national income $I$, we need to specify the international allocation of profits. In our benchmark model we assume that all profit income in the $X$ industry accrues to foreigners.[9] National income is then

$$I = rK + T, \tag{2.2}$$

where $rK$ is the exogenous capital income of the small country's representative consumer and $T$ is tax revenue, which the government redistributes to the consumer as a lump-sum payment. Utility maximization yields linear demand functions

$$X = \frac{a - p}{b}, \qquad Y^D = I - pX, \tag{2.3}$$

which imply that all income changes affect only the demand for the numeraire good $Y$.

### 2.2.2 Producers

In the oligopolistic $X$ sector, there is an exogenously given number of $n$ potential entrants ('firms'). Each of these firms possesses one unit of a specific factor, labelled 'intellectual property' (such as a license or patent), which it can employ profitably in the imperfectly competitive industry. This factor is indispensable for the production of good $X$ but is limited in availability. Consequently, at most $n$ firms can engage in the production of good $X$. Since the number of firms is exogenously constrained, pure profits are earned by the owners of the fixed factor. As we discussed earlier, we assume in our benchmark model that this factor is fully owned by foreigners.

Production of good $X$ additionally requires capital as the only variable factor of production. Firms in the industry are heterogeneous, differing in their (exogenous) capital requirement per unit of good $X$. For reasons of concreteness and tractability, we assume that there are only two possible levels of unit capital requirements, $c_L$ and $c_H$, where the indices $L$ and $H$ respectively denote a low-cost and a high-cost firm. This simplifying assumption allows us to derive closed-form solutions for all variables. Differing input requirements translate into different unit costs of the two firm types, given by $c_L r$ and $c_H r$, respectively.

Due to the existence of pure profits, firms with different variable costs can co-exist

[9] This assumption is relaxed in Section 2.5, where we introduce domestic ownership of profit income.

in equilibrium. In total, there are $n_L$ low-cost firms and $n_H$ high-cost firms, with $n_H + n_L = n$. The output of a firm of type $i$ is denoted by $x_i$, so that industry output $X$ is

$$X = n_L x_L + n_H x_H. \tag{2.4}$$

We assume that firms in the $X$ sector engage in quantity competition.[10] In equilibrium, a low-cost firm will produce more output than a high-cost firm. We will therefore also refer to the low-cost and the high-cost firms as 'large firms' and 'small firms', respectively. Moreover, we will also interpret the low-cost firms as multinational firms and the high-cost firms as national firms. This follows the empirical and theoretical results from the international trade literature that multinational firms are more productive, on average, than national firms (Helpman et al., 2004). The distinction between multinational and national firms will become important when we introduce international profit shifting opportunities below.

To simplify notation, we normalize $c_L \equiv 1$ and define the capital requirement of high-cost firms as $c_H \equiv 1 + \Delta$ (with $\Delta > 0$). Our analysis focuses on the case where the productivity gap $\Delta$ is sufficiently small (relative to the firm's profit opportunities) so that even the high-cost firms make positive profits in equilibrium. This condition is derived in Appendix B.1. In the absence of government intervention, all firms will therefore produce. As a result of government policy, the high-cost firms may, however, anticipate negative profits and thus choose not to enter the market. In this case only the $n_L$ low-cost firms remain active in the market.

### 2.2.3 Government

The government of the small country taxes profits at the statutory corporate tax rate $t$, which applies uniformly to all firms. In addition, the government decides on the share of capital costs $\delta_i$ that is deductible from the corporate tax base. These tax base deductions will generally affect the two firm types differently. Larger low-cost firms may, for example, use loss offset provisions more effectively, or they may (in the interpretation as a MNE) be able to engage in financial arbitrage transactions

[10] In Section 2.5 we analyze an alternative market structure where goods are differentiated and firms compete over prices. We show there that this setting yields the same qualitative conclusions as the homogeneous Cournot model.

that permit them to deduct a larger share of their capital costs.[11] The reverse type of tax discrimination is also possible, however, when small, high-cost firms receive capital subsidies or special tax deductions to promote their market entry or business expansion.[12]

With this specification of the tax system, the net-of-tax profits $\pi_i^n$ of a firm of type $i$ are given by

$$\pi_i^n = (p - c_i)x_i - t(p - \delta_i c_i)x_i \quad \forall\, i \in \{L, H\}, \tag{2.5}$$

where the first term on the right-hand side gives the gross profits and the second term gives the total tax payments, which depend on the tax rate and the taxable profit base.

In the following it proves convenient to represent the differences in the determination of tax bases for heterogeneous firms by firm-specific taxes $\tau_L$ and $\tau_H$ on the capital input costs. Defining

$$1 + \tau_i \equiv \frac{(1 - t\delta_i)}{(1 - t)} \quad \forall\, i \in \{L, H\}, \tag{2.6}$$

and introducing the normalized marginal costs $c_L = 1$ and $c_H = 1 + \Delta$, eq. (2.5) can be rewritten as:

$$\pi_L^n \equiv (1 - t)\pi_L = (1 - t)x_L\,[p - (1 + \tau_L)\,r], \tag{2.7a}$$

$$\pi_H^n \equiv (1 - t)\pi_H = (1 - t)x_H\,[p - (1 + \tau_H)\,(1 + \Delta)\,r]. \tag{2.7b}$$

Here $\pi_i$ denotes the profits of a firm of type $i$ after the incorporation of taxes or subsidies on capital inputs, but before the deduction of the corporate profit tax. In general, the capital input taxes $\tau_L$ and $\tau_H$ in (2.7a)–(2.7b) can be positive or negative. As is seen from (2.6), the tax on capital inputs is positive when capital costs are less than fully deductible from the corporate tax base ($\delta_i < 1$). In contrast, when the tax deductibility of capital inputs exceeds their true value ($\delta_i > 1$), the capital input tax is negative (i.e., a subsidy).

The formulation in eqs. (2.7a) and (2.7b) allows a simple representation of the govern-

[11] See Desai et al. (2004) for empirical evidence on tax-minimizing financing structures within MNEs. As shown in Chapter 1, even in the absence of explicit profit shifting strategies by multinational firms, the effective tax rate on MNE's profits is lower than that on purely domestic firms.

[12] Support programs for small businesses have proliferated in recent years. See Mirrlees et al. (2011) for a detailed description of the tax advantages of small businesses in the United Kingdom, and OECD (2010) for a listing of the most important support schemes for small and medium-size enterprises (SMEs) in OECD member states.

ment's ability to affect production decisions both on the intensive margin (how much each firm produces) and on the extensive margin (whether or not a firm enters the market). Irrespective of the sign of optimal capital input taxes, the tax system favors the low-cost firms if $\tau_L < \tau_H$, whereas it favors the high-cost firms if $\tau_L > \tau_H$.

International tax competition limits the scope of the government for choosing its statutory corporate tax rate $t$. We model tax competition by assuming that low-cost firms are able to shift profits into an outside tax haven. The government's aggregate tax revenues are then

$$T = t[(1-\alpha)n_L\pi_L + n_H\pi_H] + \tau_L n_L x_L r + \tau_H n_H x_H (1+\Delta) r. \tag{2.8}$$

Here $0 \leq \alpha \leq 1$ denotes the share of their profits that low-cost, multinational firms shift to the tax haven so that they declare only the share $(1-\alpha)$ in the small country. We impose no constraint on the sign of $T$. As is seen from eq. (2.2), positive tax collections are redistributed to the representative consumer lump sum. Conversely, if total tax revenue from the corporate tax system turns negative, then lump-sum taxes are available to finance effective subsidy payments to firms.

## 2.3 Market Equilibria

Our following analysis is based on a two-stage game. In the first stage, the government chooses its tax policy parameters $(t, \tau_L, \tau_H)$, taking into account the impact of taxation on intensive and extensive margins of production, consumer prices, and profit shifting. In the second stage, both types of firms choose their output levels given the tax system, and the low-cost, multinational firms additionally choose their optimal level of profit shifting.

We solve the model by backward induction and derive the market outcomes in the last stage. We separately consider two cases. In the first, both low-cost and high-cost firms are active in the market. In the second, only the low-cost firms produce, as the tax policy makes entry unattractive for the high-cost firms.

**Low-cost and high-cost firms active.** When all firms compete over quantities in a Cournot oligopoly, maximizing profits in (2.7a)–(2.7b), subject to (2.3) and (2.4), gives optimal quantities as

$$x_L = \frac{a - (1+\tau_L)r + n_H[(1+\tau_H)(1+\Delta)r - (1+\tau_L)r]}{b(1+n)}, \tag{2.9a}$$

$$x_H = \frac{a - (1+\tau_H)(1+\Delta)r + n_L[(1+\tau_L)r - (1+\tau_H)(1+\Delta)r]}{b(1+n)}. \tag{2.9b}$$

Comparing (2.9a) and (2.9b) immediately shows that $x_L > x_H$ when both firms face the same capital input tax ($\tau_L = \tau_H$). For later use, we derive the effects of capital input taxes on firm-specific output levels:

$$\frac{\partial x_L}{\partial \tau_L} = \frac{-(1+n_H)r}{b(1+n)} < 0, \qquad \frac{\partial x_L}{\partial \tau_H} = \frac{n_H(1+\Delta)r}{b(1+n)} > 0,$$

$$\frac{\partial x_H}{\partial \tau_H} = \frac{-(1+n_L)(1+\Delta)r}{b(1+n)} < 0, \qquad \frac{\partial x_H}{\partial \tau_L} = \frac{n_L r}{b(1+n)} > 0\ . \tag{2.10}$$

Thus, raising $\tau_i$ lowers the output of all firms of type $i$, but increases the output of the other type $j$ as a result of strategic interaction in quantities.

Combining the market demand for good $X$ in (2.3) with aggregate output from (2.4) and equilibrium quantities in (2.9a)–(2.9b) gives the equilibrium price as an increasing function of both types' unit costs and capital input taxes:

$$p = \frac{a + n_L(1+\tau_L)r + n_H(1+\tau_H)(1+\Delta)r}{1+n}. \tag{2.11}$$

Maximized profits, before deduction of the corporate profit tax $t$, are then given by

$$\pi_L = b x_L^2, \qquad \pi_H = b x_H^2. \tag{2.12}$$

Evaluating the utility function (2.1) with the optimal demands for $X$ and $Y$ using (2.2), (2.8), (2.11), and (2.12), we get indirect utility as

$$V = \frac{b}{2}\left(n_L x_L + n_H x_H\right)^2 + rK + tb(\alpha n_L x_L^2 + n_H x_H^2) + \tau_L n_L x_L r + \tau_H n_H x_H\left(1+\Delta\right)r, \tag{2.13}$$

with equilibrium quantities given by (2.9a)–(2.9b).

**Only low-cost firms active.** Given that no profit income accrues to domestic consumers in our benchmark setting, if it is optimal for tax policy to drive one set of firms from the market, then it is always optimal to eliminate the high-cost firms.

When only the low-cost firms remain in the market, output per firm in (2.9a) and the market price eq. (2.11) reduce to

$$\tilde{x}_L = \frac{a-(1+\tau_L)r}{b(1+n_L)}, \qquad \tilde{p} = \frac{a+n_L(1+\tau_L)r}{1+n_L}\ , \tag{2.14}$$

where the tilde refers to variables in the equilibrium with low-cost firms only. Gross profits for each low-cost firm are then $\tilde{\pi}_L = b(\tilde{x}_L)^2$. The representative consumer's indirect utility in this case is

$$\tilde{V} = \frac{b}{2}\ (n_L\tilde{x}_L)^2 + rK + tb(\alpha n_L \tilde{x}_L^2) + \tau_L n_L \tilde{x}_L r, \tag{2.15}$$

with the equilibrium quantity $\tilde{x}_L$ given in (2.14).

**Profit shifting decision.** A separate decision for the low-cost, multinational firms is to determine the optimal degree of profit shifting. We assume that the MNE has the opportunity to shift profits to a tax haven, where profits are taxed at the (low) tax rate $t_0$. Shifting profits imposes costs on firms, however, which may consist of transaction costs, fees for legal counseling, or the expected costs of being caught and fined. We assume that the costs of profit shifting are proportional to the fraction of profits shifted abroad. These costs are given by $s_0\alpha\pi_L$, where the parameter $s_0 \in [0,1]$ denotes the share of profits that is absorbed by the shifting costs. Thus, when the multinational firm declares a fraction $\alpha$ of its profits in the tax haven, its after-tax profits $\pi_L^n$ are

$$\pi_L^n = \pi_L[\alpha\,(1-t_0) + (1-\alpha)(1-t) - s_0\alpha]. \tag{2.16}$$

Maximizing (2.16) with respect to $\alpha$ gives the optimal profit shifting decision

$$\alpha^* = \begin{cases} 0 & \text{if} \quad t \leq t_0 + s_0 \\ 1 & \text{if} \quad t > t_0 + s_0. \end{cases} \tag{2.17}$$

Under the assumption of proportional shifting costs, the low-cost firms will thus shift either all of their profits into the tax haven, or none at all.[13]

[13] Excluding partial profit shifting at the level of each firm is a conventional assumption in the recent profit shifting literature, which incorporates firm heterogeneity. See e.g. Krautheim and Schmidt-Eisenlohr (2011), or Elsayyad and Konrad (2012).

## 2.4 Optimal Policy

We now derive the optimal tax policy chosen by the small country's government, which correctly anticipates the optimal behavior of firms and consumers. The central question we address is whether, in the presence of firm heterogeneity, the government has an incentive to tax-discriminate in favor of either the low-cost or the high-cost firms. As we will see, this decision is critically affected by the statutory corporate profit tax rate that the government is able to levy, given the competition from the outside tax haven.

Since the low-cost firms' profit shifting decision (2.17) is unaffected by the capital input taxes $\tau_i$ in our simple setup, we can solve the government's problem sequentially. First, the tax authorities choose the optimal profit tax rate $t$, taking into account that profits can be shifted to the tax haven. Second, the government imposes – possibly differentiated – taxes or subsidies $\tau_i$ on the capital inputs used by each firm.

### 2.4.1 Tax Competition and the Profit Tax Rate

Given the low-cost firms' decision to either shift all or none of their profits (eq. 2.17), the home country has two options. It can either set its profit tax at a sufficiently low rate to ensure that profit shifting is not worthwhile. Alternatively, it can switch to a high-tax regime where it forgoes all revenues from taxing the profits of the low-cost multinationals, and instead taxes the profits of the high-cost firms at the maximum rate. Our analysis focuses on the first regime, in which the home country prevents all profit shifting by setting

$$t^* = t_0 + s_0 \equiv s. \tag{2.18}$$

The profit tax rate $t^*$, which still allows to tax the low-cost firms, is higher when the shifting cost parameter $s_0$ and the haven's tax rate $t_0$ are higher. In the following we combine the two exogenous parameters $t_0$ and $s_0$ to a single value, $s$, which measures the degree of tax competition to which the small country is exposed.

Appendix B.2 derives the equilibrium in the alternative regime where the small country sets $t > s$ and taxes the profit income of the high-cost firms only. The appendix also states the precise condition under which the small country will choose one or the other regime. While the possibility of a regime switch is interesting, it has been studied in detail elsewhere (e.g. Janeba and Peters, 1999). Moreover, the core issue underlying our analysis can only be usefully addressed when both firms are taxed in equilibrium.

It should be emphasized that our objective in this section is not to provide a detailed model of profit shifting into a tax haven. Rather, the purpose is to link the corporate tax rate in the small country to exogenous changes in its economic environment, as measured by the parameter $s$, and eq. (2.18) does this in the simplest possible way. At the core of our analysis are the effects of a reduction in $s$, i.e. closer economic integration and accordingly tighter tax competition, on the optimal pattern of differentiated capital input taxes $\tau_i$. This is the issue to which we turn now.

### 2.4.2 Optimally Differentiated Capital Input Taxes

Having chosen the profit tax rate $t$, the government determines its corporate tax bases by setting capital input taxes (or subsidies) $\tau_i$. Taken together, these tax parameters yield the effective tax burden, which may differ for firms with different productivity levels. The tax choices $\tau_i$ affect the entrants' participation constraints. We start with the case where the tax burden does not deter market entry by the high-cost firms.

**Low-cost firms and high-cost firms active.** Maximizing (2.13) with respect to $\tau_L$ and $\tau_H$ and using (2.10) results in two interdependent first-order conditions for $\tau_L$ (eq. 2.19a) and $\tau_H$ (eq. 2.19b). Straightforward simplifications yield:

$$-bX - 2sb[x_L + (x_L - x_H)n_H] + x_L b(1+n) = \tau_L r(1+n_H) - \tau_H(1+\Delta)rn_H, \quad (2.19a)$$

$$-bX - 2sb[x_H - (x_L - x_H)n_L] + x_H b(1+n) = \tau_H(1+\Delta)r(1+n_L) - \tau_L rn_L. \quad (2.19b)$$

The first effect on the left-hand side (LHS) of (2.19a)–(2.19b) is an *output effect*. This effect is negative for an increase in either $\tau_L$ and $\tau_H$ as capital input taxes further decrease production in the imperfectly competitive $X$-industry. Moreover, the output effect is equally strong for the two capital input taxes $\tau_i$.

The second effect on the LHS is a *profit capturing effect*. It indicates the fraction of an increase in aggregate profits that the small country can appropriate. Given that all (net) profit income accrues to foreigners in our benchmark model, the small country's share in aggregate profit income is determined solely by its profit tax rate. Since $x_L > x_H$ always holds in equilibrium (see below), the second term is unambiguously negative in (2.19a) while its sign is ambiguous in (2.19b). Importantly, we can also infer that the second term in (2.19a) is unambiguously smaller (i.e., more negative) than in (2.19b). This is because an increase in $\tau_L$ diverts production from the more productive to the less productive firms and thus has a stronger negative effect on aggregate profits than an increase in $\tau_H$.

The third effect on the LHS is a *tax base effect*, which is unambiguously positive for an increase in either $\tau_L$ or $\tau_H$. It stands for the additional revenue from a marginal increase in the capital tax base. This effect is unambiguously larger in (2.19a) than in (2.19b), because the larger output of the low-cost firms is associated with a larger capital tax base.

The sum of these three effects determines the sign of the interdependent capital input taxes $\tau_L$ and $\tau_H$ in equilibrium. These taxes will be positive when the positive tax base effect dominates the negative output and profit capturing effects. Other things equal, this is more likely when tax competition is aggressive ($s$ is low) and the feasible profit tax rate $t$ is accordingly low. Thus, the set of optimal capital taxes solves the trade-off between expanding output in the imperfectly competitive industry, and maximizing the tax revenue from the rents accruing to foreigners. The *relative* taxation of capital inputs in the low-cost and in the high-cost firms depends on whether the difference in the third terms (the tax base effects) or the difference in the second terms (the profit capturing effects) dominates.

Having discussed the isolated effects of changes in $\tau_i$, we can now turn to the reduced-form solutions for the optimal capital input taxes. Solving the equation system (2.19a)–(2.19b) yields

$$\tau_L = \left(\frac{1}{2} - s\right)\frac{2bx_L^*}{r}, \qquad \tau_H = \left(\frac{1}{2} - s\right)\frac{2bx_H^*}{(1+\Delta)r}, \tag{2.20}$$

where $s$ is given in (2.18) and the reduced-form output levels of each firm type are

$$x_L^* = \frac{(a-r)(1-s) + \Delta r n_H/2}{b(1-s)[2(1-s)+n]}, \quad x_H^* = \frac{[a-(1+\Delta)r](1-s) - \Delta r n_L/2}{b(1-s)[2(1-s)+n]}. \tag{2.21}$$

Eq. (2.20) shows that both capital input taxes are unambiguously falling in $s$ and thus, from (2.18), in the feasible rate of profit taxation $t$. Intuitively, positive capital input taxes are an indirect way of taxing foreign profits in the $X$-industry, but this comes at the cost of aggravating the production distortion arising from imperfect competition. Therefore, capital inputs will be subsidized when the feasible rate of profit taxation is sufficiently high ($s > 1/2$), but they are taxed when profit tax rates are low as a result of increased profit shifting opportunities.[14]

The title of this chapter asks the question of whether capital input taxes should be lower or higher for low-cost firms, as compared to their high-cost competitors. We are now able to provide an answer to this question by analyzing eqs. (2.20) and (2.21). Note first from (2.21) that equilibrium output of a low-cost firm is always higher than the output of a high-cost firm, irrespective of any differences in capital taxes. This implies that the positive second terms in (2.20) are unambiguously larger for $\tau_L$. Thus $\tau_L < \tau_H$ holds (and low-cost firms are tax-favored) if and only if the feasible rate of profit taxation is sufficiently high ($s > 1/2$). In this case capital inputs are subsidized in all firms, but the subsidy level is higher in low-cost firms. In contrast, when economic integration reduces the feasible rate of profit taxation below $t = s < 1/2$, then all firms' capital inputs are taxed, but the tax is now higher for the low-cost firms.

The intuition for this reversal in the tax pattern comes from the changing relative importance of the *profit capturing* and *tax base effects* in (2.19a)–(2.19b). When the small country's profit tax can capture a large share of the profits in the $X$-industry, then the optimal policy is to give a tax preference to the low-cost firms to increase aggregate production. When the government can tax only a small percentage of the profits in the $X$-industry, however, it taxes the larger base of low-cost firms more heavily to exploit the capital tax base.

Total tax revenues, resulting from the combined impact of profit taxes and taxes on capital inputs, are always positive in equilibrium. Using (2.18), (2.20) and (2.12) gives

$$T = s(n_L\pi_L + n_H\pi_H) + \tau_L x_L r n_L + \tau_H x_H(1+\Delta) r n_H = b(1-s)(n_L x_L^2 + n_H x_H^2) > 0. \tag{2.22}$$

This shows that, even though consumer surplus is included in the objective function (eq. 2.13), it is never optimal for the small country to leave foreign-owned profits in the $X$-industry completely untaxed.

Lastly, we compute the maximized utility level of the individual in the case where both low-cost and high-cost firms are active in equilibrium by substituting (2.22) along with (2.21) in (2.13). After simplifying, this yields

$$V^* = \frac{2(1-s)\left\{n(a-r)^2 - n_H r\Delta\left[2(a-r) - r\Delta\right]\right\} + n_H n_L r^2 \Delta^2}{4b(1-s)[2(1-s)+n]} + rK, \tag{2.23}$$

[14] In this sense, eq. (2.20) represents a simple way of explaining the tax-rate-cut-cum-base-broadening reforms of corporate income taxation that have taken place in many countries during the last decades. See Devereux et al. (2002) for a detailed account of these developments.

which serves to compare the individual's welfare level with the welfare achieved in other tax regimes.

**When are all firms active in equilibrium?** We now consider the possibility that the optimal policy drives all high-cost firms from the market. The relevant objective function is then given by (2.15), from which the optimal capital tax and the resulting output per low-cost firm follow:

$$\tilde{\tau}_L = \left(\frac{1}{2} - s\right)\frac{2b\tilde{x}_L^*}{r}, \qquad \tilde{x}_L^* = \frac{a-r}{b[2(1-s)+n_L]}\ . \tag{2.24}$$

Consequently, if only the low-cost firms are active in the market, the optimal tax on their capital inputs is again negative when $s > 1/2$, but positive when $s < 1/2$. This pattern is thus the same as in the case where all firms are active, and the intuition is also analogous. Capital input subsidies, which increase output towards its efficient level, will only be in the interest of the small country's government if it is able to tax a sufficiently high share of the resulting increase in the firms' profits. In the extreme case where the cost of shifting profits become prohibitive ($s = 1$), so that the government can tax profits completely, the capital subsidy will become so high that it induces the first-best level of output in the market.

