Research and Development Tax Planning of Multinational Firms

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List of Abbreviations

ASC	Accounting Standards Codification
AT	Austria
BE	Belgium
BEPS	base erosion and profit shifting
BERD	business enterprise expenditure on R&D
BG	Bulgaria
BR	Brazil
CA	Canada
CEO	chief executive officer
CEPII	Centre d'Etudes Prospectives et d'Informations Internationales
CFO	chief financial officer
CH	Switzerland
CL	Chile
CN	China
CQI	composite quality index
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EC	European Commission
EE	Estonia
EG	Egypt
e.g.	exempli gratia
EPO	European Patent Office
ES	Spain
et al.	et alii
etc.	et cetera
ETR	effective tax rate
EU	European Union
FDI	foreign direct investment
FR	France

GAAP	generally accepted accounting principles
GDP	gross domestic product
GDP pc	gross domestic product per capita
HK	Hong Kong
HM	Her Majesty's
HU	Hungary
IAS	International Accounting Standard
IE	Ireland
i.e.	id est
IFRS	International Financial Reporting Standards
IN	India
IP	intellectual property
IPC	International Patent Classification
IT	Italy
JP	Japan
KR	South Korea
LT	Latvia
LU	Luxembourg
ML	maximum likelihood
MNE	multinational enterprise
MT	Malta
NL	The Netherlands
No.	Number
NZ	New Zealand
OECD	Organization for Economic Co-operation and Development
OLS	ordinary least squares
PL	Poland
PPP	purchasing power parity
PT	Portugal
PwC	PricewaterhouseCoopers
R&D	research and development
RO	Romania
RU	Russia
SE	Sweden
SEC	US Securities and Exchange Commission
SEEK	Strengthening Efficiency and Competitiveness in the European Knowledge Economies
SG	Singapore
SIC	standard industrial classification
SK	Slovakia
S&P	Standard & Poor's

TH	Thailand
TR	Turkey
TW	Taiwan
UA	Ukraine
UK	United Kingdom
US	United States
VE	Venezuela
Vol.	Volume
ZA	South Africa
ZEW	Centre for European Economic Research

Chapter 1

Introduction

Innovation is often considered to be the driving force behind economic growth and social welfare. This idea dates back to Schumpeter who states that 'the fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, [...]. [This process] incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism' (Schumpeter, 1942). As the creation of new innovation is risky, the private sector may fail to undertake the optimal amount of research and development (R&D) activities. Consequently, it is often argued that the state shall come in where the market may fail. There are indeed several ways to achieve that private R&D is undertaken in an economy. Tax policy surely is among the most important. The tax system immediately impacts on the risk return profile of R&D activities and thus influences corporate innovation in manifold ways. As a consequence, many countries employ tax incentives especially designed to foster R&D activity. However, another argument why governments employ various tax incentives is tax competition. Not only do we observe a tendency towards low corporate income tax rates within the European Union (EU), but also a recent trend towards special tax regimes attracting specific forms of investment. Most prominently, so-called patent box regimes have been introduced in recent years by some European governments that allow profits from intellectual property (IP) being taxed at a low or zero corporate income tax rate. The intent of such regimes does not seem to be the fostering of new R&D activity exclusively, but also the attraction of IP from abroad.

This thesis is attributed to the guiding question how an innovation-friendly tax system ideally looks like. The argument that Europe's economic future crucially depends on its ability to become a knowledge-based economy is also reflected in the Europe 2020 strategy, where the EU agreed to raise public R&D spending to

3% of the gross domestic product (GDP).[1] It is widely accepted, that a constant flow of innovations is a prerequisite for economic growth, global competitiveness and wealth. On the level of the firm, this can be translated into the need of corporate innovation for firm productivity and success in the long run. To argue which way of subsidizing innovative activity of firms brings the desired results, it is important to understand how firms will respond to the various forms of tax incentives for R&D. The core research question of this thesis is thus, how R&D related tax regulations influence R&D related business decisions at the micro-level.

Despite its importance, the interdisciplinary field of corporate taxation and R&D is not heavily researched and contains a lot of open and unanswered questions. There is consensus that taxation influences the creation of innovations in manifold ways. Potential tax savings from the tax deductibility of R&D expenses and specific R&D tax incentives have been proven to codetermine the decision on the location and scale of new R&D activity. There is a body of previous work that investigates the effects of corporate taxes on both real R&D activity (for a survey of the evidence see Hall and Van Reenen, 2000; Arundel et al., 2008; Spengel et al., 2009; Elschner and Spengel, 2010) and on how firms organize their intellectual property (see for example Dischinger and Riedel, 2011; Boehm et al., 2012; Ernst et al., 2014; Griffith et al., 2014). Furthermore, there is robust evidence that tax considerations can lead firms to relocate and shift existing R&D activities on the one hand (Bloom and Griffith, 2001; Wilson, 2009a; Paff, 2005), and intellectual property rights on the other hand (Dischinger and Riedel, 2011; Ernst and Spengel, 2011; Boehm et al., 2012; Karkinsky and Riedel, 2012; Griffith et al., 2014) to tax favorable jurisdictions. However, it is still unclear to what extent real R&D activity and intellectual property rights are mobile assets that are easily relocated due to tax planning considerations. Moreover, previous studies observed an above-average number of patent applications in low tax locations (for example Ernst and Spengel, 2011; Karkinsky and Riedel, 2012). Nevertheless, these studies leave open how firms achieve the move of intellectual property rights to low tax locations and thus, do not allow to draw a conclusion how sensitive firms react to various anti-tax avoidance measures.

The aim of this thesis is to shed light on some of the above sketched questions and provide empirical evidence on the behavior of firms regarding firms' investments in R&D. The responsiveness of firms to tax incentives, but also to anti-tax avoidance measures is crucial if governments want to regulate and subsidize the market of innovations. Therefore, the focus throughout the following analyses is a micro-economic one and the methodological approach is empirical. In all Chapters, econometric methods are applied to identify whether taxes do exert an impact on R&D related business decisions and thus, have the power to influence firm behavior. In this sense,

[1]The Europe 2020 strategy can be viewed online at http://ec.europa.eu/europe2020/.

the thesis provides empirical evidence using data on firms' international activities and taxes.

The thesis is structured as follows: In Chapter 2, I give an overview of the theoretical foundations of R&D subsidies in general and of tax incentives for R&D in particular. Theory argues in favor of subsidizing R&D activities due to the important role of innovation for economic growth and welfare. Therefore, R&D activities and firms' innovative behavior have also been intensively studied by empiricists. These findings will be summarized and briefly addressed to establish a common ground of knowledge in this field of research. Furthermore, I move to the intercept of R&D and taxation. In the empirical and theoretical literature, this rather small field only offers some first insights, but leaves open many follow-up questions. Especially, in the light of recent developments in the field of corporate taxation and the discussion about harmful tax practices of multinational enterprises (MNE) the interdisciplinary field of taxation and corporate innovation receives recent attention.

Chapter 3 presents evidence from a survey among multinational R&D intensive firms. The survey is an instrument in empirical research that allows to directly test hypotheses, to ask for motives and considerations behind actions and to assess the relative importance of factors influencing R&D related decisions. The survey was conducted in collaboration with PricewaterhouseCoopers (PwC), an internationally operating tax consultancy. PwC distributed the questionnaire among selected client firms and thus, enabled us to address a sample of a few, but globally operating firms. The results presented in Chapter 3 are partly descriptive in nature and partly allow to draw inferences about the relationship between the behavior of the surveyed firms and their characteristics. The hypotheses tested relate to business decisions regarding the investment in R&D. Consequently, questions on the location of R&D and IP, on the scale of investment and on the design of R&D tax incentives are in the focus of the survey. Furthermore, firm characteristics regarding the organizational structure of the MNE are examined and it is assessed whether they are correlated with the R&D intensity of the firm.

After having presented new insights into how R&D intensive multinationals think about tax planning matters with respect to R&D investments, I go on to address a specific research question that is related to the profit shifting literature. Chapter 4 examines the strategic selection of R&D projects to tax favorable locations. Previous literature has shown that all kinds of tax incentives, be they tax credits, additional allowances or reduced tax rates on R&D output, are effective in raising the quantity of R&D related activity. This chapter assesses the impact of corporate tax incentives on the quality of R&D projects, i.e. their innovativeness and earnings potential. It is argued that traditional forms of R&D tax incentives, like additional allowances and tax credits, exert different effects on the average profitability and innovativeness of

R&D projects than low profit tax rates on patent income. To empirically assess the predefined hypotheses, the universe of patent applications to the European Patent Office (EPO) matched with firm information from Amadeus is exploited.