Using (2.24) in (2.15) yields the maximized indirect utility when only the low-cost firms produce:

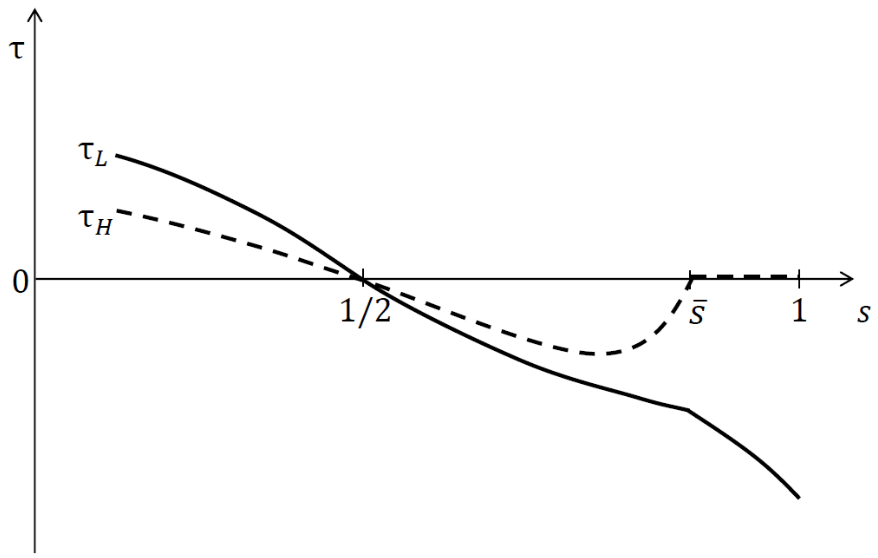
$$\tilde{V}^* = \frac{n_L(a-r)^2}{2b[2(1-s)+n_L]} + rK. \tag{2.25}$$

In the last step, we determine the critical level of $s$ above which the government wants to eliminate the high-cost firms from the market. Equating (2.23) and (2.25) shows that this is the case when $s$ is above

$$\bar{s} = 1 - \frac{n_L r\Delta}{2[a - r(1+\Delta)]}\ . \tag{2.26}$$

It is straightforward to show that (2.26) implies a critical tax rate of $\bar{t} = \bar{s} > 1/2$ iff the condition $\Delta < (a-r)/[r(n_L+1)]$ is fulfilled. But we have already shown in Appendix B.1 that this condition must be fulfilled when high-cost firms enter the market in the absence of government intervention. Thus we can infer that it can only be optimal for the government to keep the high-cost firms from entering the market when $t = s > 1/2$, i.e. in a regime where it is already discriminating against these firms.

Figure 2.1: Optimal Input Taxes and Economic Integration




How do optimal capital input taxes change at $s > \bar{s}$? Since $\bar{s} > 1/2$, we know from (2.24) that the remaining $L$-firms will surely be subsidized. Also, substituting (2.26) into the low-cost firms' optimal output choice in (2.24) confirms that the resulting market price in good $X$ is just equal to $(1 + \Delta)r$ at $\bar{s}$. Therefore, any weakly positive capital input tax on high-cost firms suffices to keep these firms from entering the market.

We are now in the position to state our main result:

**Proposition 2.1** *The pattern of optimally differentiated taxation is a function of the degree of international tax competition.*

**(i)** *With weak tax competition ($s > \bar{s} > 1/2$), the government subsidizes the capital inputs of the low-cost firms and deters entry by the high-cost firms.*

**(ii)** *With moderate tax competition ($1/2 < s < \bar{s}$), the government subsidizes capital inputs of both firms and the optimal policy favors the low-cost firms ($\tau_L < \tau_H$).*

**(iii)** *With aggressive tax competition ($s < 1/2$), the government taxes capital inputs of both firms and the optimal policy favors the high-cost firms ($\tau_L > \tau_H$).*

Figure 2.1 illustrates this proposition. Start at the right end of the graph, where $s > \bar{s}$. In this regime of *weak tax competition*, only the low-cost firms are active in equilibrium.

The capital input tax on low-cost firms, $\tau_L$ (solid line), is strongly negative, whereas $\tau_H$ (dashed line) is set to zero (or any positive level) to keep the high-cost firms from entering the market. The high-cost firms become active when economic integration proceeds and $s$ falls below $\bar{s}$. In this regime of *moderate tax competition* ($1/2 < s < \bar{s}$), the government uses the profit tax revenue to subsidize capital inputs of both low- and high-cost firms. The capital input subsidy is higher for the low-cost firms. Both the subsidies and the preferential treatment of the low-cost firms decline as $s$ falls. At $s = 1/2$, capital input taxes for both firm types are zero and the graphs for $\tau_L$ and $\tau_H$ intersect. For $s < 1/2$ we reach the regime of *aggressive tax competition* where both capital input taxes are positive. Moreover, the tax on low-cost firms exceeds the tax on high-cost firms on account of the larger tax base effect. This pattern of discrimination in maintained as $s$ continues to fall.[15]

## 2.5 Discussion and Extensions

This section discusses the robustness of our results when some of the assumptions made in the benchmark model are relaxed.

**Home ownership of firms.** In our benchmark model we have assumed that all profits accrue to foreigners. We now analyze the implications when domestic residents (partly) own the rent-generating production factor ('intellectual property'), i.e. a share $\beta_i \leq 1$ of the *after-tax* profits of firms of type $i$ go to domestic consumers.

The market equilibria and the analysis of tax competition carry over to this alternative setting from our benchmark analysis in Sections 2.3 and 2.4.1. The optimal firm-specific capital input taxes $\tau_i$ change, however, as now also the untaxed part of profits matters for domestic welfare. The expanded expression for national welfare is:

$$V = \frac{b}{2}X^2 + [t + \beta_L (1-t)] \left(b n_L x_L^2\right) + [t + \beta_H (1-t)] \left(b n_H x_H^2\right) + \tau_L n_L x_L r + \tau_H n_H x_H r + rK.$$

Using (2.18), the optimal capital taxes can be computed as

$$\tau_L = \left[\frac{1}{2} - s - \beta_L(1-s)\right] \frac{2bx_L^*}{r}, \qquad \tau_H = \left[\frac{1}{2} - s - \beta_H(1-s)\right] \frac{2bx_H^*}{(1+\Delta)\, r}\ . \quad (2.27)$$

[15] Recall, however, that for very low levels of $s$ the small country will find it optimal to discretely raise its tax and let the low-cost, multinational firms shift all their profits to the tax haven (see Appendix B.2).

Equilibrium output levels of each firm type are now

$$x_L^* = \frac{(a-r)(1-s)(1-\beta_H) + \Delta r n_H/2}{b(1-s)\left\{(1-\beta_H)\left[n_L + 2(1-s)(1-\beta_L)\right] + n_H(1-\beta_L)\right\}} ,$$

$$x_H^* = \frac{(a-r)(1-s)(1-\beta_L) + \Delta r\left[n_L/2 + (1-s)(1-\beta_L)\right]}{b(1-s)\left\{(1-\beta_H)\left[n_L + 2(1-s)(1-\beta_L)\right] + n_H(1-\beta_L)\right\}} .$$

Comparing the optimal tax expressions (2.27) with those of our benchmark case (2.20) shows that domestic ownership of firms generally reduces the level of capital input taxes, as the incentive to tax foreign-owned profits is now diminished. This is seen from the first terms of (2.27). The critical level of $s$ leading to zero capital input taxes is now given by $s_i^+ = (1-2\beta_i)/(2-2\beta_i)$, and it will differ between the two sets of firms to the extent that the domestic ownership shares differ. Thus, an additional factor now affects the differential taxation of low-cost and high-cost firms. For example, if home ownership is larger in the nationally operating high-cost firms ($\beta_H > \beta_L$), then this will add an argument to tax-discriminate in favor of high-cost firms.

As long as $\beta_i < 1$, however, the basic tax pattern established in the previous section remains valid. In particular, at given levels of $\beta_i$, a fall in the profit shifting costs $s$ will tend to increase capital input taxes (or reduce capital input subsidies) for both firm types. Moreover, the tax increase will still be more pronounced for the low-cost firms, due to the stronger incentive to tax the remaining share of foreign-earned income by means of a higher capital input tax.

**Bertrand competition with heterogeneous goods.** In the model presented so far, firms compete over quantities and produce a homogeneous good. An alternative model of an imperfectly competitive industry considers firms that compete over prices while producing heterogeneous, but substitutable, goods.[16] Here, we will briefly summarize the results of this alternative market structure. For clarity we look at only two firms, which differ in both their productivity and in the good they produce. We assume that a firm with input cost $c_i$ produces good $x_i$. Again, we normalize the input cost levels so that $c_L = 1$ and $c_H = 1 + \Delta$.

As in our benchmark model (eq. 2.1), preferences over the imperfectly substitutable

[16]In a Bertrand model with homogenous goods, only the low-cost firms would produce. Price competition among them would bring prices down to their marginal cost $r$, whenever $n_L \geq 2$. Bertrand competition in homogeneous goods thus eliminates the policy trade-off that is at the heart of our model by ruling out the - empirically observed - concurrent production of firms with different cost levels.

goods are represented by a quadratic, quasi-linear utility function (Singh and Vives, 1984)

$$U = a(x_L + x_H) - \frac{b}{2}(x_L^2 + x_H^2) - \gamma x_L x_H + Y^D, \qquad 0 < \gamma < b, \tag{2.28}$$

where $(\beta/\gamma)$ measures the degree of heterogeneity between the two goods. Given these preferences, firm $i$ faces an inverse demand curve $p_i = a - bx_i - \gamma x_j$ and sets its profit-maximizing prices accordingly.

Anticipating firm behavior, the government determines its tax policy. The feasible profit tax rate is again limited by international tax competition and is set according to (2.18). Optimal capital input are equal to[17]

$$\tau_L = \left(\frac{1}{2} - s\right)\frac{2(b^2-\gamma^2)x_L^*}{br}, \qquad \tau_H = \left(\frac{1}{2} - s\right)\frac{2(b^2-\gamma^2)x_H^*}{b(1+\Delta)r}, \tag{2.29}$$

with equilibrium output levels of each firm given by

$$x_L^* = \frac{(b-\gamma)(a-r)\left[(b+y)(1-s)+b/2\right] + \gamma r\Delta b/2}{2(b^2-\gamma^2)\left[(b+\gamma)(1-s)+b/2\right]\left[b(3/2-s)-\gamma(1-s)\right]}b,$$

$$x_H^* = \frac{(b-\gamma)(a-r)\left[(b+\gamma)(1-s)+b/2\right] - \left[b^2(3/2-s)-\gamma^2(1-s)\right]r\Delta}{2(b^2-\gamma^2)\left[(b+\gamma)(1-s)+b/2\right]\left[b(3/2-s)-\gamma(1-s)\right]}b.$$

Comparing (2.29) with (2.20) shows that the pattern of capital input taxation is unchanged from our benchmark model, and optimal tax rates depend again on the degree of international tax competition. If tax competition is moderate and profit taxation at relatively high rates is feasible ($t = s > 1/2$), the motive to expand output dominates in the setting of optimal capital input taxes and the low-cost firm receives the higher subsidy. In contrast, when tax competition is aggressive and feasible profit tax rates are low ($t = s < 1/2$), the low-cost firm's larger tax base leads to it being taxed more heavily by the capital input tax. The basic trade-off for tax policy that determines the optimal differentiation of capital input taxes is thus the same under quantity and under price competition of the heterogeneous firms.[18]

[17] For a complete derivation see Appendix B.3.

[18] Note that the *level* of capital input taxes and subsidies falls in (2.29) when the substitutability of goods is increased (i.e., $\gamma$ rises, but remains below $b$). This is because a higher substitutability of goods under price competition leads to higher output and lower profits for both firms; hence the motives to expand output and to tax foreign-owned profits simultaneously decline.

**Additional policy instruments and partial profit shifting.** Another extension arises when the small country's government has an additional policy instrument at its disposal to influence the profit shifting costs $s$. It is straightforward to infer from (2.23) that maximized utility in our benchmark case is unambiguously rising in $s$. Therefore, the small country has an incentive to engage in costly measures that increase $s$ and thus reduce tax avoidance via profit shifting. This extension is particularly relevant in settings where partial profit shifting by the low-cost, multinational firms is allowed. If measures to control profit shifting impose convex costs, the small country will only invest in this activity until the marginal gains from reduced profit shifting equal the marginal cost of the avoidance measure (Cremer and Gahvari, 2000; Johannesen, 2012).[19] Therefore, a fall in $s$ induced by economic integration will not be fully offset in the small country's policy optimum and the equilibrium level of the profit tax rate will still decline. Consequently, the basic effects on the choice of optimally differentiated input taxes $\tau_i$ will remain intact in such an extended framework. The difficulty that arises from this model extension is that all policy choices become interdependent when partial profit shifting by the low-cost firms is incorporated.

## 2.6 Conclusion

There is conclusive evidence that large, multinational firms are more productive, on average, than their smaller, domestic counterparts. This chapter has asked whether countries should therefore tax firms with different productivity levels at different effective tax rates to shift production towards the most productive businesses. Our analysis has shown that the motivation to tax discriminate according to productivity levels depends critically on the statutory corporate tax rate that is feasible in the presence of competition from an outside tax haven. When tax competition from the haven is moderate, then it is indeed optimal for the small country to introduce tax preferences for the larger, multinational firms, as this policy increases aggregate profits which can then be taxed to a sufficiently high degree. When competition from the tax haven becomes more aggressive, however, then the tax preferences for large firms are gradually reduced and eventually turned around. It then becomes profitable for the small country to impose the heavier tax on the low-cost, multinational firms as a

[19] In Cremer and Gahvari (2000) the costs are resources that have to be spent in order to limit tax avoidance. In Johannesen (2012) the costs are instead given by lost advantages of economic integration which arise when the home country taxes all cross-border interest income as a means to reduce profit shifting into tax havens.

means to indirectly capture the rents accruing to foreign-based owners of the firms, despite the aggregate productivity losses that this policy entails.

The model presented in this essay thus offers an explanation for existing trends to reduce tax advantages for highly productive, multinational firms vis-à-vis their less productive national competitors. We show that this can be interpreted as an optimal policy response to the need to cut corporate tax rates as a result of tightened international tax competition. In addition to the evidence presented in the introduction, there are other recent developments that point in the same direction. One is the overall broadening of corporate tax bases, which has been accompanied by a proliferation of special incentive schemes and tax deductions for small businesses (see OECD, 2010; Mirrlees et al., 2011). The net effect of these changes is to increase the relative taxation of large firms. A different example is the increasing focus on tough regulation and competition in network utility markets, which reduce the pre-tax profits of privatized incumbents that in many cases are multinational firms.

These trends are noteworthy because they counteract the general tendency to favor internationally mobile over internationally immobile firms and activities. While the latter trend continues to be an important one, we have argued in this essay that differences in productivity and profitability across firms may be a complementary, and perhaps equally important, determinant of corporate tax policy.

Our analysis has been held deliberately simple, and it can be extended in several directions. It is conceptually straightforward (but computationally non-trivial) to add a foreign investment opportunity for the low-cost multinational firms, thus combining firm heterogeneity with respect to both mobility and productivity in a single, unified setting. Another interesting extension would be to endogenize the cost differentials between different firms, for example by modelling different internal labor markets within large and small firms (Oi and Idson, 1999), or by incorporating $R\&D$ choices in a heterogeneous firms' framework (Long et al., 2011). Finally, from an empirical perspective, it would be highly desirable to subject our main hypothesis to a rigorous econometric test, linking quantifiable indicators of tax advantages for highly productive, multinational firms to the development of statutory corporate tax rates.

# Chapter 3

# Limiting Profit Shifting in a Model with Heterogeneous Firm Productivity

## 3.1 Introduction

With growing financial integration, multinational companies have increasingly shifted profits abroad to reduce their tax payments. Profit shifting is an effective method to lower tax payments: Egger et al. (2010b) find that multinationals pay over 50% less taxes than similar domestic firms in high tax countries.[1] Governments have reacted. With the help of targeted changes to the tax code they have tried to secure their respective tax bases. Examples for such measures are stricter transfer pricing rules or thin capitalization rules.

Such regulations have become widespread during the last years. Between 1996 and 2005, for example, the share of EU-27 countries that imposes thin capitalization rules has doubled, from 30% to 60% (see Buettner et al., 2012). Thin capitalization rules restrict the deduction of interest payments for tax purposes to a certain percentage of earnings. In Germany, for example, interest payments (net of interest expenses) can only be deducted if their value is less than 30% of earnings before interest, taxes, depreciation and amortization (EBITDA). Such rules are not restricted to borrowing

This chapter is based on Langenmayr (2011).

[1]For further empirical evidence on profit shifting see, for example, Hines and Rice (1994), Huizinga and Laeven (2008) or Weichenrieder (2009).

from affiliates, but comprise all kinds of debt finance. Due to non-discrimination rules (for example by the EU), they apply to most corporations, even if they are not active internationally. The benefit of such a broad thin capitalization rule is that it effectively limits profit shifting via debt finance.[2]

However, such broadly applicable regulations also have disadvantages. They are badly targeted, as they also apply in cases that have nothing to do with profit shifting.[3] In extreme cases, it is even possible that tax payments accrue under such rules even if the firm makes a loss (see Homburg, 2007).[4] Further costs arise as firms hire consultants or choose inefficient strategies to comply with the regulations.[5]

In this chapter, I set up a model that incorporates such costs along with the (beneficial) limitation of profit shifting. I then use this model to analyze the effects of limiting profit shifting on welfare and on the aggregate sum of profits shifted abroad. Firms in the model are heterogeneous in their productivity and compete under monopolistic competition.

The key result of the model is that strengthening a limitation on profit shifting does not necessarily lead to less profit being shifted abroad on aggregate. As the costs of such regulations force some firms out of the market, there is less competition, so that the remaining firms become more profitable. It is therefore possible that the absolute amount of profits shifted abroad increases, even though only a smaller percentage of profits can be transferred. Furthermore, additional firms may start to shift profits abroad.

Regulations to limit profit shifting have further effects, besides the ambiguous effect on the amount of profits shifted itself. As such rules force some firms to exit the market,

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[2]There are several empirical analyses of thin capitalization rules, which confirm that such rules indeed have a significant effect on firms' decisions. Buettner et al. (2012) confirm that higher taxes lead to a higher debt ratio of subsidiaries in that country. Due to thin capitalization rules, the debt ratio decreases and is less dependent on the tax rate. Weichenrieder and Windischbauer (2008) reach similar conclusions, as do Overesch and Wamser (2010), who use a difference-in-difference approach.

[3]For example, the German thin capitalization rule applies also if a group is only active nationally, and debt mostly stems from bank financing.

[4]Homburg (2007) gives the following example of a corporation making a loss of 20 million euros, with net interest expenses of 60 million euros and 10 million euros of depreciation allowances. The German thin capitalization rule limits deductible interest expenses to 15 million euros, resulting in a taxable profit of 25 million euros (implying a tax payment of about 7.5 million euros despite making a loss).

[5]Under a thin capitalization rule, firms may abstain from internal debt financing even when it would otherwise be optimal (e.g. for investments by affiliates who face high interest rates).

there is a welfare loss as consumers have fewer varieties from which to choose. The overall welfare effect depends on the market situation: If firms have high market power, it is best if governments do not limit profit shifting possibilities. If firm productivity is very heterogeneously distributed, profit shifting should be limited, as relatively many firms engage in profit shifting activities to begin with.

Limiting profit shifting is also more likely to be favorable if the costs of profit shifting are relatively low. As such costs have fallen during the last decades due to increasing global integration, this result is in line with the empirical evidence of increased regulation against profit shifting presented above.

Including heterogeneous productivity is crucial to this analysis of limiting profit shifting, as it allows to model that the effects of this specific tax policy differ among firms with different productivity levels. The literature on firm heterogeneity originating with Melitz (2003) has recently been adapted to analyze the effects of taxation. As of yet, there have been only few uses of heterogeneous productivity in the public finance literature.

A first article is Davies and Eckel (2010), who show in such a model the classic result that tax competition leads to lower-than-optimal tax rates, and that too little of the public good is produced, so that a welfare loss arises. Haufler and Stähler (2013) also offer an explanation for the international race-to-the-bottom in profit tax rates by means of a model with heterogeneous productivity. They show that an increase in market sizes of both countries leads to lower equilibrium tax rates. Baldwin and Okubo (2009) also predict a race-to-the-bottom in tax rates when the integration of goods markets increases. In another paper, Baldwin and Okubo (2009), the same authors show that a tax-cut-cum-base-broadening tax reform can increase tax revenue.

Closest to this present essay is Krautheim and Schmidt-Eisenlohr (2011). They derive equilibrium tax rates in a model with monopolistic competition among heterogeneous firms. Firms make positive profits, which the government taxes. To avoid taxation to some extent, some firms shift *all* of their profits from the home country to the tax haven. In equilibrium, only the most productive firms shift profits.

The papers described above propose general tax models with heterogeneous productivity. None of them examines a specific policy measure. The present essay specifically asks about the effects of a regulation that limits profit shifting (e.g. by a thin capitalization rule).[6]

This chapter is structured as follows. The next section introduces the reader to the model and derives a first result on the aggregate amount of profits shifted abroad. Section 3.3 analyzes the optimization problems of the two countries in more detail. Some numerical simulations in Section 3.4 clarify the theoretical results. Section 3.5 concludes.

## 3.2 Model

The model consists of two countries, the "home market" and the "tax haven". The tax haven is small; all production takes place in the home market. The economy of the home market comprises two sectors. One of them is a numeraire sector that produces a homogeneous good with a single factor (labor) under perfect competition using a technology with constant returns to scale. The final good in this sector is freely traded, its price is normalized to unity. In the second sector, firms with heterogeneous productivity manufacture differentiated goods under monopolistic competition.[7] The cost of production consists of constant, firm-specific marginal costs $a_i$ and fixed production costs $c$. Marginal costs of all potentially active firms follow a Pareto distribution in the interval $[0, a_0]$.[8] The cumulative distribution function of the marginal cost is given by

$$G(a) = \left(\frac{a}{a_0}\right)^{\gamma}, \qquad \gamma > 1. \tag{3.1}$$

The Pareto distribution implies that higher values of $a_i$ are more likely than lower values, i.e. that relatively few very productive firms exist. Firms are more heterogeneous when the shape parameter $\gamma$ is lower.[9] To simplify, $a_0$ is set to one in the following.

[6]Another paper specifically analyzing such a measure, namely a thin capitalization rule, is Haufler and Runkel (2012). In contrast to this essay, the firms' internationalization decision is not endogenous in the model; instead, it is assumed that only some firms are active internationally. The authors show that in a symmetric equilibrium, each country chooses inefficiently low tax rates and lax thin capitalization rules.

[7]To focus on profit shifting, it is assumed that there is no trade in the differentiated goods sector. This is common in the literature, see e.g. Krautheim and Schmidt-Eisenlohr (2011).

[8]The Pareto distribution is a good approximation of the empirically observed distribution of firm sizes (see Axtell, 2001). Its use is common in the literature, see e.g. Helpman et al. (2004) or Krautheim and Schmidt-Eisenlohr (2011).