Finally, in Chapter 5 I address and empirically assess the question of how tax aspects impact on location decisions of R&D investments. Specifically, I devote the attention to the location choice of real R&D activity, because this question has been largely left unattended by previous literature. Using new tax data collected in collaboration with PwC, I test whether anti tax-avoidance measures are anticipated by firms and affect the location decision of real R&D activity and the decision on where patent ownership is located. The analysis is conducted by using a conditional logit estimation model that allows to take characteristics of alternative locations into consideration. The results should contribute to the empirical literature in this field and extend it by findings regarding the tax effects on the location of real R&D activity.

Finally, a conclusion is provided in Chapter 6.

Chapter 2

Theory and Evidence on R&D Tax Incentives

2.1 The R&D Process

The investment in R&D is usually scheduled on a long-term basis. Generally, one can distinguish between two phases: During the first stage of the investment process, the firm conducts the research and development activities to create an intangible asset and thus, incurs costs. In the second stage, after the intangible asset has been created, the profit potential of the intangible asset can be exploited. If the project was a success, the earnings generated in the second stage outweigh the costs incurred in the first stage and the firm renders a profit. Otherwise, the firm would incur a loss. From a tax perspective, the costs incurred in the first stage are expenses that can be either tax-deductible or non-deductible items. Consequently, in the second stage the profits are either fully taxable - in the case the expenditures were already deducted in the first stage - or are only taxable in the amount that they exceed the depreciation allowance - in the case the expenditure was not deductible in the first stage, had to be activated in the balance sheets and is amortized in the second stage. In the following, R&D tax incentives are classified into groups as to whether they are applicable during the first or the second stage of the R&D investment process (see also Spengel et al., 2009).

2.1.1 R&D Tax Incentives in the First Stage

Tax incentives for the investment in R&D can either relate to the tax base or to the tax burden. Incentives relating to the tax base downsize the same by granting additional deductions. These could be granted in the form of additional one-time deductions for R&D assets such that more than 100% of the asset value is depreciable overall. Another possibility would be an accelerated depreciation that causes an interest advantage for the firm. Furthermore, also current expenditure may be subsidized by allowing to deduct more than the actual cost incurred. On the other hand, the tax incentive can also be implemented by granting a tax credit to the firm that reduces the overall tax burden. In this case, the tax credit is deductible from the tax payable.

The promotive effect also critically depends on whether a refund of the tax incentive is granted or not. In the situation of a loss, the firm cannot make use of an additional deduction or a tax credit, because it does not pay any taxes at all. To facilitate the usage of the tax incentive, some countries grant a direct refund in cash. This directly impacts on the liquidity of the firm and is thus, argued to be very effective to foster R&D activity (Spengel, 2013). Restrictions regarding the eligibility for the tax incentive may also apply to cross-border situations. Some countries require that the subsidized R&D activity must occur within the country and thus, do not grant the tax incentive for R&D activities that are financed from a domestic firm but carried out by some foreign firm. This mechanism discriminates against contracting out R&D to a third or affiliated firm that resides abroad. Similarly, a mechanism requiring that costs must be incurred in the country discriminates against cross-border contract R&D. For example, an additional deduction on R&D expenditure may only be granted if the R&D activity is also performed domestically. Reversely, the country where R&D activity is conducted under a contract R&D agreement may also have tax incentives in place. These, in turn, might also be restricted such that it is required that the costs are incurred domestically. If the use of tax incentives is not restricted in both countries involved in a contract R&D agreement, the firm may make use of tax incentives in both countries. Moreover, a typical characteristic of R&D tax incentives is whether the resulting IP must be retained in the country after it has been created. Hence, a cross-border transfer of IP could result in the recapture of the tax incentive for R&D expenditure (a detailed overview of worldwide tax incentives for R&D is presented in PricewaterhouseCoopers, 2011, 2012, 2013, 2014; Deloitte, 2011, 2012, 2013, 2014).

The amount of the tax incentive is either determined by the total volume of R&D expenditures incurred or by the incremental increase as compared to the previous reporting period. Moreover, R&D tax incentives are often granted only up to a threshold, which is an absolute amount that cannot be exceeded. A reason for restricting the tax incentive is the main interest of the government to foster R&D activities of small and medium sized enterprises. Furthermore, the activities of firms that will be subsidized by a tax incentive have to be predefined. The requirements that an activity is a research activity and is eligible for an R&D tax incentive are laid down in the OECD Frascati Manual (OECD, 2002a).

2.1.2 R&D Tax Incentives in the Second Stage

In recent years, so-called patent box regimes have been introduced in several countries. These regimes allow a lower or even zero corporate income tax rate for patent income that is attributed to the patent box.[1] In this sense, the patent box is a tax incentive that relates directly to the tax rate that is imposed on income from innovative activity. It has been argued that patent box regimes are another form of R&D tax incentive, that aim at fostering R&D activity. However, it critically depends on the design of the patent box regime whether R&D activity is subsidized or merely the holding of IP rights.

Patent boxes can be designed in various ways (for an overview see PricewaterhouseCoopers, 2012, 2013, 2014). First, it has to be defined what kind of IP qualifies for the patent box and what sort of income may be attributed to preferential tax regime. Some countries restrict the scope of the regime to patents only, while other countries allow all kinds of intangible assets to qualify for the patent box. The scope may range from patents and trademarks to designs, software copyrights or secret formulas to know-how and mere business secrets. Some countries also further restrict the patent box to self-created IP and do not allow acquired IP to benefit from preferential treatment. Qualifying income may be net or gross income from qualifying IP or limited to royalty income. The question whether net or gross income qualifies for the patent box regime determines the deductibility of expenses that correspond to the creation of the qualifying IP. If only the net income benefits from the reduced tax rate, corresponding expenses are deductible only against the lower patent box tax rate. However, if gross income is granted the preferential treatment, all expenses relating to the creation of the IP are deductible against the statutory corporate tax rate. Thus, the firm benefits from both deducting costs against a high tax rate and at the same time from a low income tax rate on the profits accrued.

Moreover, patent box regimes regularly allow that the corresponding R&D activity is performed abroad. This aspect together with the possibility that gross income qualifies for the preferential tax rate are characteristics that strongly attract patents and other intangibles. In this sense, it is debatable whether such patent box regime really subsidizes R&D activity.

2.1.3 Interaction between First and Second Stage

A consistent tax system is established if costs and expenditures are deducted against the same tax rate that is imposed on the corresponding profits. Consistence is

[1] A recent study by Evers et al. (2014) provides an in depth analysis of patent box regimes in place and calculates effective tax rates using the methodology introduced by Devereux and Griffith (1999) and Devereux and Griffith (2003).

achieved if a firm operates in one country only, such that the investment and the exploitation happen to be in the same jurisdiction. However, when R&D activities are performed cross-border, a coherent taxation is not assured anymore and thus, the R&D investment may not be consistently taxed. Taxpayers often make use of such inconsistencies to achieve, for example, that costs are deducted against a higher tax rate than profits are taxed or to gain a double-dip, i.e. double non-taxation.

With respect to cross-border arrangements of R&D activities, the first and second stage of the R&D process interact in several ways. First, it is possible that the R&D activities are contracted out to a third or an affiliate company that performs R&D on behalf of the financing company. The services are remunerated by a fee. Hence, a consistent taxation is ensured, because the fee is deductible in the hands of the financing company, where also profits will be subject to tax. If the contract is set up between affiliated companies the fee has to be at arm's length. In this case, the two stages are interrelated by the mark-up that determines how much profit remains taxable in the country where the R&D activity was actually performed. In this amount, the investment is taxed inconsistently and taxpayers may make use of the inconsistency in their favor.

Moreover, the grant of a tax incentive is sometimes restricted to criteria that relate to the other stage, as has been briefly mentioned in Section 2.1.1. An additional deduction on R&D assets may only be granted if the resulting IP remains in the country after it has been created. Reversely, patent box regimes may also be restricted to qualifying IP that has been created domestically. The majority of countries, however, allows that R&D is performed abroad. Furthermore, the deductibility of R&D expenditure may be recaptured under the regime of a patent box. This is the case, if the expenses that relate to the qualifying IP may only be deducted against the lower patent box tax rate. Consequently, firms may have to anticipate tax regulations that relate to the second stage already in the first stage of the investment process to optimize their investment. Although the decision process may be theoretically separated into distinct decisions about the location and the scale of R&D activity as well as the location of IP ownership (Devereux and Maffini, 2007), they depend on each other and may thus, not be filed separately from each other.

2.2 Theoretical Justification for R&D Subsidies

If R&D incentives are granted, the government intervenes in the market for R&D with the aim to regulate it. As discussed above, R&D is commonly subsidized by governments through a broad variety of measures. In Section 2.1 incentives for R&D that are implemented within the tax code have been described. However, R&D may also be subsidized directly, through the application for research funds. Without paying attention on how a subsidy is granted, the following section presents the theoretical framework that justifies state intervention regarding R&D investments.

2.2.1 Technology and Economic Growth

Macroeconomic theory describes economic growth by the Solow growth model, named after the economist Robert M. Solow (Solow, 1956). The Solow model defines output Y to be a function of total capital C and total labor L. Thus, the production function reads

$$Y = F(C, L). \tag{2.1}$$

Furthermore, investment and depreciation are the two determinants of the capital stock. While investment causes the capital stock to grow, depreciation is the loss of value through wear and tear and thus, causes the capital stock to fall. At a certain level of capital stock, the amount of investment equals the amount of depreciation and the economy finds itself in an equilibrium state. In this state, investment and depreciation just balance and the capital stock is neither shrinking nor growing over time. Solow calls this state the steady-state level of capital, which represents the long-run equilibrium of the economy.[2] The long-run equilibrium also implies that regardless of the level of capital, the economy will eventually move to the steady-state level of capital. However, this basic model cannot explain the sustained economic growth that is empirically observed all over the world, because it predicts that eventually the economy will reach a steady-state level in which capital and output are constant. Thus, the model must be extended by two further sources of economic growth, which are population growth and technological progress.

To introduce population growth into the model, one needs to think in terms of capital stock per worker. Thus, investment increases the capital per worker, while depreciation and population growth decrease it. Alongside with investment and depreciation, population growth is another factor influencing the capital stock per worker. As the population grows the capital per worker is falling. In order to keep per worker capital constant, investment must compensate not only for the depreciation rate of capital but also for the need for capital per new worker. Because the steady state of the economy requires that the capital stock per worker is constant and unchanging, the economy must grow if it falls below the steady-state level through an increase in the number of workers. In this extended model of growth,

[2] Economic growth in the Solow model is also influenced by the saving rate, which determines the level of consumption in the economy. For a more detailed explanation of the model see Mankiw and Taylor (2014a).

again capital per worker and output per worker are constant if the economy is in the steady state. Consequently, if the number of workers grows at rate n, total capital and total output must also grow at rate n. Still, the model cannot explain sustained growth in the standard of living, because this would correspond not to growth of total capital but to growth of capital per worker while the model so far only assumes constant capital per worker in the equilibrium state.

The model can be further extended by the factor of the so-called efficiency of labor (Mankiw and Taylor, 2014a). Formally, the production function is extended by the factor E such that

$$Y = F(C, L \times E). \tag{2.2}$$

The efficiency of labor E can be explained by the society's knowledge about production methods. For example, assembly-line production or computerization improved the technology of production such that each hour of a worker could be used more efficiently and thus, rendered a higher level of output of goods and services. The term $L \times E$ can also be interpreted to be the effective number of workers, where L is the number of actual workers and E the efficiency of each single worker. Consequently, total output is determined by capital inputs C and effective workers $L \times E$. Let's assume that technological progress causes the efficiency of labor to grow. If the efficiency of labor grows at a constant rate, also output grows at this rate as if the workforce had increased. The same considerations as for population growth apply to technological progress. In the steady state, the capital per effective worker as well as the output per effective worker are constant quantities. If efficiency of labor grows at rate g, the effective workforce grows equally at rate g. If we assume population growth to be zero, the actual workforce remains constant. As a consequence, the output per actual worker is growing at rate g in the steady state. Similarly, the economy's total output grows at rate g. Ultimately, this model explains sustained increases in the standard of living even though the economy is in an equilibrium state regarding its stock of capital. In other words, only technological progress explains why we empirically observe constantly rising living standards. Moreover, according to the Solow model, only technological progress is responsible for the growth in output per worker.

This conclusion emphasizes the need to stimulate the rate of technological progress. However, the Solow model is simplifying reality in many terms. For example, the model only considers one form of capital. In reality, however, there is physical capital such as bulldozers, steel plants, computers and robots, and human capital, such as knowledge, skills and education. In stimulating economic growth, policymakers may consider which type of capital yields the highest marginal products and thus, should be raised. Moreover, the model takes technological progress as exogenously given and does not explain how technological progress itself is determined. If the political aim is to raise technological progress, it needs to be well understood how it is determined though. One explanation is given by the economist Joseph Schumpeter, who viewed economic progress as a process of 'creative destruction' (Schumpeter, 1942). In the center of his argumentation are the entrepreneurs and their innovative activities. An innovation provides the entrepreneurs a monopoly position for a certain time, which the entrepreneurs can exploit until other market participants have imitated the invention. The monopoly profits motivate the entrepreneurs to innovate and they also constitute economic growth. At the same time, innovation has a destructive power, because old products will be replaced by new ones. According to Schumpeter, innovation forms the engine of economic growth.

More recent studies also provide models that explain technological advance. This research is referred to as endogenous growth theory. Early contributions were made by Romer (1986, 1990) and Lucas (1988), while more recently, Aghion and Howitt (1992) established a model of growth that is based on the idea of creative destruction. In this literature, a core question is how knowledge is created and how the process of research and development is determined in order to integrate the microeconomic characteristics of R&D into macroeconomic models.[3] These characteristics of R&D can be summarized as follows (Mankiw and Taylor, 2014a): First, the outcome of most R&D processes is knowledge, which is a public good. Thus, it is available to everyone and the property rights have to be allocated artificially by means of patent protection legislation. Second, R&D is highly profitable if the project was a success, because the temporary right to exploit a monopoly is granted to the inventor. Third, R&D renders positive externalities, because also competitors benefit from the innovation made by one firm. Moreover, R&D is characterized by a high level of asymmetric information in favor of the firm who is conducting the research but at the expense of investors and other stakeholders. Last, R&D involves indivisible goods, since high fixed costs are causing that investments are only profitable if they exceed a high threshold of invested capital. Such big scale investments may trigger the establishment of monopolies and competition to be distorted. In the following, two core characteristics of R&D are discussed in more detail, as they are good reasons why state interventions in the market of R&D are justifiable.

[3] An in depth discussion of this strand of literature would go beyond the scope of this thesis. For an introduction to growth theory see for example Weil (2008).

2.2.2 Technology Spillovers

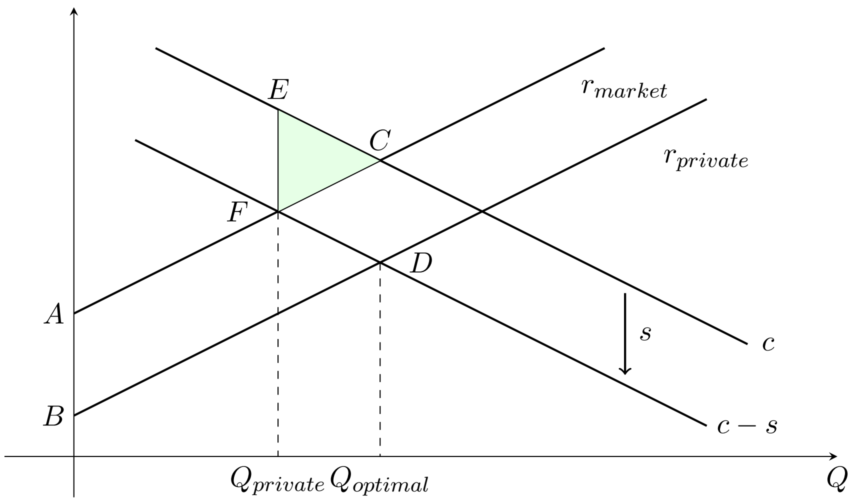
Technology spillovers are positive externalities that occur in the market for R&D (Mankiw and Taylor, 2014b). The reason for technology spillovers lies in the characteristics of R&D: Knowledge is a public good, which means that it is neither an excludable nor a rival good. Excludability refers to the fact, that no-one can be excluded from using the good, which applies for knowledge. The second characteristic applicable to knowledge is rivalry, which describes the circumstance when the use of the good by one person does not diminish another person's use. When a firm innovates, a new innovation becomes part of society's technological knowledge pool and everybody can access it without using it up. Hence, also competitors in the market benefit as they can build on that new innovation when doing research in a similar subject area. A new innovation will thus accelerate the process of further innovations in the market. This social return does not have to be remunerated by the users, as the access to knowledge is free. The fact that costs are borne only by the inventing firm, while competitors are benefiting although they do not pay any remuneration, may cause firms to invest too little into R&D and the market to fail.[4]

On the other hand, negative externalities may be present in the market for R&D as well (Mankiw and Taylor, 2014b). Negative externalities lead to social costs that are not borne by the person who has caused the costs. To internalize negative externalities, taxes are imposed on the person who engages in the activity such that the profits that arise in the hands of the person conducting the activity are reduced. As a consequence, the person will engage in less activities causing the negative externalities. With respect to R&D, a firm may harm its competitors in that it only invents the minimum necessary to be the first one regarding a specific technology but does not make a big contribution to technology as a whole. This phenomenon describes that some firms only duplicate inventions of others and is known in the growth literature as the 'stepping on toes' effect (Jones and Williams, 1998).