[9]With a lower value of the parameter $\gamma$, more low-cost firms exist. If $\gamma \to 1$, marginal cost is uniformly distributed, which represents the highest degree of heterogeneity possible in this model. In the opposite case of $\gamma \to \infty$, firms are homogeneous (with marginal costs equal to $a_0$).

Firms in the differentiated goods sector compete under Dixit-Stiglitz monopolistic competition: Each firm offers a product that is, from the consumers' point of view, only imperfectly substitutable by other goods. Therefore, firms have some market power. Consumers' preferences are given by

$$U = \mu \ln X_I + \beta X_G + X_N, \quad \text{with} \quad X_I = \left( \int_{i \in \Theta} x_i^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1 > \mu > 0. \tag{3.2}$$

$X_I$ and $X_N$ represent the quantities consumed of the differentiated and numeraire goods, respectively. $X_G$ is a public good, financed by tax revenue, and enters the utility function weighted by a factor $\beta > 1$. $\mu$ shows the importance of the differentiated goods relative to the numeraire good. $\Theta$ is the set of all differentiated goods. The Dixit-Stiglitz parameter $\sigma$ can be interpreted as the (constant) elasticity of substitution.

Maximizing the utility function (3.2) subject to the budget constraint, the demand for a particular variety of the differentiated good is given by

$$x_i = \frac{\mu}{\int p_i^{-(\sigma-1)}} p_i^{-\sigma} = \frac{\mu}{p_i^{\sigma}} P^{\sigma-1}, \qquad \text{with} \quad P = \left( \int_{i \in \Theta} p_i^{-(\sigma-1)} di \right)^{-\frac{1}{\sigma-1}}, \tag{3.3}$$

where $p_i$ is the price of variety $i$, and $P$ is the CES price index. Aggregate demand for $X_I$ is thus given by $X_I = \frac{\mu}{P}$.

Firms facing this demand function maximize their profits. Therefore they set their prices as a constant mark-up over marginal cost

$$p(a_i) = \frac{\sigma}{\sigma - 1} a_i. \tag{3.4}$$

The price is higher if the elasticity of substitution is lower, i.e. if firms have more monopoly power.

Thus, pre-tax profits of firms are given by the following equation, with the second equality taking optimal price and quantity decisions into account[10]

$$\begin{aligned} \pi_i - c &= (p_i - a_i) \cdot x_i - c \\ &= \frac{\mu}{\sigma} \left( \frac{\sigma - 1}{\sigma} \right)^{\sigma-1} \left( \frac{P}{a} \right)^{\sigma-1} - c. \end{aligned} \tag{3.5}$$

[10]In line with the previous literature, I assume that $\gamma - \sigma + 1 > 0$ to ensure that profits are finite.

The most efficient firms (i. e. the firms with the lowest marginal cost $a_i$) are the most profitable.

Profits are taxed at a constant marginal rate $t_H$ in the home country. However, firms have the possibility to shift profits to the tax haven, where the profit tax rate $t_X$ is lower than in the home country ($0 < t_X < t_H < 1$).[11] To shift profits, firms have to incur a fixed cost, $f$. As the cost of profit shifting is fixed, only the most profitable firms choose to shift their profits abroad (see Krautheim and Schmidt-Eisenlohr, 2011).

In reality, many regulations limit profit shifting. Such regulations have to target the means of profit shifting, i.e. transfer pricing or internal financing structures. Due to limited information, the government cannot fully differentiate between legitimate intra-firm transactions and profit shifting. It thus has to use broader rules that also hinder activities other than profit shifting.[12] An example are thin-capitalization rules, which dictate that only interest expenses of up to a certain fraction of profits can be subtracted from earnings for tax purposes for all firms. On the one hand, this limits the possibilities for profit shifting via debt. On the other hand, it increases *all* firms' financing costs, as they have to comply with these rules or face higher tax rates, also if they did not intend to shift profits abroad.

In the model, the government of the home country can impose such regulations, which limit the maximum percentage of profits $\alpha$ that firms are able to shift abroad. This, however, imposes costs on all firms. These costs can be interpreted in manifold ways: Firms may choose inefficient strategies to comply with the regulations, or have to hire costly consultants. If thin capitalization rules are used, financing costs may rise. As many regulations (such as the German thin capitalization rule, see fn. 3) apply to all firms, such costs arise even if the firm does not engage in profit shifting activities. Thus, limits on profit shifting impose some costs on firms, as they have to comply with the regulations, e.g. limit their debt financing. To represent these costs, every firm in the model bears an additional cost of $(1-\alpha)\tau$. The parameter $\tau$ scales the severity of the burden, which also depends on the strictness of the limitation on profit shifting,

[11] As the tax haven has no firms of its own, it collects tax revenue only if it sets a lower tax rate than the home market. Otherwise, no firm would be willing to shift profits.

[12] In EU countries, non-discrimination laws even prohibit regulations that affect only internationally active firms.

$(1-\alpha)$.[13]

Due to the fixed costs of production and profit shifting limitations, not all potential firms are productive enough to be in business. A zero-profit condition determines the cut-off value $a_\tau$, that is, the cost coefficient of the least productive firm in the market:

$$[p(a_\tau)\,x(a_\tau) - a_\tau x(a_\tau) - c]\,(1-t_H) - (1-\alpha)\tau = 0. \tag{3.6}$$

Solving this condition for $a_\tau$ yields

$$a_\tau = \frac{\sigma-1}{\sigma}\left(\frac{\mu}{\sigma}\frac{1-t_H}{c\,(1-t_H)+(1-\alpha)\,\tau}\right)^{\frac{1}{\sigma-1}} P. \tag{3.7}$$

If the tax rate in the home country or the cost of the limitation on profit shifting is higher, fewer firms are in the market. More firms are active in larger markets (as measured by $\mu$). For $\alpha = 1$ eq. (3.7) collapses to the case without a limitation on profit shifting.

Firms may incur the fixed cost $f$ to shift some of its profits abroad.[14] As the most profitable firms have the most to gain from avoiding taxes, and given that the cost of profit shifting is fixed, only firms with marginal costs below a level $a_P$ shift profits abroad. This cut-off is determined by the following indifference condition, which already takes into account that fixed costs $c$ and the burden of the limitation on profit shifting $(1-\alpha)\tau$ have to be borne in both cases:[15]

$$(1-t_H)\,\pi(a_P) = (1-t_H)\,(1-\alpha)\,\pi(a_P) + (1-t_X)\,\alpha\pi(a_P) - f. \tag{3.8}$$

The left hand side of eq. (3.8) represents the case in which the firm pays taxes only in the home country. On the right hand side, it shifts profits into the tax haven. As the cost of profit shifting, $f$, is fixed, the firm always shifts as much of its profit abroad as is possible. It is assumed that the cost of profit shifting is not deductible from the

[13] While this cost is the same across firms in *absolute* value, it is highest for low-productivity firms in *relative* terms. This is realistic, as unproductive firms are hit harder for example by thin capitalization rules (as they have fewer self-financing possibilities and are more dependent on debt finance). Nevertheless, all firms have some additional costs due to such regulations (such as consultants and investment distortions).

[14] I assume that fixed costs are such that not all firms engage in profit shifting, so that the least productive firm in the market (i.e. the firm with marginal costs of $a_\tau$) is not avoiding taxes.

[15] The tax-deductible fixed cost of production, $c$, is always deducted in the home country. Due to the higher tax rate there, this is optimal for the firm.

firm's taxable base.[16]

Inserting eq. (3.5) for the profits, the marginal cost level $a_P$ is given by

$$a_P = \frac{\sigma - 1}{\sigma} \left( \frac{\mu}{\sigma} \frac{\alpha \left( t_H - t_X \right)}{f + \alpha c \left( t_H - t_X \right)} \right)^{\frac{1}{\sigma - 1}} P. \tag{3.9}$$

Firms with marginal costs under $a_P$ shift as much of their profits as possible abroad; the other firms (with marginal costs $a_i \in [a_P, a_\tau]$) prefer to pay taxes on all profits in the home country, as the costs of profit shifting are – for them – too high relative to their earnings. A higher tax rate in the home country or a lower tax rate abroad induce more firms to shift profits abroad. Note that $a_P$ depends only indirectly (via the price index) on the costs that profit shifting limitations impose on all firms.

The cut-off values $a_\tau$ and $a_P$ depend on the price index. Using the definition of the price index and combining it with eqs. (3.4) and (3.7), the equilibrium value of the price index is

$$P = \left( \int_0^{a_\tau} p_i^{-(\sigma - 1)} di \right)^{-\frac{1}{\sigma - 1}} = \frac{\sigma}{\sigma - 1} \left( \frac{\gamma - \sigma + 1}{\gamma} \right)^{\frac{1}{\gamma}} \left( \frac{1 - t_H}{c \left( 1 - t_H \right) + \left( 1 - \alpha \right) \tau} \right)^{-\frac{\gamma - \sigma + 1}{\gamma(\sigma - 1)}}. \tag{3.10}$$

Lastly, let us consider optimal quantities of the numeraire good $X_N$ and the public good $X_G$. Demand for the numeraire good is given by $X_N = I - \mu$, whereby income $I$ consists of labor income $L$ and profit income. The public good is financed by tax revenue $T$, $X_G = T$. Thus, optimal quantities of the numeraire and the public good depend on aggregate profits and their taxation.

To look at this in more detail, consider the tax bases of the home country ($\Pi$) and the tax haven ($\Pi^*$). These tax bases are given by aggregate profits without deducting the

[16] The assumption of no deductibility is justified if the costs of profit shifting lie in distortions or soft costs (such as language barriers or an inability to effectively monitor employees) that arise because an investment (e.g. a sales and distribution office) is undertaken in a tax haven instead of in a high-tax country. It is also common in the literature with heterogeneous firms, see e.g. Krautheim and Schmidt-Eisenlohr (2011). An alternative assumption would be that these costs are deductible in the tax haven, which would not change the analysis qualitatively.

burden imposed by the limitation on profit shifting.

$$\begin{aligned}\Pi &= \int_{a_P}^{a_\tau} (\pi_i - c)\, dG(a) + \int_0^{a_P} [(1-\alpha)\pi_i - c]\, dG(a) \\ &= \frac{\mu}{\sigma}\left[1 - \alpha\left[\frac{[c(1-t_H) + (1-\alpha)\tau]\,\alpha(t_H - t_X)}{(1-t_H)[f + \alpha(t_H - t_X)c]}\right]^{\frac{\gamma-\sigma+1}{\sigma-1}} - c\frac{(\gamma-\sigma+1)(1-t_H)}{\gamma[c(1-t_H)+(1-\alpha)\tau]}\right],\end{aligned} \tag{3.11}$$

$$\Pi^* = \int_0^{a_P} \alpha\pi_i dG(a) = \alpha\frac{\mu}{\sigma}\left[\frac{c(1-t_H)+(1-\alpha)\tau}{1-t_H}\frac{\alpha(t_H-t_X)}{f+\alpha(t_H-t_X)c}\right]^{\frac{\gamma-\sigma+1}{\sigma-1}}. \tag{3.12}$$

The tax base in the home country, eq. (3.11), can be interpreted as the sum of all profits (i. e. the tax base without any profit shifting, $\frac{\mu}{\sigma}$) less the profits shifted to the tax haven (the second term) and aggregate fixed costs.

What determines how much profit is shifted abroad on aggregate? The tax base in the tax haven rises if the tax difference between the two countries increases. It falls if firms have higher costs to shift profits (higher $f$) or if the demand for differentiated goods in the home market is lower (lower $\mu$). If profit shifting limitations impose a greater burden, the tax base is lower, as there are fewer firms in the market. The tax base in the haven is also smaller if the firms are more heterogeneous (lower $\gamma$).

Importantly, it is not always the case that a limitation on profit shifting leads indeed to less profit being shifted abroad on aggregate. Differentiating eq. (3.12) with respect to $\alpha$, it becomes clear that counteracting effects are at work:

$$\frac{\partial\Pi^*}{\partial\alpha} = \int_0^{a_P}\left(\pi_i + \alpha\frac{\partial\pi_i}{\partial\alpha}\right) dG(a) + \frac{\partial a_P}{\partial\alpha}\pi(a_P). \tag{3.13}$$

The first term reflects the effects on the intensive margin, that is, the change in the amount of profit each firm shifts abroad. First, there is a direct effect $\left(\int_0^{a_P} \pi_i dG(a)\right)$, as a change in $\alpha$ changes the percentage of profits that each firm is allowed to shift abroad. Secondly, there is an indirect effect: By strengthening a limitation on profit shifting (lowering $\alpha$), the government crowds some firms out of the market. For the remaining firms, the market becomes less competitive, thus rendering them more profitable. Thus, possibly, if the increase in profitability is strong enough, these firms shift *more* profits abroad despite the profit shifting regulation. The second term captures an effect on the extensive margin, that is, on the number of firms that shift profits. As all active firms become more profitable, it is possible that firms that did not shift profits abroad before start to do so after it is strengthened.[17] The following proposition summarizes these effects.

**Proposition 3.1 (Effectiveness of Limits on Profit Shifting)** *Stricter limitations on profit shifting do not necessarily lead to less profit shifted abroad on aggregate. Such regulations are only effective if the burden associated with them is relatively small.*

**Proof.** By inspection of eq. (3.13) and using eqs. (3.5), (3.9) and (3.10) it follows that $\frac{\partial \Pi^*}{\partial \alpha} > 0 \Leftrightarrow \tau < \frac{c(1-t_H)(\sigma-1)\left[c\alpha(t_H-t_X)+f+\frac{\gamma-\sigma+1}{\sigma-1}\right]}{[c\alpha(t_H-t_X)+f](\alpha\gamma-\sigma+1)-(1-\alpha)(\gamma-\sigma+1)}$ ■

This proposition is illustrated in a numerical simulation in Section 3.4. First, however, I will derive and discuss the conditions that determine the optimal tax rates and limitation on profit shifting in the following section.

## 3.3 Optimal Tax Policies

### 3.3.1 Optimization of the Tax Haven

The tax haven sets its tax rate $t_X$ to maximize its tax revenue. As it has no firms of its own, maximizing tax revenue is the optimal policy also from a welfare point of view. Thus, its optimization problem is

$$\max t_X \Pi^*. \tag{3.14}$$

Solving (3.14) yields the tax haven's best response function,

$$t_X = t_H - \frac{1}{2}\frac{\sqrt{4t_H c f \alpha(\sigma-1)(\gamma-\sigma+1) + f^2\gamma^2} - f\gamma}{c\alpha(\sigma-1)}. \tag{3.15}$$

The tax haven reacts to stricter limitations on profit shifting (lower $\alpha$) by lowering its tax rate. If the tax rate in the home country is increased, the tax haven responds in kind, but raises its tax rate by less than the home country has raised hers. If firms are very heterogeneous (low $\gamma$), the tax rate is higher: There are more productive firms,

[17] Again, two counteracting effects are at work on the extensive margin, as can be seen by inspection of eq. (3.9). A stricter regulation makes profit shifting less attractive per se, but the increase in profits (due to less competition, i.e. a higher price index $P$) may change that.

and those firms are the first to shift profits. Therefore, the tax haven can attract quite a lot of firms even if its tax rate is not that low. If the elasticity of substitution, $\sigma$, is lower, firms have more monopoly power and realize higher profits. In this case, the tax haven sets a lower tax rate, as it has a stronger incentive to attract profits.

### 3.3.2 Optimization of the Home Country

The home country can decide about two policy instruments, the tax rate and the degree to which it restricts profit shifting. The government sets these to maximize social welfare. Welfare is given by the indirect utility function of the representative consumer, which follows from using $X_I = \frac{\mu}{P}$, $X_G = T = t_H \Pi$ and $X_N = I - \mu$ in the utility function (3.2):

$$V = L - \mu + \mu \ln\left(\frac{\mu}{P}\right) + (1 + (\beta - 1)\, t_H)\, \Pi + (1 - t_X)\, \Pi^* - N^* f - N_\tau\, (1 - \alpha)\, \tau. \quad (3.16)$$

Note that income $I$ consists of labor income $L$ and (after-tax) profit income. The fixed costs of profit shifting, $f$, are paid by all $N^* = a_P^\gamma$ firms that shift profits abroad. $N_\tau = a_\tau^\gamma$ marks the total mass of firms in the market. Fixed costs of production, $c$, are already deducted from aggregate profits.

The first order conditions for the optimal limitation on profit shifting and the optimal tax rate are

$$\frac{\partial V}{\partial \alpha} = \frac{-\mu}{P}\frac{\partial P}{\partial \alpha} + [1 + (\beta - 1)\, t_H]\frac{\partial \Pi}{\partial \alpha} + (1 - t_X)\frac{\partial \Pi^*}{\partial \alpha} - f\frac{\partial N^*}{\partial \alpha} - \frac{\partial N_\tau}{\partial \alpha}(1 - \alpha)\,\tau + N_\tau \tau = 0, \quad (3.17)$$

$$\frac{\partial V}{\partial t_H} = \frac{-\mu}{P}\frac{\partial P}{\partial t_H} + [1 + (\beta - 1)\, t_H]\frac{\partial \Pi}{\partial t_H} + \Pi\,(\beta - 1) + (1 - t_X)\frac{\partial \Pi^*}{\partial t_H} - f\frac{\partial N^*}{\partial t_H} - \frac{\partial N_\tau}{\partial t_H}(1 - \alpha)\,\tau = 0. \quad (3.18)$$

Due to the analytical complexity of the model, these first order conditions cannot be solved explicitly for $t_H$ and $\alpha$. In Section 3.4, numerical solutions will be derived and shown graphically. However, before doing so, I will give some intuition for the various effects a limitation on profit shifting has on welfare.

First, to interpret the effects of such a regulation better, eq. (3.17) can be rewritten as

$$\frac{\partial V}{\partial \alpha} = \frac{-\mu}{P}\frac{\partial P}{\partial \alpha} - [t_H(\beta - 1) + t_X]\frac{\partial \Pi^*}{\partial \alpha} - f\frac{\partial N^*}{\partial \alpha} - [1 + (\beta - 1)\, t_H]\, c\frac{\partial N_\tau}{\partial \alpha} - \left[(1 - \alpha)\frac{\partial N_\tau}{\partial \alpha} - N_\tau\right]\tau \quad (3.19)$$

using that $\frac{\partial \Pi}{\partial \alpha} = -\frac{\partial \Pi^*}{\partial \alpha} - c\frac{\partial N_\tau}{\partial \alpha}$.

The first term of eq. (3.19) captures the effect that limiting profit shifting has on consumption. This term is always positive, showing that stricter regulations (lower $\alpha$) have a negative effect on welfare: As some firms exit the market, fewer varieties are available to the consumer.[18]

The main advantage of a regulation that limits profit shifting is supposedly that less profits are shifted abroad. The change in the volume of profits shifted has two effects, which are captured in the second term of eq. (3.19). First, stricter profit shifting rules increase tax revenues in the home country. Second, they decrease the loss of income due to the tax payments in the tax haven (from the home country's point of view, taxes paid on profits in the tax haven are a pure loss, as they neither generate tax revenue nor profit income). Moreover, as shown by the third term of eq. (3.19), if fewer firms shift profits, less profit income is lost due to the fixed cost $f$, which firms incur to shift profits. Note, however, that it is not clear whether such a rule really leads to less profits being shifted abroad (see Proposition 3.1).

The fourth term of eq. (3.19) reflects that as fewer firms are in the economy, fewer firms incur the fixed costs of production, $c$. As this cost is tax-deductible, this also has implications for tax revenue. Lastly, the strictness of regulations influences the severity of the burden that is associated with such a limitation on profit shifting. First, lowering $\alpha$ implies that this burden affects fewer firms, as some firms exit the market. However, a stricter limit on profit shifting also implicates that this burden is higher for all firms. This second effect is always stronger than the first, implying that the total effect is negative (i.e. the last term of eq. (3.19) is always positive).

**Proposition 3.2 (Welfare effects of regulations to limit profit shifting )** *The welfare effects of strengthening a limitation on profit shifting are ambiguous and given by eq.* (3.19). *Besides the positive effect of keeping profits in the country, such a regulation has further effects due to the market exit of some firms. This decreases competition and makes consumers worse off as they have fewer varieties from which to choose, but may increase tax revenue (see Proposition 3.1).*

Next, let us consider the effects of a change of the tax rate in the home country, $t_H$. Again, it is helpful to rewrite the first order condition (3.18) as

$$\frac{\partial V}{\partial t_H} = \frac{-\mu}{P}\frac{\partial P}{\partial t_H} - (\beta - 1)\left(\Pi + t_H\frac{\partial \Pi}{\partial t_H}\right) + t_X\frac{\partial \Pi^*}{\partial t_H} - f\frac{\partial N^*}{\partial t_H} - [c + (1-\alpha)\tau]\frac{\partial N_\tau}{\partial t_H} \quad (3.20)$$

[18] As the CES price index reflects the price of the optimized consumption bundle, it unambiguously falls when fewer varieties are available, even though these varieties were the most expensive in the market.

The first term again captures the effect on consumption: If the tax rate is higher, it is more difficult to be profitable enough to stay in the market despite the excess burden of regulations to limit profit shifting. Thus, a higher tax rate implies fewer varieties in the market, thereby decreasing welfare. The second term captures the effect of a tax rate increase on tax revenues. First, there is a direct effect: A higher tax rate implies higher revenues, everything else being equal. However, there is also a negative indirect effect, as the tax base decreases because the higher tax rate leads to more profit shifting. The additional profit shifting also implies that income is "lost" in the tax haven, because more profits are taxed there. This effect is represented by the third summand of eq. (3.20). As more firms incur the fixed costs of profit shifting, income is further reduces, as the fourth term shows. Lastly, there also is a positive effect of market exit due to higher tax rates: As fewer firms are active, the dead weight loss of the limitation on profit shifting affects fewer firms and fewer firms have to pay the fixed costs of production.

These various effects allow no clear conclusion whether limiting profit shifting is desirable, given that it imposes costs on all firms. To see the effects of such a limitation more clearly, the next section looks at some numerical simulations of the modeled economy.

## 3.4 Numerical Analysis

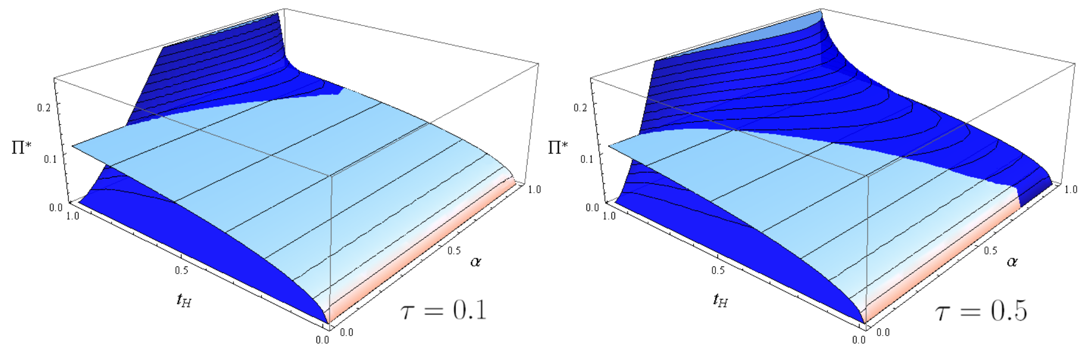
### 3.4.1 Simulation of Proposition 3.1

The theoretical model has shown that it is not clear that a regulation that limits profit shifting always succeeds in its aim of decreasing the amount of profits that is shifted to a tax haven (see Proposition 3.1). In the following, numerical simulations will illustrate this. Their results are shown in Figure 3.1.