In order to reach an optimal level of research quantity the state may intervene by subsidizing or taxing privately conducted R&D activities. Theory suggests that activities causing negative externalities should be taxed, while on the contrary activities causing technology spillovers should be subsidized. The theory, however, is ambiguous whether the effect from the positive or the effect from the negative externality prevails. Empirical work in this area, however, documents that technology spillovers are well in excess of negative externalities. The following Section 2.3 will give an overview of the findings and sizes of the effects of R&D activities. To conclude, this empirical finding justifies that governments commonly subsidize research activities on a large scale.

[4]This problem is even more relevant for basic research than for applied research.

Figure 2.1: Optimal R&D Activity in the Presence of Spillovers



Notes: Own source, according to Mankiw and Taylor (2014b).

To highlight the welfare effects achieved by subsidizing R&D graphically, one has to differentiate between the internal or private rate of return, which is the return that is directly realized by the firm itself, and the external or social rate of return, which represents the externality borne by society. Figure 2.1 depicts the welfare consequences of a subsidy for R&D if technology spillovers are present. Together, the private rate of return $r_{private}$ and social rate of return[5] constitute the market rate of return r_{market}. On the opposite, the firm faces costs which are represented in a constant cost function c. On the x-axis, the quantity of R&D activity is plotted, while the y-axis represents the price. The quantity $Q_{private}$ of R&D activity is conducted by the firm if it maximizes its payoff function. This is where the private rate of return $r_{private}$ meets the cost function c. However, due to positive externalities the market optimum for R&D activity lies above this quantity. The market rate of return r_{market} is higher than the private rate of return and meets the cost function at a higher quantity of R&D. Thus, the state provides a subsidy s to the firm that lowers the production costs to the level represented by the function $c-s$. Hence, the optimal amount of R&D activity $Q_{optimal}$ is conducted by the firm due to the grant of a subsidy in the amount of the technology spillover. The green triangle represents the net welfare effect of the subsidy. The net welfare effect is the gross welfare effect less the subsidy granted to the firm. Graphically, the gross welfare surplus is

[5]Note that the terms *private* and *social rate of return* are not used consistently throughout the literature on R&D. Alternatively, one could refer to the social rate of return as the total return to R&D, which is the sum of the private return and the returns to all other participants in the market except the firm itself.

represented by the rectangle $ABCD$ plus the triangle CEF and it is determined by the changes in the consumer and producer surplus. The total subsidy s is represented by the rectangle $ABCD$. Thus, the triangle CEF remains left as the net welfare surplus. In practice, a successful technology policy crucially depends on whether the externalities can be reliably estimated (Mankiw and Taylor, 2014b).

2.2.3 Asymmetric Information

Another characteristic of R&D is the presence of asymmetric information, which may be another source for market failure (Spengel et al., 2009). Asymmetric information describes a situation where contractual parties have a different level of information. This is a very common feature of credit markets and is therefore also applicable for the credit market for R&D investments. However, with respect to R&D investments the problem of asymmetric information is especially crucial: First, R&D investments are regularly scheduled on a long-term basis, which renders higher uncertainty about the success of the project. Second, R&D investments often require a high amount of capital. Thus, for the credit lender it is especially risky to provide capital to an R&D investment project. As a result, banks and credit institutions will demand higher risk premiums. These high interest rates will not be acceptable for those firms who expect a successful investment. Consequently, less risky projects will reduce their demands for credit contracts and leave the market. The resulting projects will be those of high risk. If this phenomenon, commonly known as adverse selection, continues to exist, the credit market for R&D investments will ultimately collapse.

How state intervention should look like in the presence of asymmetric information is less straight-forward than it is for technology spillovers (Spengel et al., 2009), as the information asymmetry exists also vis-à-vis the government. Nevertheless, R&D subsidies will reduce the problem as they also decrease the financial constraints of the investing firm. Moreover, it will be especially important for R&D investing firms to attract equity investors in order not to depend on credits that involve the payment of high interest rates. Thus, a statutory regulation that impedes on the inclusion of equity investors will increase the problem of asymmetric information on credit markets for R&D investments.

To sum up, the previous Section 2.2 provided theoretical arguments in favor of governmental intervention in the market for R&D. It has been emphasized that the market may fail to allocate costs and profits to the responsible person and thus, may fail to reach an optimal level of R&D activity. Because innovation is likely to be a crucial driver of economic growth, underinvestment in R&D may cause low economic growth rates. Hence, raising R&D activity to a sufficient level is desirable from a welfare point of view. Governmental intervention, therefore, may be theoretically justified on the prescribed grounds.

2.3 Empirical Evidence

Two questions are crucial in the policies to promote R&D: First, the positive externality has to be estimated properly in order to determine the size of the subsidy. Second, the government has to ensure that the subsidy is effective in raising the amount of R&D activity. The following Section 2.3 provides an overview of the empirical evidence in the area of R&D spillovers and subsidies. The section is subdivided into two parts. The first part, Section 2.3.1, addresses the first question and summarizes empirical findings with respect to spillover effects from R&D. Specifically, it provides an empirical foundation that technology spillovers are present in the market for R&D, justifying governmental intervention to raise R&D to an optimal level, and gives an overview of the sizes of spillover effects. This strand of research is devoted to the estimation of private and social returns to R&D. The second part is addressed in Section 2.3.2 and discusses evidence that explores whether R&D tax incentives can be indeed effective in raising the level of R&D spending. This strand of research is attributed to the estimation of tax effects on R&D investment.

2.3.1 Evidence on the Returns to R&D

The origins of research in the field of R&D returns date back to the seventies and eighties. A first survey paper has been published by Griliches (1979). Later reviews on special topics in this area were provided by Hall (1996), Mairesse and Sassenou (1991), Mairesse and Mohnen (1994) and Hall et al. (2010), while the surveys of Debresson (1990), Mohnen (1990) and Griliches (1998) address only technology spillovers from R&D. The large body of research in this field highlights that the estimation of private as well as of social returns to R&D is of high interest to both, governments but also to the private sector. Since the investment in innovation is capital intensive, it is of high interest to the investor how high the return on the investment has been. The government, on the other hand, has an interest how high the total return on investment is and whether spillovers are present in the market for R&D.

The majority of studies calculated the returns to R&D by the estimation of a production function, also referred to as the primal approach (for details see Hall et al., 2010).[6] The production function is estimated on the firm, industry, or aggregated

[6]Besides the estimation of a production function, two other approaches have been used in the literature to determine the returns to R&D. One approach, known as dual approach, that is also well established and frequently used is based on the estimation of a system of equations. Precisely, under the assumption that a firm maximizes its firm value the cost and profit functions are estimated.

country level, depending on the data sources used. According to this method, the output of R&D investment is related to various input factors, such as labor, capital and knowledge. This function is based on a standard Cobb-Douglas production function and takes on the following form

$$Y = A \times L^{\alpha} \times C^{\beta} \times K_{int}^{\gamma} \times K_{ext}^{\delta} \times e^{u} \tag{2.3}$$

where Y is a measure for production, L a measure for labor, C a measure for capital inputs, and K measures knowledge capital. One can differentiate between internal knowledge of the firm K_{int} and external knowledge K_{ext} that is available to other firms in the market. The parameter A measures the influence of non-specific factors and e is a disturbance term. Equation (2.3) can be easily translated into a linear model by taking logs and thus, is estimated by ordinary least squares (OLS) (Greene, 2012). The coefficient estimates of labor, capital and both internal and external knowledge capital represent the elasticity of output on the respective input factor. In other words, the coefficient estimates of each input factor indicates how strong output changes are due to a change in the input factor by one unit. Moreover, the results can also be translated into percentage changes.