The graphs clarify how the tax policy of the home country affects the aggregate amount of profits shifted abroad. It compares the aggregate value of profits shifted abroad in the case with a limitation on profit shifting (dark plane) and without such a limitation (light plane). The optimal response of the tax haven (i.e. the optimal $t_X$) is taken into account.

On the two axes with the independent variables are $t_H$ and $\alpha$, which constitute the home countries tax policy. The graph in the benchmark case without a limitation on profit shifting (i.e. the light layer) is independent of $\alpha$, which is drawn on the right-

Figure 3.1: Aggregate Profits Shifted Abroad




This figure shows aggregate profits shifted abroad, with a limitation imposed (dark plane) and without such a limitation (light plane). Parameter values: $L = 1, \mu = 0.5, \beta = 3, f = c = 0.1, \gamma = 1.5, \sigma = 2$. On the left, $\tau = 0.1$, on the right, $\tau = 0.5$.

hand axis. Aggregate profits in the tax haven go to zero if either $\alpha \to 0$ or $t_H \to 0$, as then there is either no possibility or no incentive to shift profits abroad. Note, however, that this does not allow any inference about welfare.

The graphs clarify that only for some combinations of $\alpha$ and $t_H$ a rule which limits profit shifting actually leads to less profits being shifted abroad on aggregate. Even with relatively low costs of profit shifting regulation (left graph), a strict regulation may induce more profit shifting if the tax rate is high. If the burden is relatively high (right graph), very strict regulations to limit profit shifting may be counterproductive no matter what the tax rate is. As explained above, this happens because such regulation decreases competition in the market.

### 3.4.2 Simulation of Proposition 3.2

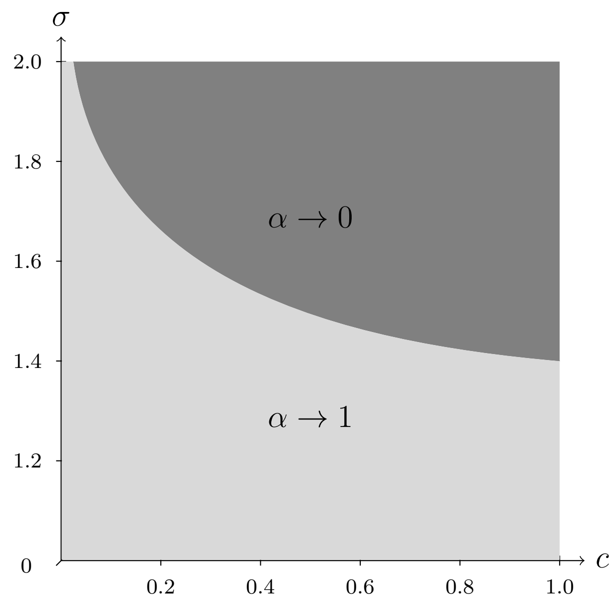
Lastly, let us consider the welfare effects, which where described in Section 3.3 and summarized in Proposition 3.2. A numerical analysis of the model confirms that it is not always optimal to limit profit shifting if this entail costs for all firms.

However, the simulations also show that if a limitation is welfare-increasing at all, then the government should set is as strict as possible, i.e. set $\alpha \to 0$ (see Appendix C).[19] Thus, the optimum in the model economy is always a corner solution, setting $\alpha$ either to 0 or to 1.

[19] A prohibition of all profit shifting possibilities is not what we observe in reality. Note, however, that in the model it is actually feasible to deter all profit shifting, which is hardly the case in reality. It should hence be interpreted as the government limiting profit shifting as much as it can, while in the other alternative the government chooses not to limit profit shifting at all.

It depends on the characteristics of the economy (i.e. on parameters) whether a country chooses to prohibit profit shifting or not. The following two figures (Figures 3.2 and 3.3) show how market and firm characteristics influence whether profit shifting should be barred.

Figure 3.2: Prohibiting Profit Shifting Given Different Market Characteristics



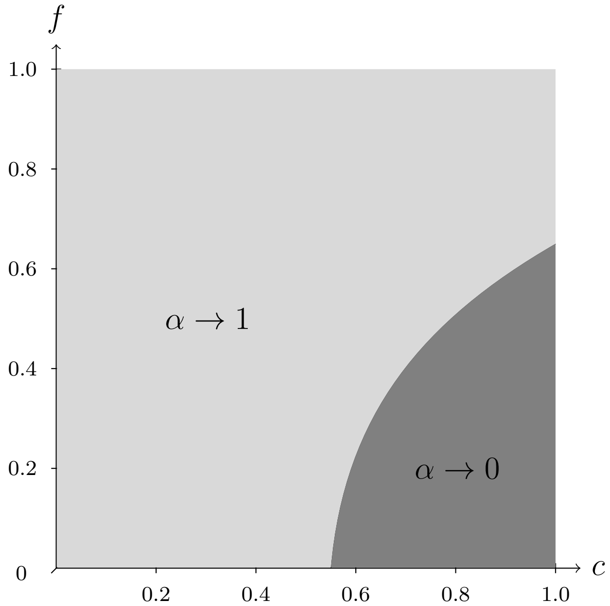

This figure shows when it is optimal to prohibit profit shifting given different market characteristics. Parameter values: $\gamma = 1.5, L = 1, \mu = 0.5, \beta = 3$ and $f = \tau = 0.1$.

Figure 3.2 summarizes the results of simulations comparing welfare without a limitation on profit shifting (i.e. $\alpha \rightarrow 1$) and after its introduction for different market characteristics. These are on the one hand the elasticity of substitution, $\sigma$, which is also a measure for competition in the market, and fixed costs, $c$, which represent barriers to entry into the market. The darker area represents parameter constellations under which it is favorable to prohibit profit shifting.

Profit shifting should not be limited if there are relatively many firms in a relatively uncompetitive market. If the elasticity of substitution is low, then it is more important for consumers to have as many firms in the market as possible. Hence, the utility loss of loosing additional varieties is higher. In contrast to what might be the first intuition, this effect is stronger when many firms are in the market (low fixed costs $c$), because the additional fixed costs of limiting profit shifting become more important when other fixed costs are low.

A further interesting aspect is the interplay of the different firm characteristics, namely

Figure 3.3: Prohibiting Profit Shifting Given Different Firm Characteristics




This figure shows when it is optimal to prohibit profit shifting given different firm characteristics. Parameter values: $\gamma = 1.5, L = 1, \mu = 0.5, \beta = 3, \tau = 0.1$ and $\sigma = 1.5$.

fixed costs $c$ and the costs of profit shifting, $f$, which is depicted in Figure 3.3. It is intuitive that the benefit from limiting profit shifting is smaller if few firms shift profits due to high costs $f$, especially because the burden imposed by regulation to hinder this falls on all firms. However, high fixed costs $c$ make it more likely that profit shifting should be limited. If fixed costs are high, the market consists mainly of highly profitable firms, which are more likely to shift profits abroad, thus increasing the benefit of limiting profit shifting.

The degree of firm heterogeneity also influences whether profit shifting should be prohibited or not. Heterogeneity is measured by $\gamma$. High heterogeneity (a low $\gamma$) implies that the distribution of firm productivity is relatively even, i.e. there are many firms with very high or low productivity levels.[20] The simulations also show that limiting profit shifting is more favorable if firms are very heterogeneous. In that case, there are relatively many large, productive firms, which would shift all of their profits abroad otherwise, and relatively few small, unproductive firms, which are affected negatively (or even forced out of the market) by the regulations.

[20] A low level of firm heterogeneity in this sense would be the case if there are many firms with similar (low) productivity levels and only very few highly productive firms.

## 3.5 Conclusion

This essay has analyzed the various effects and welfare implications of limiting profit shifting. It points out that regulations that aim to limit profit shifting may curb competition by forcing some firms out of the market. By rendering the remaining firms more profitable, it is possible that *more* profits are shifted abroad on aggregate after the introduction of a regulation that is supposed to prohibit or limit profit shifting.

In the introduction it was mentioned that such measures, e.g. thin capitalization rules, have increasingly been introduced or strengthened during the last years. The model also offers explanations for this by clarifying the effect of different parameters on the likelihood that limiting profit shifting increases welfare. It becomes clear that lower costs of profit shifting, which may have resulted from increasing financial integration, make limiting profit shifting more beneficial.

# Chapter 4

# Taxation and Corporate Risk-Taking

## 4.1 Introduction

Firm risk-taking is essential for long-term economic growth (Obstfeld, 1994). Despite governmental attempts to stimulate growth in the post-financial-crisis period via fiscal stimulus and monetary policy, the major world economies have remained stagnant. For example, annual GDP growth rates in 2008-2012 averaged only 0.52 percent in the U.S. and -0.39 percent in the European Union (OECD, 2012a). Thus, there is real demand for private sector risk-taking to stimulate growth. Recent evidence suggests that entrepreneurs have become reluctant to engage in risky ventures (Haltiwanger, 2011), and therefore, corporate risk-taking and risky corporate investment are an important source for macroeconomic growth. This essay investigates how a government can encourage firm risk-taking through the corporate tax system.

The academic literature has recently examined different determinants of risk-taking (John et al., 2008; Bargeron et al., 2010; Acharya et al., 2011; Faccio et al., 2011). These articles focus on firm-level characteristics and country-level institutions and regulations, but none explore the influence of a country's tax system on firm risk-taking. However, prior theoretical and empirical evidence document that taxes affect risk-taking at the individual level because the government effectively provides insurance for risky investments through the tax loss offset rules (Domar and Musgrave, 1944;

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This chapter is based on joint work with Rebecca Lester.

Feldstein, 1976; Poterba and Samwick, 2002; Cullen and Gordon, 2007).[1] We test if a similar economic effect exists in the corporate context by extending existing theoretical models to firms and by providing the first empirical evidence of this insurance effect using a new measure of firm risk developed by John et al. (2008). Given the large amount of aggregate corporate tax losses, the ability to recover and utilize such losses has considerable macroeconomic implications.[2]

We first extend the existing theoretical models of taxation and risk-taking to the corporate setting and examine how a country's tax rate and tax loss rules affect firm risk-taking. The model demonstrates that better loss offset rules increase corporate risk-taking. However, the effect of a country's tax rate on firm risk differs across firms. For firms that can fully offset losses, the model predicts that higher tax rates increase risk-taking. The intuition, as first proposed in Domar and Musgrave (1944) for individual portfolio choice, is that a tax system with full loss offset reduces both the mean and variance of returns on investment, which in turn increases the demand for risky assets. If a firm expects to recoup only very little of any loss incurred, however, higher tax rates will reduce risk-taking.

We then use these theoretical predictions to generate our hypotheses for the empirical tests. First, we posit that better loss offset, measured by more favorable loss carryback/carryforward periods, is positively related to corporate risk-taking. Second, we hypothesize that the statutory corporate tax rate has a positive effect on risk-taking when firms expect higher levels of loss offset, and a negative effect otherwise. Empirically, the effect of taxes on risky investment decisions will thus hinge on firms' expectations regarding loss recovery.

To test these hypotheses, we use an international firm-level panel dataset from Thomson Reuters' Worldscope that we combine with hand-collected data on corporate tax rates and tax loss rules. This cross-country sample allows us to exploit differences in tax loss carrybacks and carryforwards across 17 different jurisdictions, an empirical feature that is econometrically important given that country-specific tax loss rules are generally sticky across time. The sample begins in 1998 and ends in 2011, a thirteen year period that encompasses differing levels of industry-specific and macroeconomic

[1] Specifically, the government shares in the return on investment by assessing an income tax, but it also reduces any loss incurred by allowing the losses to offset prior or future taxable income. Thus, the tax system effectively shifts a portion of investment risk held by taxpayers to the government and provides incentives for risky investment.

[2] Large U.S. corporations generated over $2.9 trillion of aggregate losses from 1993-2004 (Cooper and Knittel, 2010).

risk, including the dot-com bubble of 1999-2000, the post-9/11 contraction, global economic expansion in the 2000s, and the financial crisis. While we control for these macroeconomic shifts with fixed effects, we expect that firms' risk preferences fluctuated throughout this period. We use a measure of firm-specific operating risk recently developed by John et al. (2008) that captures risk as the variance of returns to firm investment, measured by a firm's return on assets (ROA), consistent with the risk construct included in our theoretical model. This measure also allows us to remove the influence of home-country and industry-specific economic cycles, which generally cannot be altered by a firm's management, and thus directly reflects corporate investment decisions. Importantly, John et al. (2008) demonstrate that this measure is also correlated with long-term macroeconomic growth.

We find results consistent with our hypotheses. Loss carryback and carryforward periods are positively and significantly related to the level of firm risk-taking. Increasing the loss carryback period by one year is associated with a 48.6 percent increase in the firm risk measure.[3] Similarly, increasing the loss carryforward period by one year is associated with a 9.5 percent increase in the amount of firm risk. We also find that the economic benefit of the tax loss carrybacks increases with the tax rate, but such result does not obtain for tax loss carryforwards. These results are robust to controlling for other factors that likely affect firm risk-taking and tax status, including firm size, the firm's investment and growth opportunity set, and leverage, as well as industry and year fixed effects.

To test our second hypothesis, which considers the effect of the tax rate on firm risk-taking, we partition our sample based on firm-specific expectations regarding loss offset. While we cannot perfectly measure these expectations, we use data on prior profitability and the firm's home country statutory loss carryback/carryforward rules to create two groups for high or low loss offset. For example, we identify a firm that is active in a country that permits loss carrybacks and was profitable in the carryback years as a high loss offset firm, as it can likely offset any future loss immediately. In each subsample, we regress the risk-taking measure on the corporate tax rate and control variables. Again, we find results consistent with our hypothesis. We find that higher tax rates are positively and significantly related to risk-taking for the high loss

[3]For example, the median firm's ROA and *Risk* (measured over three years) is .05 and .105, respectively. Assuming that the average country-industry ROA is constant, this implies that a firm's ROA ratios over a three-year period based on the John et al. (2008) risk measure would be (for example) -0.055, 0.05, and .155. A one year increase in the carryback period is associated with a 48.6 percent increase in risk, which results in altered ROA ratios of -0.106, 0.05, and 0.206 over three years.

offset firms; a one percentage increase in the tax rate is associated with an 11.4 percent increase in the risk measure. If loss offset is uncertain, however, we find that higher tax rates are negatively related to risk-taking. In this case, a one percentage increase in the tax rate is associated with a 2.3 percent decrease in firm risk.

This essay is part of growing literature that considers various factors affecting firm risk-taking. Many papers address the effects of managerial incentives, including May (1995); Demski and Dye (1999); Rajgopal and Shevlin (2002); and Coles et al. (2006). More recently, the literature has documented that corporate governance (John et al., 2008), creditor rights (Acharya et al., 2011) and shareholder diversification (Faccio et al., 2011) are important determinants of corporate risk-taking. Bargeron et al. (2010) examine the effects of U.S. regulation imposed by the Sarbanes-Oxley Act.

To the best of our knowledge, there are no prior papers studying the effect of the corporate tax system on the riskiness of corporate investments. Instead, the literature that analyzes the effects of taxation on investment has thus far focused on the amount of capital investment (Hassett and Hubbard (2002) survey the extensive theoretical and empirical literature on this topic). A few studies in this strand of literature also consider loss offset provisions in addition to the tax rate. For example, Devereux et al. (1994) find that tax asymmetries do not improve the performance of tax-adjusted Q equations in predicting the level of investment. Edgerton (2010) studies how the asymmetric treatment of profits and losses affects the size of firm investment and finds that these asymmetries could have made bonus depreciation tax incentives at most 4 percent less effective than if all firms had been taxable. We offer evidence that suggests an alternative response to tax rules: Rather than increasing the level of investment, firms may simply alter the riskiness of the projects selected.

Another line of literature considers the influence of taxes on corporate decisions in the more narrow context of hedging. Graham and Smith (1999) show in a simulation analysis that tax-function convexity (which arises mostly because of loss carrybacks and carryforwards) provides an incentive to hedge for 50 % of firms. Graham and Rogers (2002) empirically test this prediction but find no evidence that tax convexity motivates firms to hedge. They show, however, that firms hedge to increase debt capacity, which also provides tax benefits. Our more general approach, which examines total risk-taking, takes into account that firms can manage risk in several ways, including investment project selection, diversification, hedging, and insurance.

In addition, the effect of taxes on risk-taking has been studied for individual portfolio choice and entrepreneurial risk-taking. These papers have contradictory conclusions.

While Asea and Turnovsky (1998) find that higher taxes make it less likely that individuals hold risky assets, Poterba and Samwick (2002) conclude that households invest more in stock (and less in taxable bonds) when personal income taxes rates rise due to the advantageous lower capital gains tax rates. Studying a sample of start-ups, Cullen and Gordon (2007) find that increases in personal income taxes have a negative effect on entrepreneurial risk-taking. Djankov et al. (2010) test the effect of corporate tax rates (but not tax loss rules) on entrepreneurship, measured by business registrations, and find that taxes have an adverse effect. In contrast to these studies, this essay examines large, publicly-traded corporations, as these firms are responsible for the bulk of aggregate investment.[4] In addition, this essay clearly shows why studies examining only the effects of tax rates on risk-taking have come to mixed conclusions, as both our model and the empirical results illustrate that this effect hinges on a firm's ability to recoup economic losses via tax loss offset provisions.

This chapter proceeds as follows. In Section 4.2, we provide a brief overview of corporate tax loss offset rules. Section 4.3 develops a theoretical model of how taxation may affect risk-taking. In Section 4.4, we outline our empirical hypotheses. A description of the research design and data is included in Section 4.5, and we discuss our results in Section 4.6. Section 4.7 provides robustness checks, and Section 4.8 concludes.

## 4.2 Overview of Tax Loss Offset Rules

In this section, we give an overview about the treatment of losses in the tax system. All developed countries impose a corporate-level income tax, which is assessed when firms report positive taxable earnings. Many countries' corporate tax rules include loss provisions that allow firms to recoup a portion of losses incurred by reducing prior or future taxable income. Specifically, if the loss is offset against past profits (a loss *carryback*), the government refunds some amount of tax the firm previously paid.[5] In countries where loss carrybacks are not allowed, or in instances where the firm has not been sufficiently profitable in prior years, the company can instead use the losses to offset income and lower its tax obligations in future periods (a loss *carryforward*).

[4] While only 0.08 percent of U.S. companies are listed, these firms account for 45.5 percent of aggregate non-residential fixed investment and 79.4 percent of aggregate pre-tax profits (Asker et al., 2011).

[5] For example, assume that a U.S. firm reported taxable income of \$100 in 2009 (and paid tax of \$35 at a 35% rate) and a taxable loss of \$80 in 2010. The firm can carry back the \$80 loss and received a refund of \$28 (\$8 $\cdot$ 35%).

Generally, the loss carryback and loss carryforward periods are limited; Table 4.1 summarizes the loss carryback periods (Panel 4.1A) and the loss carryforward periods (Panel 4.1B) for the countries studied in this essay.

Table 4.1: Statutory Loss Carryback and Carryforward Periods

Panel A: Statutory Loss Carryback Periods

| **Country** | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Belgium | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Denmark | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Finland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| France | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Germany | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| Greece | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ireland | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Italy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Luxembourg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Netherlands | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Norway | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Portugal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Spain | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Switzerland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| United Kingdom | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| United States | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

This table provides the statutory loss carryback periods from 1998 through 2011 for the countries represented in the empirical sample. Data collected from the yearly European Tax Handbook of the International Bureau of Fiscal Documentation (IBFD) and the U.S. Internal Revenue Code.

In general, loss carrybacks are preferred over carryforwards. If a firm was sufficiently profitable in the past, a loss carryback allows it to immediately receive a refund of prior year taxes paid when it incurs a loss. Otherwise, the firm must wait until a future year in which it generates positive taxable income to carryforward the loss and receive a reduction in the corresponding future tax payment. Therefore, loss carrybacks generate real cash flow for companies in the year that the loss is incurred, whereas the economic benefit of a loss carryforward is a function of expected future profits, the expected year of profitability, the expected future tax rate, and the firm's discount rate. Carryforwards thus offer an inherently more uncertain tax benefit.

A large number of firms report an economically significant amount of tax losses (Altshuler and Auerbach, 1990). Cooper and Knittel (2010) document that 45-50 percent of U.S. corporations report net operating losses on U.S. tax returns for the period 1993-2004, and these losses are valued at $2.9 trillion in total. The proportion of loss firms has increased 280 percent in the last three decades, from 12 percent of firms in

Panel B: Statutory Loss Carryforward Periods

| **Country** | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* |
| Belgium | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* |
| Denmark | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | 5 | 5 | 5 | 5 | 5 |
| Finland | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| France | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | 5 | 5 | 5 | 5 | 5 | 5 |
| Germany | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* |
| Greece | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Ireland | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* |
| Italy | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Luxembourg | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* |
| Netherlands | 9 | 9 | 9 | 9 | 9 | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* |
| Norway | *I* | *I* | *I* | *I* | *I* | *I* | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Portugal | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Spain | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 10 | 10 | 10 | 7 |
| Switzerland | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| United Kingdom | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* | *I* |
| United States | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 10 | 10 |

This table provides the statutory loss carryforward periods from 1998 through 2011 for the countries represented in the empirical sample. Data collected from the yearly European Tax Handbook of the International Bureau of Fiscal Documentation (IBFD) and the U.S. Internal Revenue Code. *I* indicates an indefinite carryforward period.

1973 to 1977 to over 47 percent in 1999 to 2003 (Edgerton, 2010), and in 2002 alone, the ratio of loss firms to those not reporting losses was over 60 percent (Altshuler et al., 2009). Prior literature finds that managers view these losses as firm assets and therefore undertake actions to preserve and maximize the associated benefits (Maydew, 1997; Albring et al., 2011).[6] In summary, this literature demonstrates that tax losses and the corresponding tax loss rules are relevant and economically significant for many firms. We expect that this importance is not only limited to the *ex-post* preservation and utilization of losses once they have been incurred. Therefore, we study whether these tax loss rules also create *ex-ante* incentives for corporate risk-taking decisions.

## 4.3 A Model of Firm Risk-Taking

To examine how taxation affects firm risk-taking, we first develop a simple model that captures both the corporate tax rate and tax loss offset provisions. We consider a representative firm, which operates in a world with uncertainty. There are two

[6] Erickson and Heitzman (2010) discuss the use of "poison pill" provisions as one real action that firms undertake to protect tax losses; these poison pill provisions effectively restrict stock ownership changes, which could otherwise trigger U.S. statutory limitations on the future utilization of loss carryforwards.

potential states of the world. In the "good" state of the world, which occurs with probability $p$, the firm successfully generates a profit from selling its product. In the "bad" state of the world (probability $1-p$), the firm incurs a loss. The firm can invest in a technology that increases both the potential profit and the potential loss. For example, this investment may be a larger machine that can produce more output but that also costs more, even when idle.

Specifically, the firm has a return of $f_g(I) > 0$ in the good state of the world. When the investment $I$ is higher, this return increases, but with diminishing returns: $f_g{}'(I) > 0$, $f_g{}''(I) < 0$. In the alternative bad state of the world, the firm incurs a loss, $f_b(I) < 0$. The loss is also larger when the investment is higher, and it increases more quickly the greater the investment in the risky technology: $f_b'(I) < 0$, $f_b'' < 0$ . The corresponding cost of the investment $I$ increases linearly with the amount of investment, and we normalize this cost to 1 per unit of investment. To guarantee that some investment in $I$ is optimal, we assume that, at low levels of $I$, the payout in the good state increases faster than the payout in the bad state, and that the marginal return of the investment is positive: $pf_g'(I=0) + (1-p)f_b'(I=0) > 1$.

A higher investment in this technology results in a higher variance of the possible returns of the firm. Defining the average profit $\overline{\pi} = pf_g + (1-p)f_b - I$, the variance of pre-tax profits is:

$$Var = p[f_g(I) - I - \overline{\pi}]^2 + (1-p)[f_b(I) - I - \overline{\pi}]^2 = p(1-p)[f_g(I) - f_b(I)]^2. \quad (4.1)$$

As the difference between the returns $f_g(I) - f_b(I)$ is increasing in $I$, the variance of profits is also rising in $I$.[7] In our model we will thus equate a larger investment in $I$ with more risk-taking by the firm.

Firms should select the appropriate level of risky investment to maximize after-tax returns to shareholders. However, the firm's investment choice may be affected by firm risk aversion. While firms are in general assumed to be risk-neutral, there are several reasons why firms may exhibit risk-averse characteristics, including non-diversified owners, liquidity constraints, costly financial distress, and non-linear tax systems (Asplund, 2002). For example, firms may avoid risky investments if such projects

[7] In Section 4.5, we discuss our empirical constructs to capture the key elements from this model. For example, we use the standard deviation of profits as our measure of the level of risk at the firm, which reflects the variance of returns to firm assets discussed in this section. This is consistent with the common definition of risk as the variance of returns to some investment (Domar and Musgrave, 1944; Feldstein, 1969; Stiglitz, 1969; Asea and Turnovsky, 1998).

increase the probability of financial distress (Purnanandam, 2008). Géczy et al. (1997) show that firms with tighter financial constraints are more likely to hedge currency risks. Finally, firm risk-aversion has been linked to managerial preferences. A risk-averse manager will consider risk in investment decisions if compensation is linked to firm performance (Tufano, 1996; Guay, 1999b; Hall and Murphy, 2002; Lewellen, 2006). May (1995) finds that the personal wealth invested in firm equity is related to the riskiness of acquisitions. Similarly, Coles et al. (2006) find a positive relationship between the sensitivity of CEO wealth to stock volatility (vega) and firm risk.

In summary, prior literature establishes that firms indeed exhibit risk-averse characteristics. Therefore, we model the objective function of the firm as a utility function (see e.g. Sandmo, 1971; Appelbaum and Katz, 1986; Asplund, 2002), which allows us to take into account varying levels of risk aversion, including risk neutrality as a special case.

The firm maximizes its utility, which is a function of its after-tax profits, $\pi$. The utility function $U(\pi)$ is continuously differentiable, so that $U'(\pi) > 0$ and $U''(\pi) \leq 0$. The firm pays a corporate income tax at rate $t$ on its profit ($0 < t < 1$). If the firm incurs a loss, it receives a tax refund on some fraction $\lambda \in [0, 1]$ of the loss.[8] Thus, the expected utility of the firm is given by

$$EU(\pi) = pU\left[(1-t)\left(f_g(I) - I\right)\right] + (1-p)\,U\left[(1-\lambda t)\left(f_b(I) - I\right)\right]. \tag{4.2}$$

The firm chooses the optimal level of investment in the risky technology by maximizing its expected utility. The first order condition for the optimal level of $I$ is

$$\frac{\partial EU(\pi)}{\partial I} = pU'[\pi_g](1-t)\left[f_g'(I) - 1\right] + (1-p)\,U'[\pi_b]\;(1-\lambda t)\left[f_b'(I) - 1\right] = 0, \tag{4.3}$$

where $\pi_g = (1-t)(f_g(I) - I) > 0$ denotes the after-tax profit in the good state of the world, and $\pi_b = (1-\lambda t)(f_b(I) - I) < 0$ is the after-tax profit in the bad state of the world. The first term of eq. (4.3) demonstrates that a higher investment in the risky technology increases the firm's profit in the good state of the world. In contrast, the second term shows that the loss increases with the size of the investment if the bad state occurs.

[8] This is a simplification of actual loss offset provisions. A loss offset parameter of $\lambda = 1$ would apply to a firm that i) operates in a country that permits loss carrybacks and ii) has been profitable in the carryback period. Otherwise, $\lambda < 1$, with the exact value of $\lambda$ depending on statutory loss carryforward rules as well as the firm's expected future profitability. We discuss this distinction related to the definition of $\lambda$ in Section 4.5.1.

Based on the model of expected utility and the optimal level of $I$, we now derive predictions about how a country's tax system can affect a firm's level of risk-taking. We first consider the loss offset parameter $\lambda$, and then turn to the effects of a country's tax rate $t$.

### 4.3.1 Effect of Tax Loss Offset Rules ($\lambda$) on Firm Risk-Taking

Implicit differentiation of the first order condition (4.3) with respect to $\lambda$ shows that risk-taking increases when firms are better able to recoup economic losses incurred from risky investment (i.e., when $\lambda$ is higher):

$$\frac{dI}{d\lambda} = \frac{-t\left[f_b'(I) - 1\right](1-p)\left[U'(\pi_b) + U''(\pi_b)\,\pi_b\right]}{-SOC} > 0, \tag{4.4}$$

where the second order condition $SOC$ is negative and given in the proof of Proposition 4.1. Greater loss offset results in a higher investment in the risky technology because it reduces the downside of risk-taking (the loss) by increasing the tax refund in the bad state of the world. Moreover, when there is a larger tax refund available, the loss occurs at a lower marginal utility. We summarize the effects of loss offset rules on risk-taking in the following proposition:

**Proposition 4.1 (The effect of loss offset provisions on risk-taking)**
*Better loss offset (higher $\lambda$) increases firm risk-taking, as measured by the variance of the returns in the different states of the world.*

**Proof.** Consider eq. (4.4). The second order condition is $SOC = pU''(\pi_g)(1-t)^2\left[f_g'(I) - 1\right]^2 + pU'(\pi_g)(1-t)\,f_g''(I) + (1-p)\,U''(\pi_g)(1-\lambda t)^2[f_b'(I) - 1]^2 + (1-p)\,U'(\pi_b)(1-\lambda t)\,f_b''(I) < 0$. It is fulfilled (i.e. negative) as $U''(\pi) < 0$ and $f_g''(I)$, $f_b''(I) < 0$. Thus, the denominator of eq. (4.4) is positive. Note that $U''(\pi_b)\,\pi_b > 0$ as $\pi_b < 0$. As $f_b'(I) < 0$, the numerator is also positive, so that $\frac{dI}{d\lambda} > 0$. ■

The size of the effect of loss offset provisions on risk-taking varies with the tax rate. The direct effect, which is shown in the numerator of eq. (4.4), is positive: As the tax refund in the case of a loss rises with the tax rate, loss offset provisions provide better incentives for risk-taking when the tax rate is higher. There are, however, ambiguous indirect effects that become clear when one differentiates the second order condition with respect to $t$: Not only does a higher tax rate affect the tax refund in the bad state of the world, but it also lowers the after-tax return in the good state of the world.

Next, we consider the effect of the tax rate on firm risk-taking in more detail.

### 4.3.2 Effect of the Tax Rate (t) on Firm Risk-Taking

We start again by implicitly differentiating the first order condition (4.3) and obtain

$$\begin{aligned}\frac{dI}{dt} &= \frac{1}{-SOC}\left\{-pU''(\pi_g)\,\pi_g\left[f_g'(I)-1\right]-pU'(\pi_g)\left[f_g'(I)-1\right]-\right.\\ &\quad \left.(1-p)\,U''(\pi_b)\,\lambda\pi_b\left[f_b'(I)-1\right]-(1-p)\,U'(\pi_b)\,\lambda[f_b'(I)-1]\right\}. \end{aligned} \tag{4.5}$$

For ease of interpretation, we rewrite eq. (4.5) using the Arrow-Pratt coefficient of relative risk aversion, $R_R(\pi) = -\frac{U''(\pi)}{U'(\pi)}|\pi|$.[9] Then, after simplifying, $\frac{dI}{dt}$ becomes

$$\frac{dI}{dt} = \frac{U'(\pi_g)\,p\left[f_g'(I)-1\right]\left[R_R(\pi_g)-1\right]-\lambda U'(\pi_b)(1-p)\left[f_b'(I)-1\right]\left[R_R(\pi_b)+1\right]}{-SOC}. \tag{4.6}$$

The first summand in the numerator captures the effect of the tax rate on the profit in the good state of the world. The tax rate lowers the return to additional risky investment by reducing after-tax profits, but it also increases the marginal utility of the additional profit. The level of the firm's risk aversion determines which of these two effects dominates. For low levels of risk aversion, higher taxes will reduce firm risk-taking.

The second summand shows the effect of the tax rate if the firm generates a loss. The amount of actual loss offset is a function of both the amount of allowable loss offset ($\lambda$) and the applicable tax rate ($t$).[10] Note that this effect arises only when there is some available loss offset (i.e., $\lambda > 0$); if $\lambda = 0$, then the second summand will be equal to zero. Consequently, we next analyze the effects of the tax rate on firm risk-taking for the two extreme cases: full loss offset and no loss offset.

We first consider the case of full loss offset ($\lambda \to 1$). If the firm is risk-neutral, taxes do not affect risk-taking. However, for a risk-averse firm, taxes will decrease both the

[9] As $\pi^L < 0$, we define the coefficient of relative risk aversion using the absolute value of $\pi$ so that it has a positive value for firms that incur a loss.

[10] This result is intuitive because the amount of recoverable loss will depend upon the country's statutory tax loss provisions ($\lambda$) and the tax rate ($t$). For example, assuming that two companies can both carryback losses and were sufficiently profitable in prior years (i.e, the same $\lambda$), the amount of recoverable loss will be greater in the country with the higher tax rate.

mean and the variance of returns; that is, the government will share equally in the profit (at tax rate *t)* and the loss (at $\lambda \cdot t = t$). Given this "insurance" provided by the government, firms will *increase* risk-taking with an increase in the tax rate.[11] This result holds regardless of the level of risk-aversion that the firm demonstrates.

We next consider the case of no loss offset ($\lambda \to 0$). The effect of taxes on firm risk-taking then depends on the level of firm risk aversion. If the risk-aversion of the firm is low ($R_R < 1$), tax rates *decrease* risk-taking. The negative effect of taxes on the additional return in the good state of the world subsumes the positive effect, arising from the fact that the additional utility occurs at a higher marginal utility. If the firm is very risk-averse ($R_R > 1$), tax rates always *increase* risk-taking.

To the best of our knowledge, there are no empirical estimates of firm-level coefficients of risk aversion. However, as we discussed above, managers may impose risk aversion on the firm through their individual preferences and investment project selection. Consequently, we draw upon prior estimates of individual risk aversion. Recent empirical studies point out that relative risk aversion is constant and relatively low (Chiappori and Paiella, 2011). Using existing evidence on the effect of wage changes on labor supply, Chetty (2006) finds a mean estimate of the coefficient of relative risk aversion of 0.71, with all estimates in a range between 0.15 and 1.78 in the baseline case. We expect that the level of risk-aversion will be attenuated relative to estimates for individuals based on predictions derived from principal-agent contracting. Specifically, managers generally receive some fixed compensation (a salary) as well as a variable component (bonus or stock-based compensation) to align the incentives of the manager with those of the shareholders; because some portion of the salary will be received regardless of the firm's performance, the manager is likely to exhibit less risk aversion than if all of the compensation was a function of firm profits. Therefore, we hypothesize that the risk aversion coefficient of the firm will be less than 1. In this case, taxes decrease risk-taking if there is no loss offset ($\lambda \to 0$).

We summarize the effects of tax rates on firm risk-taking in the following proposition:

**Proposition 4.2 (The effect of tax rates on risk-taking)**

1. *If there is full loss offset ( $\lambda \to 1$), higher tax rates increase the risk taken by a risk-averse firm. If the firm is risk-neutral, taxes have no effect.*

[11] This effect is similar to the one first shown by Domar and Musgrave (1944), who evaluate individual portfolio investment risk-taking for a scenario with full, partial, or no loss offset.

2. *If there is no loss offset ( $\lambda \to 0$), higher tax rates decrease firm risk-taking if the firm is only moderately risk-averse ($R_R < 1$). For very risk-averse firms ($R_R > 1$), taxes always increase risk-taking.*

**Proof.** The denominator of eq. (4.6) is positive, as the second order condition is negative (see proof of Proposition 4.1). It is thus sufficient to look at the numerator of eq. (4.6).

On 1): Taxes increase risk-taking for firms with $R_R > 0$ if $U'(\pi_g)\, p \left[f_g'(I) - 1\right] \leq -U'(\pi_b)(1-p)[f_b'(I) - 1]$. From eq. (4.3) we know that this is fulfilled with equality when $\lambda = 1$. Thus, $\frac{dI}{dt}\Big|_{\lambda=1} > 0$.

On 2). Inspection of eq. (4.6) shows that the sign of eq. (4.6) is fully determined by $[R_R(\pi_g) - 1]$ when $\lambda = 0$. ■

The model has shown that in addition to the tax rate, loss offset provisions are a decisive determinant of the overall effect of taxes on risk-taking. If no loss offset is possible, a higher tax rate decreases firms' willingness to take risk. With full loss offset, this effect is reversed: higher taxes instead increase firm risk-taking. Holding the tax rate constant, the model shows that better loss offset generally increases risk-taking.

## 4.4 Hypotheses

In this section, we derive our hypotheses to empirically test the theoretical predictions outlined in Section 4.3. As discussed in Section 4.2, the amount of loss offset that a company will receive is a function of i) statutory tax rules, including the loss carryback/carryforward period, and ii) the company's prior profitability and future expectation of income. The combination of the country-level rules and firm-specific profitability determines the amount of the theoretically derived, firm-specific $\lambda$. Our two hypotheses test each of these elements separately.

Our first hypothesis examines the statutory tax rules. Specifically, we assess a country's loss carryback/carryforward periods and the statutory tax rate. We focus on these rules first because they can be directly altered by a country as part of its fiscal policy. Proposition 4.1 states that better loss offset increases firm risk-taking. Consistent with this proposition, we expect that firms in countries with longer carryback and carryforward periods will exhibit greater risk-taking because these rules increase the period over which companies could generate profits to offset any losses incurred; that is, longer periods provide greater insurance benefits. Therefore, our first hypothesis is as follows:

**Hypothesis 4.1a** *Tax loss carryback and carryforward periods are positively related to corporate risk-taking.*

While we predict a positive relation between the loss offset period and risk-taking, prior evidence suggests that the effect of loss offset on firm investment decisions is very small. For example, Devereux et al. (1994) model firm investment by specifically taking into account tax losses and find that these tax-loss-specific models perform no better in predicting such investment than models that ignore tax asymmetries. Similarly, Edgerton (2010) investigates the relation between the level of firm investment and a firm's tax status as determined by the availability of loss carrybacks/carryforwards and finds minimal economic association. These studies, however, examine the level of firm investment, not the type or riskiness of investments made. With respect to firm risk-taking, prior literature has shown that many factors affect investment decisions, including corporate governance (John et al., 2008), creditor rights (Acharya et al., 2011), and shareholder diversification (Faccio et al., 2011) and therefore, these tax rules may not provide sufficient economic incentive to significantly alter a firm's risk profile.

We next investigate how the relation between risk-taking and tax loss rules, if any, is affected by a country's tax rate. Due to counteracting effects, the theoretical model did not outline specific predictions. On one hand, the tax refund in the case of a loss is larger when the tax rate is higher. On the other hand, the tax rate itself may have negative effects on the incentives to undertake risky investments. We posit that the former effect dominates. We formulate this in a second part of our first hypothesis:

**Hypothesis 4.1b** *A positive relation between tax loss carryback and carryforward periods and corporate risk-taking increases with the country tax rate.*

A positive relation would be consistent with the findings of Feldstein (1976) and Poterba and Samwick (2002), both of which document that risk-taking rises with the tax rate. Their findings, however, relate to individual investment portfolios and may not be applicable for corporations. Furthermore, because taxation decreases the amount of profit earned from successful risky investment, tax rates instead may be negatively related to corporate risk-taking (see e.g. Djankov et al., 2010).[12]

These first two hypotheses focus on how statutory rules can affect the economic benefit of loss recovery. However, the effectiveness of country-level loss offset rules in altering firms' risk-taking will also be influenced by firm-specific factors – most notably, a firm's prior and expected profitability. Therefore, to study the effect of country-level tax rates on the firm, we must also consider these firm-specific expectations regarding future loss offset.

Based on Proposition 4.2, we predict that taxes and risk-taking will be positively related for firms that can expect significant loss offset (the "high $\lambda$" firms in the model). For these firms, taxation lowers both the mean and the variance of the investment, inducing managers to assume more risk. Indeed, prior literature has found such an effect for small, non-corporate firms (Cullen and Gordon, 2007).[13] Therefore, to investigate this relation in a corporate context, we predict the following:[14]

**Hypothesis 4.2a** *Tax rates are positively related to firm risk-taking for firms that can expect significant loss offset ("high $\lambda$ firms").*

Next, we examine firms that may receive only limited benefit from tax loss rules, i.e. "low $\lambda$ firms" in the model. For these firms, taxation will affect successful risky investments via a tax on income, but the firm will be unable to receive much offset for any losses incurred.[15] Consequently, managers have less incentives to engage in risk-taking, as the tax decreases any positive return, while the firm has to carry the full downside of the risky investment. For these firms, we predict the following:

[12]Note that Djankov et al. (2010) focus only on the effect of tax rates on investment in their cross-country study. They do not consider the effect of losses in their analysis, which we showed in our model to be an important element of this relation.

[13]Cullen and Gordon (2007) focus primarily on single individual income tax filers from 1964 through 1993 who are estimated to be entrepreneurs. We instead study corporations because we are interested in how corporate taxation affects risk-taking given that publicly-traded firms are economically significant and responsible for a material amount of annual investment spending. Furthermore, our study includes a more recent sample period of 1998-2011.

[14]Note that this predicted relation assumes some level of risk aversion at the firm. This follows not only from our model, but also from the literature (Tufano, 1996; Géczy et al., 1997; Purnanandam, 2008). Consistent with our predictions, Gordon (1985) models (but does not test) the effect of taxation on corporate risk-taking assuming risk neutrality and finds no change.

[15]This is similar to the results of Green and Talmor (1985), who model (but do not empirically test) tax liabilities as a call option on the firm; even with the inclusion of partial loss offset provisions, they conclude that the firm has incentives to avoid risky projects because of the government's claim against the firm.

**Hypothesis 4.2b** *Tax rates are negatively related to firm risk-taking for firms that expect limited or no loss offset ("low $\lambda$ firms").*

In the next section, we discuss the research design and sample used to empirically test these hypotheses.

## 4.5 Research Design & Sample Selection

### 4.5.1 Research Design

A cross-country setting is ideal to test our research question because it allows us to examine the effect of differing tax rules across many jurisdictions, particularly given that the tax loss carryback and carryforward periods are relatively sticky within each country. To test the first Hypothesis (4.1a and 4.1b), we use the following regression specification:

$$Risk_{ijt} = \beta_0 + \beta_1 LC_{jt} + \beta_2 CTR_{jt} + \beta_3 LC * CTR_{jt} + \beta_n X_{ijt} + \theta_k + \rho_t + \epsilon_{it}, \quad (4.7)$$

where $Risk_{ijt}$ is a measure of the riskiness of firm $i$'s investment in country $j$ in year $t$ (discussed further below); $LC_{jt}$ captures the number of years in the statutory loss carryback or loss carryforward period within a firm's home country; and $CTR_{jt}$ is the statutory corporate tax rate in the firm's home country.[16] $LC * CTR_{jt}$ measures the incremental effect of a country's loss rules on corporate risk-taking, given the level of a country's tax rate. $X_{ijt}$ is a set of firm- and country-specific controls, discussed further below; $\theta_k$ captures industry fixed effects; and $\rho_t$ are year fixed effects. Lastly, we cluster standard errors by firm and country-year to account for within-firm and within-country-year correlation in our sample (Petersen, 2009). Based on Hypothesis 4.1a, we expect that the coefficient on $LC_{jt}$, $\beta_1$, will be positive and significant. Hypothesis 4.1b predicts that the effect of the loss offset periods increases with a country's tax rate because higher tax rates yield higher economic benefits in the event losses are sustained. Therefore, we expect a positive coefficient for $\beta_3$ as well. We do not predict the sign of $\beta_2$ in this regression because Proposition 4.2 shows that the relation between risk-taking and the corporate tax rate varies based on firm-specific expectation of loss offset; we

[16] The variable CTR is de-meaned in this specification, so that the coefficient $\beta_1$ can be interpreted as the effect of the loss rules on risk-taking, given the average corporate tax rate in the sample.

outline these cross-sectional predictions in additional detail below in discussion of the tests of Hypotheses 4.2a and 4.2b.

A firm's risk can be measured as the variance of returns to a firm's investments or assets over time. John et al. (2008) find that riskier corporations indeed have more volatile returns to capital. Consistent with this definition, we modeled risk in Section 4.3 as the variance of profits generated from a risky investment over different states of the world. To empirically measure this construct, we calculate our dependent variable $Risk_{ijt}$ as a function of a firm's return on assets (ROA). If a firm assumes a greater amount of risk than its peers, its ROA will be higher in some periods when risky investment succeeds and lower in other periods when the risky investment fails. We thus proxy for risk-taking by i) computing the difference between the country-industry ROA average and the firm's ROA, measured as the ratio of EBIT to assets and ii) calculating the standard deviation of this measure over a three-year period. This approach is similar to John et al. (2008), Faccio et al. (2011), and Acharya et al. (2011) and allows us to remove the influence of home-country and industry-specific economic cycles, which cannot be altered by a firm's manager. This measure permits a clean analysis of firm-specific risk that directly reflects corporate operating and investment decisions.

We measure $LC$ with the number of years in a firm's home country tax loss carryback ($LCB$) and carryforward ($LCF$) period. The country's tax rate ($CTR$) is the statutory corporate income tax rate.[17]

We control for a firm's *Size* (log of total assets), as larger firms undertake the bulk of aggregate investment (Djankov et al., 2010). However, these larger firms may also have fewer risky opportunities and lower overall operating risk (John et al., 2008). Furthermore, prior literature documents that a firm's tax liability may be correlated with firm size (Zimmermann, 1983; Porcano, 1986; Rego, 2003). We include the market-to-book-ratio (*MB*, market capitalization to shareholders' equity) and *Sales Growth* (calculated as the one-year percentage change in revenues) to control for the firm's investment opportunity set, as firms with a greater set of possible investments likely engage in more risk-taking (Guay, 1999b; Rajgopal and Shevlin, 2002) but may also be less profitable and taxable. Given the cross-country sample used, we control for *GDP Growth* (as in John et al., 2008), constructed with data from the IMF's World Economic Outlook Database and calculated as the one-year percentage change in a country's GDP. *ROA*, measured as EBIT/assets, controls for a firm's ability to fund

[17] We use the average combined tax rate of central and sub-central governments. If the tax system is progressive, we use the top marginal tax rate.

investments and risky projects. Finally, we include *Leverage* (ratio of total liabilities to total assets) to control for firm risk related to costly financial distress, interest tax shields that may contribute to a firm's tax status, and incentives to assume excessively risky projects on behalf of shareholders after debt has been sold (Harris and Raviv, 1991; Leland, 1998). Appendix D provides a summary of these variables and the data sources used.