With respect to the private rate of return, the results vary strongly between below 10% and above 100% return on investment (Hall et al., 2010). The studies are not fully comparable, because different time periods, different countries and different estimation methods are used. Nevertheless, according to Hall et al. (2010), based on the estimation of a production function as briefly sketched above, a reasonable estimate for the private return to R&D in a developed country will lie in the range between 20% and 30%. Slightly lower estimates will be received by following the dual approach, an estimation based on the cost and profit functions of the firm. Those will range between 10% and 20%.

Turning to the estimation of the social rate of return, the literature documents a high variation in the results. In general, two approaches have been applied by previous studies. First, case studies on specific R&D projects have been useful in calculating the overall returns to the R&D investment (for an early example on the agricultural sector see Griliches, 1958). One drawback, however, with case studies is a bias towards studying winners instead of losers (Hall et al., 2010). Thus, the results may be biased upwards and are difficult to generalize. On the other hand,

From them the demand for input factors and the supply of output respectively can be derived. The basic idea of the model is presented in Bernstein and Nadiri (1991). Alternatively, a minor group of studies relies on financial and reporting data of the firm and is summarized by Hall and Van Reenen (2000), Czarnitzki et al. (2006) and Grandi et al. (2009). The idea is to econometrically relate the firm's assets to its total value as measured by market value or Tobin's q. The accounting approach is described in more detail by Lev (2001).

an advantage is that the identification of specific returns to the R&D investment is easier as compared to econometric approaches. As a second approach, econometric analysis has been commonly used to determine social rates of return. Similarly to the calculation of private rates of return described above in this section, it is based on the estimation of a production function. The core question in this regard is the estimation of the coefficient δ on the external knowledge capital parameter K_{ext}, as defined in equation (2.3).

The results on the calculation of the social rate of return based on the econometric approach range between 80% (Goto and Suzuki, 1989) to negligible effects in a study of Wolff and Nadiri (1993). Industry-specific estimates even reach an amount of 100% and above (see for example Bernstein and Yan, 1997; Bernstein, 1998; Griffith et al., 2004). However, the results of various studies have to be compared with great care due to a different measurement of spillovers across studies. Nevertheless, Hall et al. (2010) emphasize that most studies document statistically significant and sizable effects of technology spillovers from one industry to another. Thus, one can conclude that the intervention by governments to foster and raise the level of R&D activity is justifiable by empirical results indicating that R&D generate positive externalities for society.

2.3.2 Evidence on the Effectiveness of R&D Incentives

In general, R&D incentives may be granted by means of direct subsidies or via the tax system by some kind of tax incentives, as summarized in Section 2.1. One advantage of direct grants lies in their accuracy to target the firms or industries that should be subsidized. Thus, it is possible to monitor the financial position of the firm and to ensure that the subsidy is not just a windfall gain to the firm (Elschner and Spengel, 2010). On the other hand, R&D incentives granted in the form of a tax incentive are accessible to every firm in a simple way. Hence, the incentive scheme does not discriminate against small companies that are lacking information about complex application procedures and time to manage the high level of bureaucracy. In the following, empirical findings are briefly summarized on both, direct R&D subsidies and tax incentives for R&D.

Regarding the effectiveness of direct R&D subsidies on the amount of private R&D investment, earlier studies are less unanimous and report additionality effects as well as crowding-out effects (for a review of the evidence see also Becker, 2014). Additionality effects substantiate the hypothesis that governmental subsidies for R&D raise the overall level of private R&D spending. On the contrary, the subsidy would not lead to the desired result if crowding-out effects were present, which would mean that firms substitute their private R&D funds for public funds but do not invest more in R&D overall. However, new econometric methods enabled to control for selection bias, which has been present towards R&D intensive firms. As these firms are more likely to conduct R&D even in the absence of a subsidy, the crowding-out effect is likely to be found when studying R&D intensive firms. More recent studies reject that crowding-out is present when R&D is publicly stimulated (see for example Duguet, 2004; Carboni, 2011; Czarnitzki and Hussinger, 2004; Aerts and Schmidt, 2008; Hussinger, 2008).[7] On the contrary, they report additionality effects indicating that direct R&D subsidies are effective in raising the overall level of R&D spending.

Moreover, a growing number of studies report that direct subsidies are more effective in raising R&D spending of small and medium sized firms than of large multinational companies (see among others Lach, 2002; Hyytinen and Toivanen, 2005). One reason may be that small firms are more liquidity constrained. Empirical findings pointing in a similar direction are documented by González and Pazó (2008) and Becker and Hall (2013) who compare high- and low-tech industries. The authors report that direct subsidies were more effective in raising research activities in the low-tech sector, while Becker and Hall (2013) find no statistical significant effect for the high-tech sector. They argue that these results are likely to reflect some kind of inducement effect. The findings, therefore, argue in favor of windfall gains for high-tech firms. Interestingly, recent research finds evidence that the relationship between the amount of R&D subsidy and the level of private R&D investment follows an inverted U-shape (Guellec and van Pottelsberghe de la Potterie, 2003; Goerg and Strobl, 2007). If this was the case, the increase of small grants exerts a positive effect on the level of private spending. However, exceeding a certain threshold a large grant will work in the opposite direction and decrease private spending, most likely because large grants are partly windfall gains for the firm. To conclude, these studies suggest that smaller grants which are available to a broad audience may be more effective in raising the overall level of R&D spending than a few but large grants.

With respect to R&D tax incentives, the empirical evidence is largely unanimous that R&D tax incentives exert a positive effect on the size of R&D spending. Commonly, the effects of tax incentives are estimated in a price elasticity estimation. Tax incentives are granted in the form of additional deductions or credits and thus, reduce the price of the investment project. The so-called user cost of R&D are a measure for the price of an investment in R&D and are based on a cost of capital approach by Hall and Jorgenson (1967) and King and Fullerton (1984) and further

[7] For an older study that finds both, additionality as well as crowding-out effects, see for example Busom (2000).

developed by OECD (1991) and Devereux and Pearson (1995).[8] The user cost of R&D are included as explanatory variable in the estimation of the amount of R&D, measured for example by R&D expenses. The coefficient on the user cost represents the price elasticity of R&D with respect to tax incentives. As an increase in the tax credit rate or the tax allowance leads to a reduction of the user cost of R&D, a negative coefficient estimate indicates that the tax incentive is effective in raising the level of overall R&D spending. An elasticity of -0.5 for example means that a tax incentive of 1 unit increases the overall R&D spending by half a unit.

In a review study of the literature, Hall and Van Reenen (2000) conclude that a one dollar tax incentive for R&D causes the firm to spend one additional dollar on research. This corresponds to a price elasticity of around unity, as has been found by Bloom et al. (2002). Similarly, a recent review of the later evidence provided by Becker (2014) sums up that the price elasticity across various studies lies around one. The comparability of the studies is somehow critical as the studies consider different countries in their analyses. Nevertheless, the results range from an elasticity of -0.14 in the Canadian province Quebec (Baghana and Mohnen, 2009) to -1.8 in a sample of Italian firms (Parisi and Sembenelli, 2003). Therefore, the conclusion may be drawn that R&D tax incentives are in any case instrumental in raising the volume of investment in R&D of private firms. The empirical evidence provides negative and statistically significant estimates of the long-run price elasticity throughout various studies. A recent meta-analysis by Negassi and Sattin (2014) supports these holdings by finding robust evidence that R&D tax credits are strongly significant in fostering private R&D activity. Similarly as for direct R&D subsidies, the degree of effectiveness of R&D tax incentives critically depends on firm size and technology intensity (Elschner et al., 2011b). Accordingly, small and medium sized enterprises as well as technology intensive firms react stronger as compared to big and less technology intensive firms (for example Swenson, 1992; Mamuneas and Nadiri, 1996; Harhoff, 2000; Baghana and Mohnen, 2009). Further determinants of the effectiveness of an R&D tax incentive are its complexity and the continuity with which the incentive is granted over time (Bloom, 2007; OECD, 2002b). Due to higher uncertainty, complex incentives and incentives that are not granted continuously are less effective in raising private R&D activity. A simulation study of Elschner et al. (2011a), moreover, reveals that an immediate cash refund of unused tax incentives exerts a positive impact on the effectiveness of the tax incentive.