Our second hypothesis tests the effect of tax rates on firm risk-taking, which depends on both statutory rules and firm profitability (Proposition 4.2). To test this hypothesis, we estimate our theoretically derived measure of expected loss offset ($\lambda$) and partition the sample accordingly. This measure is intended to capture the *firm-specific expectation* of future loss offset, which we hypothesize will affect the firm's investment project selection; that is, when making an investment decision, we expect that a manager will consider the likely return to such investment (profit or loss) and the extent to which any future loss will be insured by the government via tax loss carrybacks and carryforwards. "High $\lambda$" observations include those firm-years in which i) the firm operates in a country where loss carrybacks are allowed, and ii) the firm previously reported positive earnings over the commensurate carryback period. Thus, this designation captures those firms that would be most likely to receive an immediate refund of prior taxes if a loss is sustained in a later year. Conversely, "low $\lambda$" firms are those firm-year observations in which i) the firm operates in a country where no loss carrybacks are permitted, such that the firm must rely on future profitability in order to obtain any loss offset, but ii) the firm is unlikely to be profitable in the short term based on historical operating performance.

In each of the subsamples, we estimate the following regression model:

$$Risk_{ijt} = \gamma_0 + \gamma_1 CTR_{jt} + \gamma_n X_{ijt} + \theta_k + \rho_t + \epsilon_{it}. \tag{4.8}$$

where the variables are as previously defined. The coefficient of interest is $\gamma_1$. As outlined in Proposition 4.2, we predict a positive effect ($\gamma_1 > 0$) for high $\lambda$ firms and a negative effect for low $\lambda$ firms. Controls and fixed effects are as described for the first set of regressions.

### 4.5.2 Sample Selection

In both regression specifications, we use a large cross-country firm-level panel dataset constructed from Thomson Reuters' Worldscope. We select all firms in Worldscope from 1998 through 2011 for seventeen different countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Switzerland, United Kingdom, United States) to create an original sample of 240,356 firm-year observations.[18] We choose this sample period because it includes differing levels of macroeconomic and industry-specific risk, including the dot-com bubble of 1999-2000, the post-9/11 contraction, global economic expansion in the 2000s, and the financial crisis. While we control for these macroeconomic shifts with fixed effects, firms' risk preferences may have fluctuated throughout these years, making it an suitable (and recent) period to examine firm risk-taking. We select these countries given the relatively comparable level of tax enforcement as compared to emerging market nations and because prior cross-country taxation studies focus on a similar geographic sample (e.g. Devereux et al., 2002; Devereux and Griffith, 2003).

Table 4.2: Sample Selection

| | Obs. dropped | Obs. remaining |
|---|---|---|
| Initial Worldscope dataset for countries in sample, 1998-2011 | | 240,356 |
| Eliminate observations for cross-listed firms | (5,789) | 234,567 |
| Eliminate observations for financial or utility firms | (62,162) | 172,405 |
| Eliminate observations missing total assets | (3,220) | 169,185 |
| Eliminate observations missing data for risk measure | (35,770) | 133,415 |
| Eliminate observations missing data for control variables | (49,206) | 84,209 |
| **Final Cross-Country Sample** | | **84,209** |

Worldscope provides balance sheet data on all listed firms in the sample countries. We drop observations for cross-listed firms (5,789 firm-years) to ensure that we appropriately match the correct country-specific tax rules with the firms included in our sample.[19] We also eliminate observations related to financial and utilities firms (62,162 firm-years) because these firms are subject to regulatory rules that affect profitability, taxability, and the level of risk-taking. We drop observations missing total assets or where total assets are less than zero (3,220 firm-years) as well as observations missing the requisite time series data to calculate the three-year risk measure (35,770 firm-years). This latter step results in the elimination of observations from

[18] We exclude Sweden because of the country's rules related to specific tax reserves, which cannot be directly compared to carryback/carryforward rules in the other countries.

[19] As Worldscope uses consolidated balance sheet data, there is some measurement error as we have some multinational firms in our sample. For these firms, we cannot identify in which country each part of the return was taxed. There should, however, be no systematic relationship between the measurement error and our variables of interest. Moreover, parent firms in the home country are much larger than foreign subsidiaries, and more profitable (Dischinger et al., 2013). In the sample of European multinationals used by Dischinger et al. (2013), average fixed assets of parent firms are $285.4 million, while average fixed assets of foreign subsidiaries were only 27.7 million.

2010 and 2011 because sufficient data is not available to construct the risk measure over three subsequent years. Finally, we eliminate observations missing data to calculate the control variables for a final sample of 84,209 firm-year observations.[20] All data are transformed to US dollars using exchange rates provided by Officer (2011). Table 4.2 summarizes the sample selection.

We merge this dataset with country-level tax loss carryback/carryforward data collected from the yearly IBFD European Tax Handbook and the U.S. Internal Revenue Code, as well as statutory corporate tax rate data from the OECD tax database. As shown in Table 4.1B, many countries have an indefinite loss carryforward period. Because we include the number of loss carryforward years in our regression analysis as a key variable of interest, we set the carryforward period for these countries to 20 years (i.e. the maximum finite period in the sample) in order to estimate equations (4.7) and (4.8). This assumption biases away from finding a positive and statistically significant relation between loss carryforwards and risk-taking because it reduces the estimated carryforward period and estimated insurance benefit relative to the actual period over which firms could offset losses. Therefore, to the extent that we find a positive relation in equation (4.7), such relation should be understated by this assumption.

Table 4.3 provides the descriptive statistics for our sample. All firm-level variables are winsorized at the 1% and 99% level prior to inclusion in the summary statistics in Panel 4.3A. We observe that firms in the sample report average (median) risk (the standard deviation of $ROA$ from the industry-country mean) of .305 (.105). When we compare the country-specific means for this variable to those reported in Table II of John et al. (2008), we find comparable amounts.[21]

The average (median) loss carryback period for our sample is 1.54 (2.00) years. The mean statutory corporate tax rate for the seventeen countries in our sample is 36.1 percent. In untabulated analysis, we find that the average rate has declined over time, from 38.5 percent in 1998 to 33.5 percent in 2009, consistent with the fact that countries, in an attempt to lure foreign direct investment, compete over tax rates in a "race to the bottom".

The descriptive statistics indicate that our sample includes firms that, on average, exhibit sales growth of 29.0 percent (median: 8.9) and have a market-to-book ratio of

[20] Specifically, we require data on current and lagged revenues, total liabilities, GDP information, market value of equity, and book value of equity to construct the control variables.

[21] For example, John et al. (2008) report an average of .04, .06, and .04 for Austria, Ireland, and Portugal; in our sample, the average standard deviation of ROA for these three countries is .04, .05, and .03, respectively.

Table 4.3: Descriptive Statistics

Panel A: Variable Descriptive Statistics

| | Obs. | Mean | Median | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Risk | 84,209 | 0.305 | 0.105 | 0.692 | 0.000 | 5.805 |
| LCB | 84,209 | 1.536 | 2.000 | 0.867 | 0.000 | 3.000 |
| LCF | 84,209 | 16.907 | 20.000 | 5.436 | 5.000 | 20.000 |
| CTR | 84,209 | 0.361 | 0.393 | 0.055 | 0.125 | 0.560 |
| Size | 84,209 | 11.899 | 11.871 | 2.322 | 5.565 | 17.794 |
| ROA | 84,209 | -0.072 | 0.057 | 0.532 | -4.629 | 0.496 |
| Sales Growth | 84,209 | 0.290 | 0.089 | 1.088 | -1.242 | 11.410 |
| Leverage | 84,209 | 0.606 | 0.534 | 0.626 | 0.000 | 8.188 |
| GDP Growth | 84,209 | 0.051 | 0.055 | 0.067 | -0.178 | 0.319 |
| MB | 84,209 | 2.857 | 1.732 | 6.958 | -30.115 | 78.632 |

Variable definitions are described in Appendix D. All firm-level variables are winsorized at 1% and 99%, minimum and maximum are given after winsorizing.

Panel B: Observations by Country

| | # Obs. | % of sample |
|---|---|---|
| Austria | 701 | 0.832 |
| Belgium | 1,009 | 1.198 |
| Denmark | 1,591 | 1.889 |
| Finland | 1,279 | 1.519 |
| France | 6,138 | 7.289 |
| Germany | 6,139 | 7.290 |
| Greece | 2,440 | 2.898 |
| Ireland | 485 | 0.576 |
| Italy | 1,882 | 2.235 |
| Luxembourg | 198 | 0.235 |
| Netherlands | 1,480 | 1.758 |
| Norway | 1,404 | 1.667 |
| Portugal | 510 | 0.606 |
| Spain | 1,087 | 1.291 |
| Switzerland | 1,832 | 2.176 |
| United Kingdom | 11,940 | 14.179 |
| United States | 44,094 | 52.363 |
| Total | 84,209 | 100.000 |

Panel C: Observations by Year

| | # Obs. | % of sample |
|---|---|---|
| 1998 | 6,574 | 7.807 |
| 1999 | 7,448 | 8.845 |
| 2000 | 7,570 | 8.990 |
| 2001 | 7,498 | 8.904 |
| 2002 | 7,387 | 8.772 |
| 2003 | 7,044 | 8.365 |
| 2004 | 6,908 | 8.203 |
| 2005 | 6,842 | 8.125 |
| 2006 | 6,941 | 8.243 |
| 2007 | 6,942 | 8.244 |
| 2008 | 6,723 | 7.984 |
| 2009 | 6,332 | 7.519 |
| Total | 84,209 | 100.000 |

2.8 (median: 1.7). Thus, the sample appears to appropriately include firms that have risky investment opportunities. Furthermore, the mean ROA (-.07) indicates that loss firms are included in the sample, a necessary condition for investigating if losses and the corresponding tax rules are associated with risk-taking. We note that the sample includes both income and loss firms, though, given that the median firm is profitable (ROA of .06).

Panel 4.3B summarizes the observations by country. We have included the United States because of its economic significance and note that this data selection step results in an unbalanced panel, in which approximately half of the observations are from this country.[22] Besides the large size of the U.S. economy, such distribution also reflects the larger share of U.S. incorporated firms, relative to many European countries. The remaining observations are dispersed among 16 other developed Western Europe countries, with France, Germany, and the U.K. reporting 7.3, 7.3, and 14.2 percent of the sample, respectively. Panel 4.3C shows that the observations are distributed equally across the sample period.

Table 4.4 provides correlation statistics. *Risk* is significantly correlated with both measures of a country's tax loss regime (*LCB* and *LCF*), as well as with the country's tax rate (*CTR*) with correlations of 0.15, 0.14, and 0.15, respectively. Leverage is also positively and significantly correlated with *Risk* (0.41), a relation consistent with prior findings that document the effects of costly financial distress on the firm. *Sales Growth* exhibits a positive and significant correlation with *MB* and *GDP Growth*, but we note that the correlations are relatively small (0.06 each). This suggests that these controls may capture different elements of a firm's risky investment opportunity set and growth options.

## 4.6 Empirical Results

### 4.6.1 Loss Offset Provisions

Table 4.5 provide the main empirical results of the test of the first hypothesis. Panel 4.5A presents the results from regressing the measure of risk-taking on loss carryback and carryforward periods, the country's tax rate, and an interaction term that captures the incremental effect of the loss carrybacks/carryforwards, given the level of

[22] In robustness tests, we exclude the U.S. firm-years from the sample. In general, the inferences are the same, albeit weaker.

Table 4.4: Correlation Matrix

| | Risk | LCB | LCF | CTR | Size | ROA | Sales Gr. | Leverage | GDP Gr. | MB |
|---|---|---|---|---|---|---|---|---|---|---|
| Risk | 1.000 | | | | | | | | | |
| LCB | 0.153* | 1.000 | | | | | | | | |
| LCF | 0.141* | 0.257* | 1.000 | | | | | | | |
| CTR | 0.149* | 0.566* | 0.192* | 1.000 | | | | | | |
| Size | -0.309* | -0.036* | -0.039* | -0.037* | 1.000 | | | | | |
| ROA | -0.551* | -0.082* | -0.095* | -0.080* | 0.429* | 1.000 | | | | |
| Sales Growth | 0.099* | 0.012* | 0.024* | 0.017* | -0.111* | -0.112* | 1.000 | | | |
| Leverage | 0.405* | 0.070* | 0.036* | 0.066* | -0.221* | -0.562* | 0.009* | 1.000 | | |
| GDP Growth | -0.052* | -0.077* | -0.081* | -0.128* | -0.001 | 0.022* | 0.063* | -0.016* | 1.000 | |
| MB | -0.021* | 0.022* | -0.017* | 0.029* | -0.008* | 0.073* | 0.061* | -0.145* | -0.000 | 1.000 |

Variable definitions are described in Appendix D. * indicates significance at 5%.

tax rate. Column 1 includes the results for the main variables of interest without controls; Column 2 (3) reflects coefficients from separately including LCB (LCF) in the regression; and Column (4) includes the full specification with all tax variables and controls.

The coefficients of loss carrybacks and loss carryforwards are positive and highly significant across each of these columns. The results in Column 4 show that a one year increase in a country's loss carryback period is associated with a 48.6 percent increase in firm risk. To better understand what this result implies, consider the median firm in the sample with a ROA and *Risk* (measured over three years) of 0.05 and .105, respectively. Assuming that the average country-industry ROA is constant, this suggests that a firm's ROA ratios over a three-year period based on the John et al. (2008) measure could be (for example) -0.055, 0.050, and .155. A 48.6 percent increase in risk would suggest that the altered three year ratios could instead be -0.106, 0.05, and 0.206; in other words, this change in carryback period is associated with almost a doubling of the span between the best and worst yearly ROA. Similarly, a one year increase in the loss carryforward period is associated with a 9.5 percent increase in the amount of firm risk. Thus, we conclude a country's loss carryback and carryforward periods are positively related to the level of future firm risk, supportive of Hypothesis 4.1a.

We also find a positive and significant coefficient on the interaction term *LCB*CTR*. This results supports our prediction for Hypothesis 4.1b, confirming that a country's loss offset provisions are more economically relevant to firms, the higher the country's tax rate. The interaction term for loss carryforwards, however, is insignificant. This result suggests that loss carryforward provisions may be associated with firm risk-taking, but their importance is independent of the tax rate. One explanation for this result could be that uncertainty regarding future tax rates (i.e., the rates that will be relevant in the period that losses are used) reduces the perceived economic benefit. Therefore, loss carryforwards alone may provide sufficient risk-taking incentives, irrespective of the current tax rate.

Throughout the regression results, we note that the control variables exhibit the expected relation with firm operating risk. *Size* and *ROA* are negatively associated with the dependent variable, consistent with the fact that smaller, less profitable firms have greater levels of operating risk than larger, more mature firms. *Sales Growth* and *MB*, our controls for a firm's investment opportunity set and growth prospects, are positively related to the measure of firm risk. Finally, firm *Leverage* is positively related to the dependent variable as well, consistent with prior literature that documents that

Table 4.5: Relation Between Firm Risk and Loss Carrybacks & Carryforwards

Panel A: Levels Specification

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| LCB | 0.076*** | 0.061*** | | 0.055*** |
| | (3.76) | (3.67) | | (3.80) |
| LCF | 0.012*** | | 0.008*** | 0.008*** |
| | (4.01) | | (4.22) | (3.81) |
| std. CTR | -0.009 | 0.005 | 0.046 | -0.016 |
| | (-0.25) | (0.24) | (1.56) | (-0.59) |
| LCB*CTR | 0.104** | 0.052** | | 0.070** |
| | (2.54) | (2.30) | | (2.38) |
| LCF*CTR | -0.002 | | 0.002 | -0.000 |
| | (-0.54) | | (0.79) | (-0.14) |
| Size | | -0.029*** | -0.028*** | -0.028*** |
| | | (-7.41) | (-7.09) | (-7.23) |
| ROA | | -0.530*** | -0.531*** | -0.525*** |
| | | (-18.07) | (-18.27) | (-17.95) |
| Sales Growth | | 0.025*** | 0.024*** | 0.024*** |
| | | (7.29) | (7.06) | (7.07) |
| Leverage | | 0.160*** | 0.163*** | 0.164*** |
| | | (8.89) | (9.17) | (9.17) |
| GDP Growth | | 0.117 | 0.206 | 0.206 |
| | | (0.49) | (0.79) | (0.97) |
| MB | | 0.003*** | 0.003*** | 0.003*** |
| | | (4.60) | (4.72) | (4.67) |
| Constant | -0.050 | 0.400*** | 0.366*** | 0.255*** |
| | (-0.72) | (5.68) | (5.20) | (3.87) |
| Observations | 84,209 | 84,209 | 84,209 | 84,209 |
| $R^2$ | 0.060 | 0.354 | 0.352 | 0.357 |

This table presents results from an OLS regression of a firm's risk measure on country tax variables. The dependent variable is a three-year measure of risk. Variable definitions are described in Appendix D. Each specification includes industry and year fixed effects. T-statistics presented in parenthesis. Standard errors are clustered by firm and by country-year. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel B: Changes Specification

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Δ LCB | 0.014 | 0.016 | | 0.013 |
| | (0.28) | (0.84) | | (0.29) |
| Δ LCF | 0.021*** | | 0.023*** | 0.023*** |
| | (2.98) | | (3.28) | (3.18) |
| Δ std. CTR | -0.119* | 0.059*** | -0.120** | -0.123* |
| | (-1.67) | (3.09) | (-2.05) | (-1.90) |
| Δ LCB*CTR | -0.016 | 0.009 | | -0.006 |
| | (-1.06) | (0.88) | | (-0.46) |
| Δ LCF*CTR | 0.011*** | | 0.010*** | 0.010*** |
| | (2.63) | | (3.34) | (2.94) |
| Δ Size | | -0.536** | -0.539** | -0.539** |
| | | (-2.44) | (-2.45) | (-2.45) |
| Δ ROA | | 0.260 | 0.261 | 0.261 |
| | | (1.50) | (1.50) | (1.50) |
| Δ Sales Growth | | -0.000 | -0.000 | -0.000 |
| | | (-1.11) | (-1.09) | (-1.09) |
| Δ Leverage | | 0.002 | 0.002 | 0.002 |
| | | (0.41) | (0.41) | (0.41) |
| Δ GDP Growth | | 0.461* | 0.347 | 0.348 |
| | | (1.84) | (1.57) | (1.57) |
| Δ MB | | 0.000 | 0.000 | 0.000 |
| | | (0.85) | (0.54) | (0.54) |
| Constant | 0.110*** | 0.346*** | 0.177*** | 0.175*** |
| | (2.59) | (2.79) | (3.35) | (3.37) |
| Observations | 70,383 | 70,383 | 70,383 | 70,383 |
| $R^2$ | 0.001 | 0.008 | 0.009 | 0.009 |

This table presents results from an OLS regression of changes in a firm's risk measure on changes in country tax variables. The dependent variable is a three-year measure of risk. Variable definitions are described in Appendix D. Each specification includes industry and year fixed effects. T-statistics presented in parenthesis. Standard errors are clustered by firm and by country-year. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

higher debt makes firms riskier.

In Panel 4.5B, we explore the relation between firm risk and country tax rules with a changes specification; that is, we regress changes in firm risk on changes in the country's loss carryback and carryforward periods, as well as changes in the tax rate. The number of observations declines due to the requirement of data to calculate these changes for all variables. We find that our results still hold; $LCB$ and $LCF$ are positively related to firm risk, although we note that the relation with $LCB$ is not significant. Given that there are only two changes in the $LCB$ period, this is not surprising. Interestingly, we find that the relation with $LCF$, as well as the interaction, has stronger significance in each regression relative to the results in Panel 4.5A.

In summary, the results from Table 4.5 support the prediction that a country's loss carryback and carryforward rules are positively associated with future firm risk-taking. For loss carrybacks, this relation is greater the higher the country's tax rate, consistent with the fact that the economic benefit of carrybacks increases with the tax rate.

### 4.6.2 Firm-Level Effects of Corporate Tax Rates

Table 4.6 presents the results of testing Hypotheses 4.2a and 4.2b, which examine the effect of corporate tax rates on firm risk-taking given a firm's expectation about future loss offset. As discussed in Section 4.5.1, we separately test the relation for firms that are likely to have a high probability of loss offset (high $\lambda$ firms) and those with a low probability of loss offset (low $\lambda$ firms).

Panel 4.6A includes results from regressing the firm's risk measure on the country tax rate and controls. Column 1 presents the results for a sample of firm-years identified as high $\lambda$. As defined above, these observations include firms that i) operate in a country that permits loss carry-backs and ii) have reported prior profitability, such that any future loss could be immediately offset by a refund of these prior taxes due. As predicted, we find that higher tax rates are positively and significantly related to risk-taking for the high loss offset firms; a ten percentage point increase in the tax rate is associated with an 11.6 percent increase in the risk measure. This result illustrates the insurance effect first hypothesized in Domar and Musgrave (1944); that is, the countries represented in this sample effectively provide insurance via the tax regime by reducing both the mean and the variance of the investment return, making risk-taking more attractive.

In contrast, the observations in Column 2 are those firm-years defined as "low $\lambda$"

Table 4.6: Relation Between Firm Risk and Tax Rate

Panel A: Levels Specification

| | (1) High $\lambda$ | (2) Low $\lambda$ |
|---|---|---|
| CTR | 1.161*** | -0.241** |
| | (3.80) | (-2.07) |
| Size | -0.028*** | -0.007** |
| | (-6.53) | (-1.98) |
| ROA | -0.575*** | -0.323*** |
| | (-14.05) | (-6.26) |
| Sales Growth | 0.023*** | 0.002 |
| | (5.20) | (0.64) |
| Leverage | 0.174*** | -0.041 |
| | (6.67) | (-1.48) |
| GDP Growth | 0.272 | 0.228* |
| | (0.66) | (1.86) |
| MB | 0.004*** | 0.000 |
| | (3.60) | (0.17) |
| Constant | 0.110 | 0.280*** |
| | (0.84) | (7.02) |
| Observations | 44,315 | 2,463 |
| $R^2$ | 0.330 | 0.239 |

Panel B: Changes Specification

| | (1) High $\lambda$ | (2) Low $\lambda$ |
|---|---|---|
| Δ CTR | 1.242*** | 0.018 |
| | (5.16) | (0.09) |
| Δ Size | -0.905** | 0.011 |
| | (-2.04) | (0.80) |
| Δ ROA | 0.459 | -0.164*** |
| | (1.21) | (-6.72) |
| Δ Sales Growth | -0.000 | 0.000* |
| | (-0.80) | (1.77) |
| Δ Leverage | 0.005 | 0.077*** |
| | (0.68) | (3.23) |
| Δ GDP Growth | 0.839** | 0.010 |
| | (2.57) | (0.06) |
| Δ MB | -0.000 | 0.000 |
| | (-0.90) | (0.75) |
| Constant | 0.515*** | 0.006 |
| | (3.18) | (0.42) |
| Observations | 37,881 | 2,463 |
| $R^2$ | 0.014 | 0.185 |

This table presents results from an OLS regression of a firm's risk measure on the country tax rate, accounting for the level of loss offset expected, in both levels (Panel A) and changes (Panel B) specifications. In each panel, Column 1 includes the results from regressing the risk measure on the country's tax rate for firms that should be able to recover losses immediately ("high $\lambda$" firms); these observations are identified as those in countries that permit loss carrybacks and that have also reported profits in prior year such that any loss sustained could be immediately offset. Column 2 includes firm-year observations for firms that would be unlikely to receive loss offset ("low $\lambda$" firms); these firms operate in countries that do not permit loss carrybacks and are unlikely to be profitable based on historical financial performance. Variable definitions are described in Appendix D. Each specification includes industry and year fixed effects. T-statistics presented in parenthesis. Standard errors are clustered by firm and by country-year. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

because i) no loss carryback is permitted in the countries where these firms are headquartered, and ii) we estimate that these firms will be more likely to generate losses in future years given the lack of prior profitability. We estimate that these firms will not generate sufficient income in the short term to recoup any economic losses incurred. As predicted in Hypothesis 4.2b, we observe a negative and significant coefficient of -0.241 on $CTR$. In this case, a ten percentage increase in the tax rate is associated with a 2.3 percent decrease in firm risk.