Last, early evidence suggests that the timing effects of direct incentives and of tax incentives for R&D are different. While tax incentives have a short-run effect on R&D but little effects in the long-run, for direct incentives the opposite is the

[8] The measurement of the user cost of R&D is summarized in the Appendix to Hall and Van Reenen (2000).

case. These exert positive effects on R&D spending in the medium- to long-run, rather than in the short-run (David et al., 2000; Guellec and van Pottelsberghe de la Potterie, 2003). A possible explanation could be that firms themselves decide about the claim of a tax incentive and thus, may use the subsidy to finance projects that render high profits in the short-run. On the contrary, direct subsidies are granted by some governmental institution that decides which projects merit support. Consequently, governmental institutions may favor projects that yield returns in the medium- and long-run. Moreover, the study by David et al. (2000) finds that direct and tax incentives are substitutes and that the increase in one incentive tool reduces the effectiveness of the other tool. Becker (2014) concludes that public policy in respect of R&D subsidies may be most effective if both tools, direct and tax incentives, are granted in a coordinated way. Thus, the evidence supports the argument of implementing both direct subsidies as well as subsidies via the tax system (Atkinson, 2007).

2.4 Conclusion

The aim of this thesis is to further extend the empirical literature in the interdisciplinary field of taxation and corporate innovation. Although it is well established that R&D tax incentives are instrumental in raising the level of R&D activity, further questions remain unanswered. For example, in an open economy where tax competition is present, how do firms choose their location for R&D activity and for the holding of IP rights? First evidence suggests that an above average number of patent applications takes place in low-tax jurisdictions (for a more detailed discussion of the evidence see Sections 3.1, 4.1 and Section 5.1). However, the literature leaves open to what extent real R&D activity is also mobile and follows corporate income tax rates. Furthermore, it is unclear which tax planning structures firms implement in order to reach their desired target investment location.

Consequently, the core research question that will be addressed in the following chapters is how firms react to existing tax regulations that are either designed to incentivize R&D activity or to secure the fiscal sovereignty of states over profits from R&D activity? The insights gained should shed light on the behavior of firms in the complex field of taxation and innovation and lastly, on the microeconomics of R&D.

Chapter 3

A Survey Study on R&D Intensive Multinationals*

3.1 Introduction

The focus of this study is to gain a deeper understanding of how tax planning takes place in R&D intensive multinational firms. Innovative multinationals are notorious for having increased tax planning opportunities. By locating intangible assets at low tax affiliates, they can reduce the tax burden on a relevant fraction of their economic rents. In recent years, our understanding of the existence and functioning of this type of tax planning strategy has increased at a remarkable rate. The empirical literature provides compelling evidence for a tax-driven allocation of intangibles within multinational groups (see Grubert and Slemrod, 1998; Dischinger and Riedel, 2011; Karkinsky and Riedel, 2012; Griffith et al., 2014). Consistently, the tax accounting literature documents that R&D intensive firms, all other things equal, display lower effective tax rates (ETR) than non-innovating firms (Graham et al., 2011; Robinson et al., 2010; Graham et al., 2014).

The corporate production process in R&D intensive multinational firms, however, does not only involve administration of intangible assets. These companies also have to decide on where to set up R&D facilities and final output production for consumers. Innovative activity indeed turns out increasingly mobile with firms locating their R&D units away from their home countries, and in multiple locations (Abramovsky et al., 2008). Surprisingly, the existing literature has largely ignored the particularities of tax planning in R&D intensive firms with respect to these choices. In view of the OECD's ambitions to take action against multinational tax

*This chapter is joint work with Jost H. Heckemeyer and Christoph Spengel and published as working paper Heckemeyer et al. (2014).

avoidance (OECD, 2013b), however, it seems very important to better understand the role that tax considerations and tax executives play in investment decisions of R&D intensive multinationals beyond the management of IP. In the same vein, in their comprehensive review of empirical tax research Hanlon and Heitzman (2010) call for more research on tax decision-making inside the firm.

Using data from a confidential survey taken in 2012 of international top financial and tax managers, we develop and test a theory, based on the organizational design literature, for the intensity in which the tax department coordinates with managers from other business units to intervene with real investment decisions. We argue that in the decision-making process, the tax department can get involved in decision control or engage in decision management. Following Fama and Jensen (1983b), decision control involves the ratification and monitoring of initiated projects, whereas decision management includes, in particular, the initiation and set-up of projects and thus occurs at a much earlier stage of the decision process. According to organizational design theory, the optimal allocation of decision rights is determined by coordination costs, i.e. the costs of knowledge transfer between managers, that are incurred when centralization of management and control is high, and the costs of autonomy that arise when management and control are exercised separately. We argue that this coordination problem also drives the choice of whether the tax department serves a controlling function ensuring tax compliance in the investment process or whether, instead, it acts more as a manager interfering with principal investment choices such as location and financing. Moreover, we consider R&D intensity to be an important determinant of both the costs of coordination and the costs of autonomy. First, there is high pressure in R&D intensive industries to keep the time to market short and the costs caused by time delays associated with coordination between business units are very high. Second, costs of autonomy are low in R&D intensive firms as tax-inefficiencies from autonomous decision-making without involvement of tax experts can be reversed by separating and tax-optimally allocating intangibles within the multinational group.

Furthermore, we enrich our analysis with descriptive statistics relating to business decisions during the R&D investment process. We directly test hypotheses and ask for the motives of firms regarding the decision how much resources are spent on R&D, where R&D activity takes place and where IP should be hold, what drives firms to consider locating patents at low-tax affiliates and how it is achieved. Previous studies that focused on the link between corporate taxation and innovation have based their analyses on large data, which did not allow them to answer questions like the above. Moreover, large data does not allow to identify what kind of structures are set up within multinational firms to organize R&D globally.

As archival data is inappropriate to address our research question, we conduct an in-depth survey among worldwide operating multinationals headquartered in different countries and active in diverse industries. Survey studies have been increasingly employed in tax, accounting and finance research to gain insights that would not be obtainable on the basis of publicly available accounting information. For example Graham and Harvey (2001) survey chief financial officers (CFO) on their views and practice of cost of capital, capital budgeting and capital structure. Graham et al. (2005) investigate the determinants of reported earnings and disclosure decisions, Graham et al. (2011) analyze the location decision of real investments and repatriation decisions, while in a follow-up study Graham et al. (2014) examine the incentives for tax planning, especially focusing on reputational concerns. A survey study of (Robinson et al., 2010) is more related to the managerial accounting literature and investigates the decision to evaluate the tax department as a cost center as opposed to a profit center. To the best of our knowledge, we are the first ones to provide survey evidence on the particularities of tax planning in R&D intensive multinationals.

In this study, we present evidence from 47 respondent firms. Admittedly, the sample of respondents is small, but we emphasize that 30 respondent firms are among the top 2,000 R&D investors and 15 are among the top 200 R&D investors worldwide as listed on the EU Industrial R&D Investment Scoreboard.[1] 9 respondent firms are among the Top 50 patent applicants at the European Patent Office.[2] Altogether, our sample firms spent more than \$50,000 million on R&D, according to their latest published financial statements, corresponding to approximately 8% of the total business R&D spending within the OECD in 2012 or to 7.7% of the total R&D expenditure spent in 2012 by the 2,000 largest R&D investors worldwide listed on the EU Industrial R&D Investment Scoreboard.

Our descriptive analyses reveal that country characteristics like infrastructure, culture, legal stability and skills of the workforce are more important than taxes for the location decision of R&D as well as for IP. However, among various tax factors, the most important factor for the location of R&D activity is the regulation that determines the deductions for R&D expenditure, while the most important factor for the location of IP is the double tax treaty network. We conclude that the R&D and IP location decision are two distinct decisions that are made separately. From the descriptive survey answers, it seems that in the location decision of IP tax planning considerations are of higher importance as compared to the R&D location decision.

Regarding our regression analysis, we indeed document supporting evidence that

[1]The EU Industrial R&D Investment Scorboard lists the 2,000 largest R&D investors worldwide. These 2,000 firms represent more than 90% of the total R&D expenditure by private businesses worldwide. For more information, see http://iri.jrc.ec.europa.eu/scoreboard.html.

[2]See http://www.epo.org/about-us/annual-reports-statistics/annual-report.html.

in R&D intensive multinational firms the tax department operates more as a controller than as a manager. In particular, tax departments of R&D intensive firms make less tax planning effort, are less ambitious to minimize the tax burden of the firm, are later involved in the decision-making process of a new investment project, but are more likely to have a veto right in the decision on a new investment project as compared to less R&D intensive firms. Conditional on R&D intensity, however, the level of intangible assets in the firm is associated with more tax planning efforts and ambitions. Our results are statistically significant and robust towards several sensitivity checks.