Panel 4.6B includes the results from a specification that regresses changes in loss offset expectations on changes in the country's tax rate. Our results for the high $\lambda$ firms still hold, while we observe an insignificant relation for the low $\lambda$ firms.

Importantly, these results show that the effect of taxation on corporate risk-taking is not uniform across firms. While loss carrybacks and carryforwards provide economic incentives for firms to engage in risk-taking behavior (from Table 4.5), firm-specific expectation of loss utilization must be considered when determining how tax rates will affect risk-taking.

## 4.7 Robustness and Discussion

We conduct several additional tests to explore other effects within our sample of firms and to ensure the robustness of these results. This section discusses these tests.

### 4.7.1 Firm Size

As the preceding chapters have shown, tax effects often vary with firm size. In the context of tax loss offset, it is relevant that larger firms are active in more product lines and thus more likely able to offset losses in some product lines against profits in others (Mirrlees et al., 2011). Therefore, we expect that the positive effect of loss offset provisions is smaller for larger firms, as these firms are more likely able to offset losses within the firm.

We test this prediction by interacting the loss offset variables with the *Size* variable. The regression results with this interaction term are reported in Table 4.7. We find that the coefficient on the interaction terms for both loss carrybacks and loss carryforwards is negative and significant. This result is consistent with the prediction above and implies that the positive relation between loss offset periods and risk-taking is smaller

Table 4.7: Regression Results with Size Interaction

| | (1) | (2) |
|---|---|---|
| LCB | 0.371*** | 0.192*** |
| | (4.27) | (4.13) |
| LCF | 0.047*** | 0.021*** |
| | (5.82) | (3.42) |
| std. CTR | -0.019 | -0.008 |
| | (-0.53) | (-0.30) |
| LCB*CTR | 0.091** | 0.069** |
| | (2.33) | (2.32) |
| LCF*CTR | -0.000 | -0.001 |
| | (-0.04) | (-0.31) |
| LCB*Size | -0.024*** | -0.011*** |
| | (-4.07) | (-3.66) |
| LCF*Size | -0.003*** | -0.001** |
| | (-5.41) | (-2.32) |
| Size | | 0.008 |
| | | (1.00) |
| ROA | | -0.520*** |
| | | (-18.32) |
| Sales Growth | | 0.024*** |
| | | (6.98) |
| Leverage | | 0.159*** |
| | | (8.66) |
| GDP Growth | | 0.206 |
| | | (0.97) |
| MB | | 0.003*** |
| | | (4.66) |
| Constant | -0.062 | -0.190* |
| | (-0.91) | (-1.69) |
| Observations | 84,209 | 84,209 |
| $R^2$ | 0.163 | 0.358 |

This table presents results for the test of the first hypothesis, interacting the tax variable(s) of interest with *Size*. Variable definitions are described in Appendix D. Each specification includes industry and year fixed effects. T-statistics presented in parenthesis. Standard errors are clustered by firm and by country-year. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

for these firms.

### 4.7.2 Robustness Tests

We conducted several tests to ensure that the results observed are not sensitive to certain empirical design choices. First, we explore the exclusion of the U.S. within our sample. As noted above, the inclusion of the U.S. results in an unbalanced panel of firms. We drop the U.S. firm-years and note that our results still hold.

Secondly, we also define the risk measure over a longer period of five years. Table 4.8 presents the results of the regressions using this five-year measure. As in Table 4.5, we observe a positive and significant relation between the loss offset rules and the risk measure, and the interaction effect with the LCB and the country's tax rate is also positive and significant. Results in Panel 4.8B are also similar to Table 4.6; high (low) $\lambda$ firms exhibit a positive (negative) association with the country's tax rate. In the changes specification (not reported) we get similar results, albeit partly with lower significance.

Finally, we define high and low $\lambda$ firms with alternative definitions. Rather than defining these as a function of prior profitability, we also use tax expense and gross margin to partition firms into categories. Again, our results still hold.

## 4.8 Conclusion

This essay has studied how a country's tax code affects corporate risk-taking. By extending models of taxation, risk-taking, and investment to firms, we show that the effect of corporation taxation on firm risk is a function of the statutory tax loss offset rules and statutory tax rates, as well as firm-specific expectation regarding loss offset possibilities. We then test these theoretical predictions by regressing a recently developed measure of firm risk-taking on the number of years that a firm's home country permits for loss carrybacks and carryforwards. Our results show that the level of future corporate risk-taking is related to the available loss offset period, and this relation is stronger, the higher the home country's statutory rate. We infer from these results that firms view these tax rules as important when selecting the riskiness of firm investment. We then partition firms based on the estimated expectation of available future loss offset and find that the effect of tax rates on risk-taking varies across the subsamples, as theoretically predicted.

Table 4.8: Relation Between Firm Risk and Tax Rate with 5-Year Risk Measure

Panel A: Test of Hypotheses 4.1a and 4.1b

| | (1) |
|---|---|
| | 5Y Risk |
| LCB | 0.065*** |
| | (3.84) |
| LCF | 0.008*** |
| | (2.82) |
| std. CTR | 0.002 |
| | (0.07) |
| LCB*CTR | 0.085** |
| | (2.22) |
| LCF*CTR | -0.003 |
| | (-0.98) |
| Size | -0.029*** |
| | (-7.86) |
| ROA | -0.510*** |
| | (-22.05) |
| Sales Growth | 0.032*** |
| | (7.57) |
| Leverage | 0.157*** |
| | (7.14) |
| GDP Growth | -0.133 |
| | (-0.47) |
| MB | 0.003*** |
| | (4.28) |
| Constant | 0.264*** |
| | (3.43) |
| Observations | 58,529 |
| $R^2$ | 0.322 |

Panel B: Test of Hypotheses 4.2a and 4.2b

| | (1) | (2) |
|---|---|---|
| | High $\lambda$, 5Y | Low $\lambda$, 5Y |
| CTR | 0.766** | -0.293** |
| | (2.08) | (-2.37) |
| Size | -0.027*** | -0.008** |
| | (-6.26) | (-2.49) |
| ROA | -0.549*** | -0.285*** |
| | (-19.58) | (-5.24) |
| Sales Growth | 0.025*** | 0.006 |
| | (6.43) | (1.12) |
| Leverage | 0.157*** | -0.071*** |
| | (4.58) | (-3.47) |
| GDP Growth | -0.469 | 0.182* |
| | (-0.79) | (1.77) |
| MB | 0.006*** | 0.000 |
| | (4.27) | (0.32) |
| Constant | 0.276* | 0.338*** |
| | (1.77) | (4.72) |
| Observations | 30,351 | 1,587 |
| $R^2$ | 0.283 | 0.233 |

This table presents the results of the tests of both hypotheses when using a risk measure defined over five years. Variable definitions are described in Appendix D. Each specification includes industry and year fixed effects. T-statistics presented in parenthesis. Standard errors are clustered by firm and by country-year. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

The empirical results do not permit us to ascertain if firms change their behavior in response to taxes, or if our results stem from a selection effect (e.g. because firms with different risk profiles relocate strategically in countries with a suitable tax system). Nevertheless, we feel that our results permit certain policy recommendations. To the extent that governments want to encourage risk-taking, the use of loss offset rules, particularly carrybacks, may provide appropriate incentives. The use of the tax rate to encourage risk-taking should be viewed more critically, as changes in rates may provide incentives only for firms that can expect to offset losses. Moreover, tax rate increases are likely to have adverse effects on a country's ability to compete for foreign direct investment.

# Conclusion

This thesis has considered corporate taxation – with a focus on the implications of heterogeneity in productivity and on firm risk-taking – in four essays, each looking at a very specific question. Despite the different research questions, in this conclusion I will draw some inferences that are common to all essays.

The essays in this thesis have all shown in some ways surprising or unexpected consequences of tax rules. Chapter 1 revealed that the arm's length principle, which is widely seen as making profit shifting impossible (as long as firms adhere to it), leads in itself to lower tax payments of MNEs, compared to the tax payments of domestic firms. One might expect that favoring highly productive firms is optimal from a welfare perspective. However, as the second chapter pointed out, it depends on the degree of tax competition if a preferential treatment of highly productive enterprises is indeed the optimal policy. Chapter 3 illustrated that a regulation that is thought to inhibit profit shifting can also have surprising consequences. In extreme cases it has the opposite effect and increases the share of profits shifted abroad. Lastly, Chapter 4 showed that higher tax rates raise the willingness of some firms to take risks, even though each firm gets to keep less of the profits generated by the risky investment.

All these results have in common that they describe effects that are unlikely to come up spontaneously in the discussion of a policy measure. Some of the effects (e.g. those described in Chapters 1 and 3) are even opposite to what policymakers intended. This highlights the importance of public finance research not only for the understanding of tax policies, but also for the political decision-making about these policies.

To be useful for policymakers, research needs to give a simplified, but realistic representation of the tax code. For a long time, research in public finance has focussed on tax rates and treated more complicated regulations as a black box, e.g. by assuming "costs of profit shifting" that follow some functional form that is not empirically founded. Considering only tax rates is definitely not always sufficient: As Chapter 4 showed, the effect of tax rates on risk-taking depends crucially on the firm's ability to offset losses. In addition, the modelling of a specific regulation itself may provide new insights. An example is Chapter 1, which studied the arm's length principle and demonstrated that this principle is insufficient to guarantee that the tax burden of MNEs is as high as that of domestic firms.

In this thesis, I have pointed out several mechanisms in which specific regulations (such as the arm's length principle or loss offset rules) and the complexities of the corporate sector (such as different productivity levels) come together to influence firm behavior and tax revenues in very specific ways. Much more research can be done in this direction, and I hope that it will generate helpful insights for academics and policymakers.

# Appendices

# A Appendix to Chapter 1

## A.1 Proof of Proposition 1.1: Tax Burden of MNEs

By contradiction: Suppose to the contrary that $t_i^{eff} > t_H$. Then,

$$\frac{t_H(p_i^t - r)x_i^t + t_L(r - a_i)x_i^t}{(p_i^t - a_i)x_i^t} \; > \; t_H \quad \Leftrightarrow \quad (t_H - t_L)(r - a_i) \; < \; 0,$$

a contradiction as $t_H > t_L$ and $r \geq a_i$ for all $a_i \leq a_t^*$, since $r \geq a_t^*$. To see the latter, we need to verify that

$$r \geq a_t^* = \frac{1 - t_H}{1 - t_L}\,(1 + \tau)\,r\left(\frac{c}{c + f}\right)^{\frac{1}{\sigma - 1}} + \frac{t_H - t_L}{1 - t_L} r. \tag{A.1}$$

Assumption (1.7) states that $\tau$ is bounded above by $\tau \leq \left(\frac{c+f}{c}\right)^{\frac{1}{\sigma-1}} - 1$. In the case where (1.7) holds with equality, $(1 + \tau)\left(\frac{c}{c+f}\right)^{\frac{1}{\sigma-1}} = 1$. In this case, $a_t^* = \frac{1-t_H}{1-t_L} r \cdot 1 + \frac{t_H - t_L}{1-t_L} r = r$. If (1.7) holds with inequality, then $(1 + \tau)\left(\frac{c}{c+f}\right)^{\frac{1}{\sigma-1}} < 1$, and thus $r > a_t^*$.

To prove the systematic relationship between the tax burden and the productivity of MNEs, we need to sign

$$\frac{\partial t_i^{eff}}{\partial a_i} = \frac{\left(t_H \frac{\partial p_i^t}{\partial a_i} - t_L\right)(p_i^t - a_i) - (t_H p_i^t - t_H r + t_L r - t_L a_i)\left(\frac{\partial p_i^t}{\partial a_i} - 1\right)}{(p_i^t - a_i)^2}, \tag{A.2}$$

which carries the same sign as

$$(t_H - t_L)\left(p_i^t - r + (r - a_i)\frac{\partial p_i^t}{\partial a_i}\right) = (t_H - t_L)\,\frac{r}{\sigma - 1} > 0,$$

where the last equality uses eq. (1.14).

## A.2 Proof of Propositions 1.2 and 1.3: Composition and Mass of Active Firms and Price and Quantity Effects

**Proof of Proposition 1.2: Composition and mass of active firms**
To show that $a_t^* \geq a^*$, we need to verify from equations (1.9) and (1.17):

$$\frac{1-t_H}{1-t_L}\left(1+\tau\right)r\left(\frac{c}{c+f}\right)^{\frac{1}{\sigma-1}}+\frac{t_H-t_L}{1-t_L}r \geq \left(\frac{c}{c+f}\right)^{\frac{1}{\sigma-1}}\left(1+\tau\right)r.$$

Rearranging shows that $a_t^* \geq a^*$ if and only if $\frac{1-t_H}{1-t_L}+\frac{t_H-t_L}{1-t_L}\left(\frac{c+f}{c}\right)^{\frac{1}{\sigma-1}}\frac{1}{1+\tau} \geq 1$, which always holds under assumption (1.7) as $t_L < t_H$.

**Proof of Proposition 1.3: Price and quantity effects of arm's length taxation**
For each firm, the price change due to taxation at arm's length is equal to

$$\Delta_p\left(a_i\right) \equiv p_t\left(a_i\right)-p\left(a_i\right)=-\frac{\sigma}{\sigma-1}\frac{t_H-t_L}{1-t_H}\left(r-a_i\right). \tag{A.3}$$

Using (1.7), $\Delta_p\left(a_i\right) \leq 0$, since $r \geq a_i$ for all $a_i \leq a^*$. The effect on quantities follows from comparing equilibrium values under taxation with the benchmark case. Inspection of (A.3) completes the proof.

## A.3 Heterogeneous Independent Suppliers

In this appendix, we derive our main result in an alternative model specification in which both integrated as well as outsourcing firms are heterogeneous. This variant of the model is closer to the established literature (see e.g. Antràs and Helpman, 2004), but has the disadvantage that the arm's length transfer price under CUP is not unique. It is thus further from an ideal environment for the application of the arm's length principle.

In contrast to the model in the main part of the paper, assume now that *all* suppliers differ in productivity, i.e. they produce with a firm-specific input cost of $a_i$. Otherwise, the model environment is as in the main text.

Internal input prices, determined by Nash bargaining, are as in the main model (eqs. 1.24, 1.27). They depend on input quantities, which are a function of the firm's productivity under both outsourcing and integration:

$$m_O = \left[ \frac{(1-\beta)\,\mu}{a_i} \frac{\sigma - 1}{\sigma} \right]^{\sigma} X^{-(\sigma-1)}, \tag{A.4}$$

$$m_I = \left[ \frac{(1-\beta)\left(1-\delta^{\frac{\sigma-1}{\sigma}}\right)(1-t_H)\,\mu}{a_i - (1-\beta)(1-\delta)(t_H - t_L)\,\rho} \frac{\sigma-1}{\sigma} \right]^{\sigma} X^{-(\sigma-1)}. \tag{A.5}$$

As the "ideal" arm's length price coincides with the main model, we directly look at the implementation of arm's length pricing via CUP. Then, the transfer price used for taxing integrated firms is again given by the price an outsourcing firms pays its supplier. Thus, using (A.4) and $R = \mu \left(\frac{m_O}{X}\right)^{\frac{\sigma-1}{\sigma}}$ in (1.27), we see that in equilibrium, outsourcing firms pay their supplier for a unit of the input

$$r_O(a_i) = (1-\beta)\, \frac{R\,(a_i)}{m_O\,(a_i)} = \frac{(1-\beta)\,\mu}{X^{\frac{\sigma-1}{\sigma}} m_O^{\frac{1}{\sigma}}} = \frac{\sigma}{\sigma-1} a_i. \tag{A.6}$$

As in the main model, this is a mark-up on the actual cost of input production. However, it is no longer unique. We thus have to specify which observable transaction is used to determine transfer prices for taxation. While firms would – other things being equal – prefer to use a transaction of a relatively unproductive firm, the tax authority would want to use input purchases of a firm close to the integration cutoff. We choose the least favorable setting for our point, i.e. that the tax authority is able to dictate which market transaction is used as the arm's length benchmark. To maximize tax revenues it will choose the cut-off firm, which has an input cost coefficient of $a^*$, so that the arm's length transfer price under CUP is

$$\rho^{CUP} = \frac{\sigma}{\sigma-1} a^*. \tag{A.7}$$

To compare the tax burden of the two firm types, we again use the effective tax rate. For an outsourcing firm, it is

$$t_O^{eff} = \frac{t_H\,(R_O - r_O m_O)}{R_O - r_O m_O} = t_H. \tag{A.8}$$

In contrast, integrated firms' tax payments relative to their profits are given by

$$t_I^{eff}(\rho^{CUP}) = \frac{t_H\,(R_I - \rho m_I) + t_L\,(\rho m_I - a_i m_I)}{R_I - a_i m_I} = t_H - (t_H - t_L) \frac{\frac{\sigma}{\sigma-1} a^* - a_i}{p_I - a_i}. \tag{A.9}$$

By the definition of the cut-off $a^*$, all integrated firms have an input coefficient $a_i < a^*$. Thus, $t_I^{eff}(\rho^{CUP}) < t_I^{eff}(\rho^{IDEAL}) < t_O^{eff}$.

The effective tax rate is again lowest for the most productive firms:

$$\frac{\partial t_I^{eff}(\rho^{CUP})}{\partial a_i} = -\left(t_H - t_L\right) \frac{-\left(p_I - a_i\right) - \left(\frac{\sigma}{\sigma-1}a^* - a_i\right)\left(\frac{\partial p_i}{\partial a_i} - 1\right)}{\left(p_I - a_i\right)^2}. \tag{A.10}$$

Rearranging shows that the numerator is negative:

$$-\left(\frac{\sigma}{\sigma-1}a^* - a_i\right)\frac{\partial p_i}{\partial a_i} - (p_i - \rho) < 0. \tag{A.11}$$

$\frac{\partial p_i}{\partial a_i} > 0$ follows after inserting (A.5) in the demand function, $\frac{\sigma}{\sigma-1}a^* > a_i$, and $p_I > \rho^{CUP} = \frac{\sigma}{\sigma-1}a^*$ because tax payments may not be negative. Therefore, also in this setting $\frac{\partial t_I^{eff}}{\partial a_i} > 0$.

## A.4 Proof of Lemma 1.2: Optimal Organization with Incomplete Contracts

The cutoff $a^*$ is characterized by $\pi_I^{HQ}(a^*, \cdot) = 0$, where

$$\pi_I^{HQ}(a^*, \cdot) = R_I - r_I m_I - t_H(R_I - \rho m_I) - t_L(\rho - a_i)m_I - c - f. \tag{A.12}$$

Rearranging and using eq. (1.24) for $r_I$ yields

$$\pi_I^{HQ}(a^*, \cdot) = \left[1 - (1-\beta)(1-\delta^{\frac{\sigma-1}{\sigma}})\right](1-t_H)R_I + \left[1 - (1-\beta)(1-\delta)\right](t_H - t_L)\rho m_I + t_L a_i m_I - c - f.$$

From (1.29) and (1.22) it follows that $\frac{\partial R_I}{\partial a_i} < 0$ and $\frac{\partial m_I}{\partial a_i} < 0$; and $\frac{\partial a_i m_I}{\partial a_i} < 0$ as $\frac{\sigma}{1-(1-\beta)(1-\delta)(t_H - t_L)\frac{\rho}{a_i}} > 1$. The denominator of the last fraction is always positive, as prices would be negative otherwise (see footnote 35 in Chapter 1). It follows that $\frac{\partial \pi_I^{HQ}}{\partial a_i} < 0$. Thus, firms with $a_i \leq a^*$ integrate while firms with higher input coefficients outsource.

Raising $\rho$ shifts $\pi_I^{HQ}(a^*, \cdot)$ upwards, showing formally that reducing the tax base of MNEs allows less productive matches to integrate profitably: $a^*$ is an increasing function of $\rho$. Similarly, if the added organization costs of MNEs, $f$, rise, $\pi_I^{HQ}(a^*, \cdot)$ falls, implying that fewer firms become MNEs.

## A.5 Proof of Proposition 1.4: Tax Burden of MNEs under Incomplete Contracts

**Part (i) of Proposition 1.4:**

First, we examine the "ideal" arm's length price, i.e. $\rho_i^{IDEAL} = \frac{\sigma}{\sigma-1} a_i$. We prove that $t_I^{eff}(\rho_i^{IDEAL}) < t_O^{eff} = t_H$ by contradiction:

Suppose to the contrary that $t_I^{eff}(\rho_i^{IDEAL}) > t_H$. Then, from (1.34),

$$(t_H - t_L)\frac{\rho_i^{IDEAL} - a_i}{p_I - a_i} < 0. \tag{A.13}$$

This is a contradiction, as $t_H > t_L$ and $\rho_i^{IDEAL} = \frac{\sigma}{\sigma-1} a_i > a_i$. The consumer price $p_I$ is necessarily above marginal cost, $a_i$, as firms would make a loss otherwise.[1]

**Part (ii) of Proposition 1.4:**

Next, consider the CUP transfer price, $\rho^{CUP} = \frac{\sigma}{\sigma-1}$. As the effective tax rate is decreasing in $\rho$, the use of CUP will lower the tax burden if $\rho^{CUP} < \rho_i^{IDEAL}$. Comparison of eqs. (1.35) and (1.37) shows that this is the case if $a_i < 1$, i.e. if integrated firms have a true cost advantage. As explained in footnote 40, this does not necessarily hold for all firms. Therefore, those MNEs whose suppliers are more productive than those of outsourcing firms face an even lower tax rate when the arm's length price is approximated via CUP. For firms that integrate despite having higher costs than the market, CUP is less favorable than the "ideal" arm's length price.

**Part (iii) of Proposition 1.4:**

To prove the systematic relationship between the tax burden and the productivity of MNEs, we need to sign

$$\frac{\partial t_I^{eff}}{\partial a_i} = -(t_H - t_L)\frac{-(p_I - a_i) - (\rho - a_i)\left(\frac{\partial p_I}{\partial a_i} - 1\right)}{(p_I - a_i)^2}, \tag{A.14}$$

which carries the same sign as

$$(\rho - a_i)\frac{\partial p_I}{\partial a_i} + (p_I - \rho). \tag{A.15}$$

Using the ideal arm's length price, this term is positive for all firms, implying $\frac{\partial t_I^{eff}(\rho_i^{IDEAL})}{\partial a_i} > 0$. Under CUP, eq. (A.15) is clearly positive for all MNEs with $a_i < \frac{\sigma}{\sigma-1}$.

[1] As negative taxes are not paid out, taxation does not provide an incentive to set prices below marginal cost.

For integrated firms with higher marginal cost, the arm's length principle constitutes a tax disadvantage: it can be seen in eq. (1.38) that firms with $a_i > \frac{\sigma}{\sigma-1}$ face an effective tax rate larger than $t_H$. Therefore, also under CUP, the most productive firms are taxed the least.