Our findings add to a strand of research that studies the interrelationship between organizational architecture and tax planning. Recently, Armstrong et al. (2012) investigate the impact of tax director compensation contracts on effective tax rates. Phillips (2003) examines the effects of compensation based performance measures of chief executive officers and business-unit managers and finds that after-tax compensation significantly lowers the reported generally accepted accounting principles-ETR (GAAP ETR) and cash ETR of a firm. Whereas these studies are concerned with performance reward, Robinson et al. (2010) consider performance measurement and evaluate why firms choose to evaluate a tax department as a profit center as opposed to a cost center. In their analysis, they use the degree of coordination between the tax department and operating units as an exogenous variable. In this Chapter, however, we want to *explain* the degree of coordination between the tax department and managers from other business units. Thus, our study puts the focus on the third component of organizational architecture, allocation of decision rights, whereas the previous studies consider the first two components, performance measurement and reward. Similar to these earlier papers, we take another important step towards unraveling the black box of tax avoidance. In this sense, this Chapter can also be connected to other studies which open part of the black box of tax decision-making. In particular, Gallemore and Labro (2013) investigate the internal information environment within firms and its effect on the reported ETR. They find that firms with high internal information quality report lower ETRs. The unobservable construct of internal information environment is measured by five proxies, which are analyst following, analyst forecast accuracy, management forecast accuracy, the speed by which management announces financial figures such as earnings after fiscal year closing and the absence of material weaknesses in internal control. Furthermore, Dyreng et al. (2010) propose the conjecture that top executives may have a certain style and therefore set a certain tone at the top with respect to tax planning. They track executives who had worked for more than one firm over a longer period of time and indeed find a significant effect of executives on the GAAP and cash ETR. More recently, management research has started to focus on tax aspects, as well. Glaister and Hughes (2008) provide a case study on UK firms analyzing the relationship between corporate strategy formulation and taxation. They find strong support for the view that strategy decisions take priority, while tax decisions follow subsequently in the order of precedence.

Our study contributes to several further strands of the literature. In general, there is a universe of theoretical and empirical research dealing with the distorting effect of taxation on investment decisions. This literature provides robust evidence that taxes impact on both marginal and infra-marginal investment in domestic and cross-border contexts (De Mooij and Ederveen, 2003; Feld and Heckemeyer, 2011; Hassett and Hubbard, 2002; Bond and Van Reenen, 2007). Investment in R&D, however, is special (Elschner and Spengel, 2010). It is particularly risky because innovation efforts require a long-term perspective with high initial costs and uncertain outcome. On the other hand, once successful, R&D tends to yield very high economic rents, because intellectual property rights establish monopolies for a certain period of time. Time to market plays a crucial role in order to be able to earn these rents. Moreover, R&D activity is supposed to create positive externalities through unpaid knowledge spillovers and considered to be crucial for competitiveness and economic growth. As a consequence, various countries have put in place R&D tax incentives to foster innovative activity. The effectiveness of this type of incentives has been studied extensively in the past. R&D tax credits and additional allowances, for example, are generally found to positively impact on the scale of R&D investment (Hall and Van Reenen, 2000; Arundel et al., 2008; Spengel et al., 2009; Elschner and Spengel, 2010). Furthermore, there is evidence that tax considerations can lead firms to relocate and shift existing R&D activities to tax favorable jurisdictions (Wilson, 2009b; Paff, 2005). Bloom and Griffith (2001) speak of 'footloose R&D' to emphasize the international mobility of R&D activity.

The most substantial international tax planning opportunities in R&D intensive multinationals are associated with the output of the innovation process, i.e. valuable intangible assets, rather than with inputs. A recent strand of research provides robust evidence for a tax-driven allocation of intangibles within multinational groups. For example, Mutti and Grubert (2009) show that US companies obtain high royalty revenues preferably in low tax subsidiaries. Dischinger and Riedel (2011) find that subsidiaries subject to relatively low corporate tax rates show a higher level of intangible asset investment than other affiliates in a multinational group. Karkinsky and Riedel (2012), Ernst and Spengel (2011) and more recently also Griffith et al. (2014) substantiate this finding on the basis of patent data.

Finally, our study is connected to a strand of literature that investigates the interrelationship between the tax sensitivity of capital investment and profit shifting opportunities. The literature shows that if foreign earnings are exempt upon repatriation, or taxation is deferred, the host-country tax rate is an important determinant of foreign direct investment (for example Janeba, 1995; De Mooij and Ederveen, 2003; Feld and Heckemeyer, 2011). Shifting profits from a given host country to low-tax affiliates reduces, all other things equal, the effective tax burden. In other words, the effective tax rate levied on infra-marginal or marginal returns is no longer determined by the local tax rate of the country where the real business activity takes place but by the tax rate of the jurisdiction where profits are shifted. As a consequence, profit shifting might reduce the sensitivity of investment to local tax rates and, vice versa, restricting profit shifting opportunities can lead to increased investment responses to the local tax rate (for example Hong and Smart, 2010; Haufler and Runkel, 2012). Empirical evidence for the negative relationship between profit shifting opportunities through IP tax planning and the sensitivity of investment to source country taxation is provided by Overesch and Schreiber (2010). Based on German outbound foreign direct investment (FDI) micro data Overesch and Schreiber (2010) find that R&D intensive firms' outbound investments react less tax sensitively than outbound investments of less R&D intensive firms. Our study relates to this previous piece of research in that we try to investigate the functions of the tax department in R&D intensive firms by using organizational design theory and taking a closer look inside the firm.

The remainder of the Chapter is structured as follows. Section 3.2 develops our hypothesis. The research design and data are discussed in Section 3.3. Furthermore, Section 3.4 explains our estimation approach. Last, Section 3.5 presents our results and robustness checks and Section 3.6 concludes.

3.2 Hypothesis Development

According to organizational design theory, the organizational architecture of a firm depends on three columns: performance measurement, reward and punishment of performance, and the partitioning of decision rights between agents within the firm (Jensen and Meckling, 1992; Zimmerman, 2014). Previous studies have focused on the first two columns of organizational architecture, that is the choice of performance measurement of corporate tax departments (Robinson et al., 2010) and the role of compensation-based incentives in corporate tax planning (Phillips, 2003; Armstrong et al., 2012). In this study, we are particularly interested in the factors that determine the allocation of decision rights to the tax department and thus put the focus on the third column of organizational design.

Along the decision-making process, the hierarchical structure of a firm must allocate decision rights over four essential steps to different managers or agents (Jensen and Meckling, 1992; Zimmerman, 2014). These four steps are the *initiation* of a certain action, its *ratification*, followed by its *implementation* and, finally, *monitoring tasks*. Fama and Jensen (1983b) use the term *decision management* to summarize activities that fall under initiation and implementation and the term *decision control* to summarize ratification and monitoring. Considering the construction of a new plant, for example, the initiation proposal about whether and where to invest in new facilities may primarily come from division managers with specialized knowledge of the production process and product demand from customers.[3] In the ratification process, senior management assembles knowledge from specialists in finance, human resources, legal, and other departments. Construction of the project, i.e. implementation, is the responsibility of the proposing managers or a separate facilities department within the firm. After construction is completed, internal accountants prepare financial reports to monitor the division operating the project.

Obviously, when firms are sufficiently complex, the relevant knowledge needed to make an investment decision is dispersed among several agents in the firm. Hence, several agents will be involved in the decision-making process and the firm needs some mechanism to structure the way decisions are made. We are interested in the role of tax experts in this process. We think that two scenarios are possible. On the one hand, the tax department could primarily be involved in controlling tasks, supporting ratification and monitoring of the project, and thus acting separately from management activity. A tax department that acts as a controller rather than a manager concentrates, for example, on ensuring that local and international tax legislation is complied with but it does not intervene in the structuring of the project. The management of the project would, in this case, be rather decentralized in the hands of the specialized division managers. On the other hand, the tax department could act much more as a manager and be involved in the initial stage of the decision process, for example by preselecting potential investment locations and coordinating directly with the initiating division managers. Thus, the decision process would be more centralized and management and control functions would be exercised in a less separated fashion.

The question of whether the tax department acts more as a manager or as a controller reflects the optimal choice of coordination intensity with other departments and divisions in the firm. Coordination intensity with experts and managers from other departments or divisions will be increasing in the tax department's intervention in decision management. For example, if the tax department gets involved in project initiation, specialized division managers and the tax department will have to coordinate to preselect potential investment locations, taking into account important tax aspects and non-tax factors related to local conditions of production and demand. The cost of coordination result from communication and the so caused

[3] The example is taken from Zimmerman (2014), p. 146.

delay in making a decision. Cost of delay are costs for missing out opportunities, because transferring knowledge (i.e. coordinating) takes time (Szulanski, 2000; Zimmerman, 2014).