## A.6 Alternative Specification of the Effective Tax Rate

In this appendix, we consider an alternative specification of the MNE's effective tax rate that focusses on its activities in $H$. While it is more common to study tax payments of the firm as a whole, concentrating on the headquarter clarifies that the arm's length price is not only above marginal cost, but also above internal input prices.

To show that Proposition 1.4 is also valid if one only considers activities in $H$, consider the following alternative specification of the effective tax rate, $t_I^{eff2}$, which relates tax payments in $H$ to the profit that remains in the headquarter:

$$t_I^{eff2} = \frac{t_H \left(R_I - \rho m_I\right)}{R_I - r_I m_I} = t_H - t_H \frac{\rho - r_I}{p_I - r_I}. \tag{A.16}$$

Thus, in this case, the effective tax rate depends on the difference between the arm's length price of the input, $\rho$, and the internal input price $r_I$. Combining eqs. (1.24) and (1.29) shows that in equilibrium, the latter is

$$r_I = \frac{\sigma}{\sigma - 1} a_i - (1 - \beta)(1 - \delta)(t_H - t_L) \frac{\rho}{\sigma - 1}. \tag{A.17}$$

First, consider the "ideal" arm's length transfer price (given in eq. 1.35). Then, $r_I$ is smaller than $\rho_i^{IDEAL}$:

$$r_I \left(\rho_i^{IDEAL}\right) = \rho_i^{IDEAL} \left[1 - (1-\beta)(1-\delta)(t_H - t_L)\frac{1}{\sigma - 1}\right] < \rho_i^{IDEAL}. \tag{A.18}$$

Given that $p_I > r_I$ (as the headquarter would make a loss otherwise), eqs. (A.16) and (A.18) imply that MNEs are taxed at a lower rate than domestic firms, which are taxed at the rate $t_H$: $t_I^{eff2}\left(\rho_i^{IDEAL}\right) < t_H = t_O^{eff}$.

When the arm's length price is approximated via CUP (see eq. 1.37), this effect is strengthened for firms that are more productive than the market:

$$r_I\left(\rho^{CUP}\right) = \rho^{CUP}\left[a_i - (1-\beta)(1-\delta)(t_H - t_L)\frac{1}{\sigma - 1}\right] < r_I\left(\rho_i^{IDEAL}\right) \text{ if } a_i < 1. \tag{A.19}$$

As $p_I^{CUP} < p_I^{IDEAL}$ if $a_i < 1$, CUP transfer prices imply an even lower effective tax rate for MNEs with $a_i < 1$.

Lastly, it holds again that $\frac{\partial t_I^{eff2}}{\partial a_i} > 0$ (the proof proceeds analogously to the main proposition). Hence, the results from Proposition 1.4 are robust to this different definition of the effective tax rate, which highlights the role of internal input prices for the tax burden of the headquarter.

## A.7 Extension to Transfer Price Manipulation in the First Model

Allowing for transfer price manipulation, the profit function of a MNE is equal to

$$\pi_i^m = (1-t_H)\left[p_i^m - (1+\delta)\, r\right] x_i^m + (1-t_L)\left[(1+\delta)\, r - a_i\right] x_i^m - c - f - \delta^2 \gamma x_i^m, \tag{A.20}$$

where $\delta$ measures the extent of transfer price manipulation and $\gamma$ is a factor that scales the cost of tax evasion. Manipulating the transfer price comes at a convex cost, which we presume, for simplicity, to have quadratic form.[2] Our analysis in the main model is thus the limiting case where $\gamma \to \infty$.

MNEs now maximize profits by choosing both the amount of tax evasion ($\delta$) and their price ($p_i^m$). This yields

$$\delta = \frac{1}{2\gamma}\left(t_H - t_L\right) r, \tag{A.21}$$

$$p_i^m = \frac{\sigma}{\sigma - 1}\left(\frac{1-t_L}{1-t_H} a_i - \frac{t_H - t_L}{1-t_H} r - \frac{\frac{1}{4\gamma}\left(t_H - t_L\right)^2}{1-t_H} r^2\right) < p_i^t. \tag{A.22}$$

Given the option to manipulate transfer prices, MNEs further reduce consumer prices, since the amount of tax they can evade increases with each unit sold. This effect is stronger when the cost of transfer price manipulation $\gamma$ is low, or the statutory transfer price $r$ is high. The optimal degree of transfer price manipulation equates the marginal cost of transfer price manipulation, $2\delta\gamma$, with its benefits, $(t_H - t_L)\, r$, which

[2] This way of modeling transfer price manipulation follows Egger and Seidel (2011).

are increasing in the tax rate differential and the arm's length price of the input.

Because being a multinational allows firms to evade taxes by transfer price manipulation, organizing as a MNE becomes more attractive. Therefore, the cost cutoff for vertical integration rises

$$a_m^* = \frac{1-t_H}{1-t_L}(1+\tau)\,r\left(\frac{c}{c+f}\right)^{\frac{1}{\sigma-1}} + \frac{t_H-t_L}{1-t_L}r + \frac{\frac{1}{4\gamma}(t_H-t_L)^2}{1-t_L}r^2 > a_t^*. \qquad \text{(A.23)}$$

More firms integrate if the cost of transfer price manipulation is low or if the gains are high (high tax rate difference and/or high $r$).

## A.8 Proof of Proposition 1.5: Implications of Transfer Price Manipulation

To compare $\hat{r_I}$ with $r_I$, consider the equilibrium value of $\hat{r_I}$ by inserting eqs. (1.42), (1.22) and (1.40) in eq. (1.41), which yields

$$\hat{r_I} = \frac{\sigma}{\sigma-1}a_i - \frac{(1-\beta)(1-\delta)}{\sigma-1}\left[(t_H-t_L)\,\rho + \frac{(t_H-t_L)^2\rho^2}{4\gamma}\right]. \qquad \text{(A.24)}$$

Comparison with the corresponding value in the benchmark case, $r_I = \frac{\sigma}{\sigma-1}a_i - \frac{(1-\beta)(1-\delta)}{\sigma-1}(t_H-t_L)\,\rho$, proves that $\hat{r_I} \leq r_I$.

Next, consider $\hat{m_I}$. $X$ is exclusively determined by outsourcing firms and thus independent of transfer price manipulation. Comparing $\hat{m_I}$ from eq. (1.42) with its benchmark from eq. (1.29) shows that $\hat{m_I} \geq m_I$ if and only if

$$(1-\delta)(t_H-t_L)\,\rho \leq (1+\alpha)(1-\delta)(t_H-t_L)\,\rho - (1-\delta)\,\alpha^2\gamma. \qquad \text{(A.25)}$$

As can be seen by using the equilibrium value of $\alpha$ from eq. (1.40), (A.25) is always fulfilled.

As $x_I = m_I$, it follows from the demand curve (1.2) that $\hat{p}_I \leq p_I$. Therefore, as $\alpha^* > 0$, $\hat{t}_I^{eff}$ (eq. 1.43) is unambiguously lower than $t_I^{eff}$ (eq. 1.34).

Lastly, the mass of integrated firm is larger if there is transfer price manipulation, i.e. that the cut-off rises: $\hat{a}^* > a^*$. Analogously to Appendix A.4, the cut-off is characterized by $\hat{\pi}(a^*, \cdot) = 0$, where

$$\hat{\pi}(a^*, \cdot) = \hat{R}_I - \hat{r}_I \hat{m}_I - t_H(\hat{R}_I - (1+\alpha)\rho \hat{m}_I) - t_L((1+\alpha)\rho - a_i)\hat{m}_I - c - f. \quad \text{(A.26)}$$

Rearranging and using eq. (1.41) for $\hat{r}_I$ yields

$$\begin{aligned} \hat{\pi}(a^*, \cdot) \quad = \quad & \left[1 - (1-\beta)(1 - \delta^{\frac{\sigma-1}{\sigma}})\right](1 - t_H)\hat{R}_I + [1 - (1-\beta)(1-\delta)] \cdot \\ & \left[(1+\alpha)(t_H - t_L)\rho \hat{m}_I - \alpha^2 \gamma \hat{m}_I\right] + t_L a_i \hat{m}_I - c - f. \end{aligned}$$

From above, we know that $\hat{m}_I \geq m_I$. Therefore, $\hat{\pi}(a^*, \cdot)$ is larger than $\pi(a^*, \cdot)$ from eq. (A.12) if $(1 + \alpha(t_H - t_L)\rho \hat{m}_I - \alpha^2 \gamma \hat{m}_I > (t_H - t_L)\rho m_I$. In equilibrium, this condition holds, as can be verified by inserting eq. (1.40) for $\alpha$. As fixed costs $c + f$ are the same as in the benchmark, the cut-off for integration rises if transfer prices can be manipulated.

# B Appendix to Chapter 2

## B.1 The Critical Cost Gap $\Delta$

This appendix derives an upper bound on the cost gap $\Delta$, which ensures that high-cost firms will find it profitable to enter the market for good $X$ in the absence of government intervention. For market entry by high-cost firms to occur, a necessary condition is that the market price that results from the supply of the low-cost firms alone exceeds the unit production costs of high-cost suppliers.

The inverse demand function when only low-cost firms produce is given by $p = a - bn_L x_L$. Standard profit maximization by oligopolists with the low cost level $r$ results in an output per low-cost firm of $x_L = (a-r)/[b(n_L+1)]$ and a resulting market price of $p = (a + n_L r)/(n_L+1)$. This price exceeds the unit production costs $(1+\Delta)r$ of high-cost firms if and only if

$$\Delta < \bar{\Delta} = \frac{a-r}{(n_L+1)r}. \tag{B.1}$$

The condition derived in eq. (B.1) is thus a necessary condition for high-cost firms to enter the market.[1]

## B.2 A Regime With Complete Profit Shifting by MNEs

This appendix explores the outcomes if the small country sets its tax rate above $s$, thus accepting that MNEs shift their profits abroad. In this case the low-cost firms will set $\alpha^* = 1$ from (2.17) and not declare any profits in the small country. Once the threshold $t = s$ is surpassed, the small country's objective function is unambiguously rising in $t$ as profits are – from the small country's point of view – lost to foreign shareholders. Therefore the small country will tax the high-cost firms at the maximum rate, $\hat{t} = 1$, where the 'hat' denotes the regime with complete profit shifting by MNEs. Tax revenues in the small country are then given by

$$\hat{T} = n_H b \hat{x}_H^2 + \hat{\tau}_L n_L \hat{x}_L r + \hat{\tau}_H n_H \hat{x}_H (1+\Delta) r. \tag{B.2}$$

[1] Our treatment leaves out the possibility that low-cost firms collude and engage in predatory pricing to keep the high-cost firms out of the market. If this possibility is incorporated, the cost differential must be smaller than in (B.1) to ensure that high-cost firms will produce in equilibrium.

Optimal capital input taxes are derived by inserting (B.2) and firm's optimal quantities (2.9a)–(2.9b) in (2.1) and maximizing the resulting indirect utility function $\hat{V}$. This yields

$$\hat{\tau}_L = \frac{\Delta}{2}, \qquad \hat{\tau}_H = -\left\{ \frac{2[a-(1+\Delta)r] - n_L \Delta r}{2[n_H(1+\Delta)r]} \right\}. \tag{B.3}$$

As the low-cost firms now shift their profits abroad, the small country taxes their capital inputs instead. This enables it to capture some of the rents arising from the MNEs' productivity advantage. In contrast, capital inputs of high-cost, domestic firms are subsidized. The subsidy to high-cost firms increases aggregate output in the $X$ sector while the increased profits of high-cost firms are fully taxed away by the corporate profit tax $\hat{t}$.

The consumer's indirect utility in the case with complete profit shifting is derived by inserting (B.3) and the resulting optimized output levels (2.9a)–(2.9b) in (2.1). This gives

$$\hat{V} = \frac{2\left[a-(1+\Delta)r\right]^2 + n_L \Delta^2 r^2}{4b} + rK \equiv \frac{\Theta}{4b} + rK. \tag{B.4}$$

The corresponding value of indirect utility in the benchmark case without profit shifting is given in (2.23). Introducing $\Lambda \equiv n(a-r)^2 - 2n_H r\Delta(a-r) + n_H \Delta^2 r^2$, this can be written as

$$V^* = \frac{2(1-s)\Lambda + n_L n_H \Delta^2 r^2}{4b\left[2(1-s)+n_L+n_H\right](1-s)} + rK., \tag{B.5}$$

It will be optimal for the small country to prevent profit shifting, and to set its profit tax rate according to (2.18), if $V^*$ in (B.5) exceeds $\hat{V}$ in (B.4). This condition is:

$$V^* - \hat{V} \quad \propto \quad 2\Lambda + \frac{n_H n_L r^2 \Delta^2}{(1-s)} - [2(1-s)+n_H+n_L]\Theta > 0, \tag{B.6}$$

where $\Theta > 0$ and $\Lambda > 0$ are defined above. It is then straightforward to see that (B.6) is the more likely to be fulfilled, the lower is economic integration (the higher is $s$) and hence the higher is the feasible profit tax rate $t^*$ in the equilibrium without profit shifting. Moreover, (B.6) is more likely to be fulfilled when $\Delta$ is high so that the productivity difference between multinational and national firms is large. In this case, the low-cost multinational firms produce a large fraction of total output, thus making it more costly to forego the profit taxation of these firms in the high-tax ('hat') regime.

## B.3 Bertrand Competition With Heterogeneous Goods

This appendix derives optimal capital input taxes when two firms compete over prices and goods are heterogeneous. Preferences are given by a quadratic, quasi-linear utility function (eq. 2.28) in which two goods $(x_L, x_H)$ enter as imperfect substitutes. Consumer optimization leads to the following demand functions for the goods produced by the low-cost and the high-cost firm:

$$\begin{aligned} x_L &= \frac{a}{(b+\gamma)} - \frac{b}{(b^2-\gamma^2)}\, p_L + \frac{\gamma}{(b^2-\gamma^2)}\, p_H, \\ x_H &= \frac{a}{(b+\gamma)} - \frac{b}{(b^2-\gamma^2)}\, p_H + \frac{\gamma}{(b^2-\gamma^2)}\, p_L. \end{aligned}$$

Taking these demand functions into account, each firm sets its price to maximize profits, which are given by (2.7a)-(2.7b). Optimal prices thus are

$$\begin{aligned} p_L &= \frac{(b-\gamma)}{(2b-\gamma)}\, a - \frac{b}{(4b^2-\gamma^2)} \left[2b\,(1+\tau_L)\,r + (1+\tau_H)\,(1+\Delta)\,r\gamma\right], \\ p_H &= \frac{(b-\gamma)}{(2b-\gamma)}\, a - \frac{b}{(4b^2-\gamma^2)} \left[2b\,(1+\tau_H)\,(1+\Delta)\,r + (1+\tau_L)\,r\gamma\right]. \end{aligned}$$

The corresponding equilibrium quantities are

$$x_L = \frac{a(b-\gamma)(2b+\gamma) - (2b^2-\gamma^2)(1+\tau_L)r + b\gamma(1+\tau_H)(1+\Delta)r}{(2b^2-\gamma^2)^2 - b^2\gamma^2} b, \quad \text{(B.7)}$$

$$x_H = \frac{a(b-\gamma)(2b+\gamma) - (2b^2-\gamma^2)(1+\tau_H)(1+\Delta)r + b\gamma(1+\tau_L)r}{(2b^2-\gamma^2)^2 - b^2\gamma^2} b. \quad \text{(B.8)}$$

Maximizing the utility function (2.28) after inserting (B.7)-(B.8) yields the welfare maximizing capital input taxes, which are given by (2.29).

# C Appendix to Chapter 3

Table C.1 states some results of numerical simulations of the model. The fixed parameters are $\tau = 0.1, \mu = 0.5, \beta = 3$ and $L = 1$.

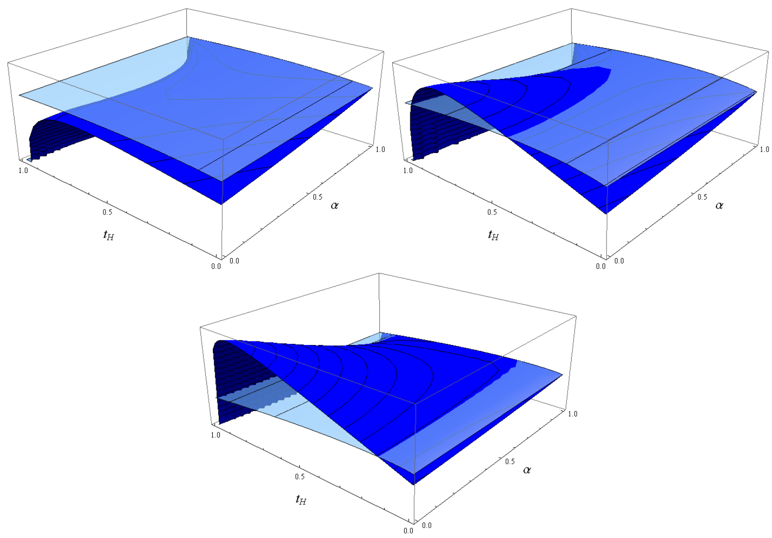
Table C.1: Results of the Numerical Simulation

| Parameters | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $c$ | 0.1 | 0.5 | 0.1 | 0.5 | 0.1 | 0.5 | 0.1 | 0.5 | 0.1 | 0.5 | 0.1 | 0.5 | 0.1 | 0.5 | 0.1 | 0.5 |
| $f$ | 0.1 | 0.1 | 0.5 | 0.5 | 0.1 | 0.1 | 0.5 | 0.5 | 0.1 | 0.1 | 0.5 | 0.5 | 0.1 | 0.1 | 0.5 | 0.5 |
| $\gamma$ | 1.5 | 1.5 | 1.5 | 1.5 | 2 | 2 | 2 | 2 | 1.5 | 1.5 | 1.5 | 1.5 | 2 | 2 | 2 | 2 |
| $\sigma$ | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Equilibrium tax policies | | | | | | | | | | | | | | | | |
| $t_H$ | 0.99 | 0.20 | 0.99 | 0.87 | 0.97 | 0.26 | 0.96 | 0.85 | 0.79 | 0.88 | 0.94 | 0.89 | 0.80 | 0.85 | 0.89 | 0.86 |
| $t_X$ | 0.43 | 0.09 | 0.36 | 0.37 | 0.35 | 0.10 | 0.26 | 0.29 | 0.53 | 0.60 | 0.64 | 0.59 | 0.46 | 0.45 | 0.46 | 0.43 |
| $\alpha$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |

Results of the numerical simulation for parameter values $\tau = 0.1, \mu = 0.5, \beta = 3$ and $L = 1$.

It becomes clear that is always either optimal not to limit profit shifting at all ($\alpha \to 1$) or to prohibit profit shifting completely ($\alpha \to 0$). This is also clarified by the three graphs in Figure C.1, which plot welfare depending on the tax rate $t_H$ and on $\alpha$.

Figure C.1: 3D-Plots of Simulated Welfare Levels



This figure shows 3D-Plots of simulated welfare levels for varying levels of $\sigma$ (from left to right: $\sigma = 1.75, \sigma = 2$ and $\sigma = 2.25$). Parameter values: $L = 1, \mu = 0.5, \beta = 3, f = c = \tau = 0.1$ and $\gamma = 1.5$.

The graphs clarify that it is not always welfare-increasing to introduce a limitation on profit shifting: In the graph on the left, welfare with such a limitation is always lower than in the benchmark case where profit shifting is not limited. If such a rule should be introduced, it is optimal to set it as strict as possible (that is, at the left side of the graph).

# Appendix to Chapter 3

Figure C.1 depicts welfare for different values of the elasticity of substitution, $\sigma$. It shows that limiting profit shifting becomes more favorable if the elasticity of substitution is higher. In that case, it is less important for the consumer to have different varieties available. Hence, the negative effect of a limitation on profit shifting (i.e. market exit by some firms and thus the loss of these varieties) is less pronounced if $\sigma$ is high.

# D Appendix to Chapter 4

Table D.1: Variable Definitions and Data Sources

| Variable | Definition | Source |
|---|---|---|
| Return on asset (*ROA*) | Ratio of EBIT (XWC18191) over assets (XWC02999), where EBIT are earnings before interest and taxes | Thomson Reuters' Worldscope |
| Firm risk-taking proxy over three years (*Risk_3Y*) | Three-year earnings volatility, defined as $Risk\_3Y = \sqrt{\frac{1}{2}\sum_{t=1}^{3}\left(D_{ijct} - \frac{1}{3}\sum_{t=1}^{3} D_{ijct}\right)^2}$, where $D_{ijct} = ROA_{ijct} - \frac{1}{N_{jct}}\sum_{k=1}^{N_{jct}} ROA_{kjct}$. $N_{jct}$ indexes firms $i$ in industry $j$ and country $c$ in year $t$. In words, this is the standard deviation over three years of a firm's *ROA*'s deviation from the industry-country specific average *ROA*. *ROA* is winsorized at 1% to account for loss-making firms with extremely low assets. *Risk_3Y* is winsorized at 1% on both sides of the sample distribution. | Thomson Reuters' Worldscope |
| Firm risk-taking proxy over five years (*Risk_5Y*) | Five-year earnings volatility, defined as $Risk\_5Y = \sqrt{\frac{1}{4}\sum_{t=1}^{5}\left(D_{ijct} - \frac{1}{5}\sum_{t=1}^{5} D_{ijct}\right)^2}$, where $D_{ijct} = ROA_{ijct} - \frac{1}{N_{jct}}\sum_{k=1}^{N_{jct}} ROA_{kjct}$. $N_{jct}$ indexes firms $i$ in industry $j$ and country $c$ in year $t$. In words, this is the standard deviation over five years of a firm's *ROA*'s deviation from the industry-country specific average *ROA*. *ROA* is winsorized at 1% to account for loss-making firms with extremely low assets. *Risk_3Y* is winsorized at 1% on both sides of the sample distribution. | Thomson Reuters' Worldscope |
| Loss carryback (*LCB*) | Period for which losses can be carried back, in years. | IBFD European Tax Handbook, U.S. Internal Revenue Code |
| Loss carryforward (*LCF*) | Period for which losses can be carried forward, in years. | IBFD European Tax Handbook, U.S. Internal Revenue Code |
| Tax rate (*CTR*) | Statutory corporate tax rate. If applicable, central and sub-central/local rates are summed up, using an average sub-central rate. If the tax system is progressive, the top marginal tax rate. | OECD tax database |
| Firm size (*Size*) | Natural logarithm of a firm's total assets (Worldscope data code: XWC02999), winsorized at 1% and 99%. | Thomson Reuters' Worldscope |
| Sales Growth (*Sales Growth*) | Year-to-year percentage change in revenues (XWC01001), winsorized at 1% and 99%. | Thomson Reuters' Worldscope |
| Leverage (*Leverage*) | Leverage, i.e. ratio of total liabilities (XWC03351) to total assets (XWC02999), winsorized at 1% and 99%. | Thomson Reuters' Worldscope |
| Market-to-book ratio (*MB*) | Ratio of market capitalization (XWC08001) to common equity (XWC03501), winsorized at 1% and 99%. | Thomson Reuters' Worldscope |
| GDP growth rate (*GDP Growth*) | Year-to-year percentage change in gross domestic product (GDP), measured in current prices | IMF World Economic Outlook Database |

All firm-level data is transformed to US-Dollar using exchange rates provided by Officer (2011).

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