In this coordination problem, the cost of coordination have to be balanced with the cost of autonomy (Emery, 1969). Cost of autonomy emerge from the forgone use of valuable knowledge in the decentralized decision-making process, which can result in inefficient or even entirely wrong decisions. In our context, the costs of autonomy (of the initiating division managers) can best be understood as forgone tax savings due to inefficient use of the tax experts' knowledge.[4]

Figure 3.1 illustrates the relationship between coordination intensity I, represented on the horizontal axis, and associated costs C, represented on the vertical axis. The ascending curves represent coordination costs, while the descending curves represent the autonomy costs. With increasing coordination intensity the cost of coordination increase, while the cost of autonomy decrease. The total costs are the sum of coordination and autonomy costs, represented by the U-shaped curve. The minimum of the total cost curve indicates the optimal level of coordination intensity, here at I_1.[5] In our context, the horizontal axis, depicting coordination intensity, also reflects the nature of the tax departments' tasks. At the right end of the continuum, the tasks of the tax department are managerial in nature, i.e. highly coordination intensive. At the left end, they are of a controlling type with little coordination between tax experts and managers of other business units. Accordingly, the tax departments' choice of coordination intensity with other business units ultimately reflects the decision on the nature of its tasks. Hence, the minimum of the total cost curve represents the optimal bundle of the tax department's managerial and controlling tasks.

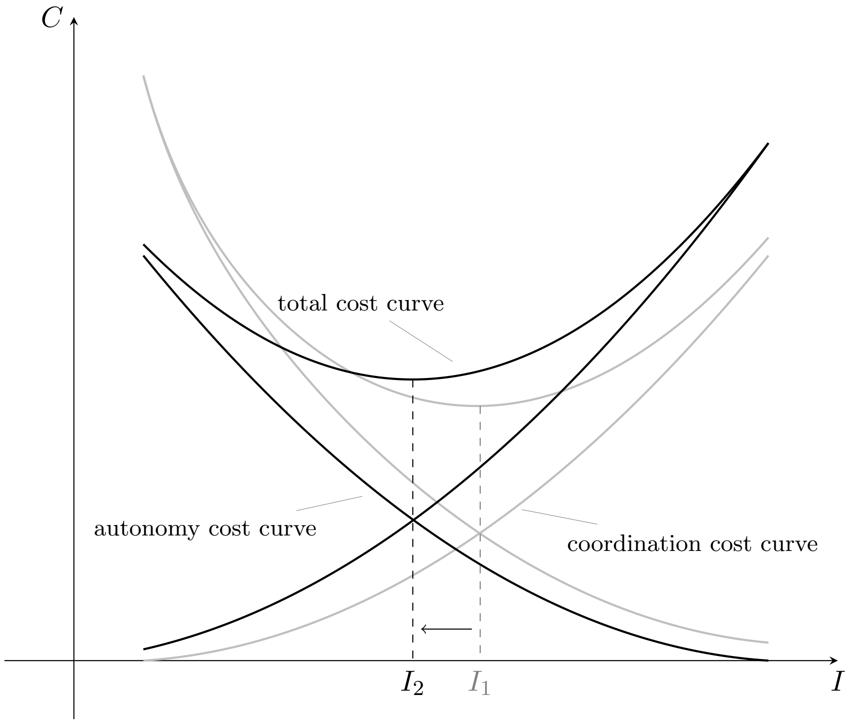
We argue that in R&D intensive firms, the optimal level of coordination intensity between the tax department and other business units is lower relative to non-innovating firms, here at I_2.[6] In other words, the tax department in highly R&D intensive firms carries out more controlling activities rather than managerial tasks

[4]We use the more general concept and term 'autonomy costs' as e.g. in Emery (1969), instead of referring to the term 'agency costs' as used in Jensen and Meckling (1992), Fama and Jensen (1983a) and Fama and Jensen (1983b). Agency costs occur when agents dispose of private information and do not share common interests. Here, we want to leave open the question whether the tax department and other specialized division managers have conflicting or congruent interests. In any case, with decreasing coordination, the efficiency costs of autonomous decision-making tend to increase.

[5]The optimal coordination intensity, i.e. the minimum of total costs, is at the point of equality of the absolute slopes of the autonomy cost and the coordination cost curves, which in Figure 3.1 coincides with the intersection of the two curves.

[6]Again, the optimal coordination intensity, i.e. the minimum of total costs, is at the point of equality of the absolute slopes of the autonomy cost and the coordination cost curves, which in Figure 3.1 coincides with the intersection of the two curves.

Figure 3.1: Coordination Intensity Choice



Notes: Own source, according to Emery (1969). The ascending curves represent the coordination cost curves, while the descending curves represent the autonomy cost curves. The U-shaped curves represent the total cost curves. The grey curves depict the initial situation. We hypothesize that in R&D intensive firms both curves are shifted to the left, as represented by the black curves. The total cost minimum is at the point of equality of the absolute slopes of the autonomy cost and coordination cost curves. In this figure, the point of equal absolute slopes coincides with the intersection of the two cost curves.

as compared to less R&D intensive companies. We present two principal reasons for our hypothesis:

First, coordination costs in terms of delay costs from lost opportunities are especially high in R&D intensive businesses. The first applicant of a patent has the chance to be granted a monopoly and to extract the associated economic rents, while the runner-up will potentially face important economic and legal barriers to market entry. Moreover, in many high-tech industries, products and innovations follow sharp life cycle patterns. Missing out on the start of a new product cycle means that chances to successfully commercialize one's product are drastically reduced because the pioneers will have seized the market, at least for the lifetime of that new innovation. As a consequence, many companies engaged in R&D put a strong focus on 'time to market' which becomes the primary target dimension in the management of R&D projects (Brem, 2008). In Figure 3.1, the coordination cost curve for R&D intensive firms is represented by the black ascending curve. It is shifted to the left relative to the 'standard' coordination cost curve for non-innovating firms, representing the increased costs of delay at given levels of coordination intensity.

A second reason for the optimal level of coordination intensity being comparably low in R&D intensive firms relates to the costs of autonomy that arise as a decreasing function of coordination intensity. More specifically, we argue that R&D intensive firms have enhanced opportunities to shift paper profits toward low-tax jurisdictions because R&D activity tends to produce both highly mobile and highly specific intangible assets, which can be separated from the R&D inputs and migrated to low-tax subsidiaries in a tax efficient way.[7] R&D intensive firms thus may care less about taxes in the investment decision process because they have considerable tax planning opportunities at a later stage, i.e. after the investment project has been implemented, and can substantially reduce their effective tax burden no matter where the real economic activity takes place.[8] Hence, the autonomy costs in terms of forgone tax savings that result from low coordination intensity between the tax department and other division managers initiating an investment project are low because inefficiencies from a tax point of view can be partially reversed by tax planning with IP. Graphically, this mechanism available to R&D intensive firms is reflected by the black descending autonomy cost curve which is shifted to the left relative to the autonomy cost curve for non-innovating firms. As both the autonomy and the coordination cost curves for R&D intensive firms are shifted to the left, so is the optimal coordination intensity between the tax department and initiating division managers (from I_1 to I_2 in Figure 3.1).

In sum, the optimal level of coordination intensity in R&D intensive firms is reduced for two reasons: First, coordination between R&D managers and the tax department is costly, because the cost of delaying an R&D related decision may be exorbitantly high. Second, R&D intensive firms often hold IP that enables them to engage in tax planning no matter where the economic activity actually takes place. These opportunities may help them to compensate tax inefficiencies from low coordination in the initial stage of the investment decision by engaging in IP tax planning *ex post*. Thus, our hypothesis is the following:

> *Hypothesis: In R&D intensive firms, the tax department carries out more controlling rather than managerial tasks than in less R&D intensive firms.*

We argue that the tax department's management-control choice manifests itself

[7] For empirical evidence on the tax sensitivity of intangible asset location, see Dischinger and Riedel (2011) and Karkinsky and Riedel (2012).

[8] In line with this notion, Overesch and Schreiber (2010) provide empirical evidence that the impact of taxes on investment decisions decreases with increasing R&D intensity.

in four dimensions, which we are able to directly observe in our survey. These are the effort the tax department makes for tax planning relative to compliance and reporting, the department's ambitions to minimize the overall tax burden of the firm relative to tax risk management, the temporal involvement of the tax department in investment decisions and the ultimate decision rights the tax department has in the investment decision. These characteristics are supposed to describe the nature of the tax department's tasks. We argue that the more the company's tax experts act as managers in the business decision process, the more time they spend on active tax planning relative to mere reporting and compliance tasks. We also suppose that a decision managing tax department tends to have high ambitions to minimize the firm's tax burden and it gets involved early in the initiation phase of the decision process, whereas a controlling tax department comes in at later stages for ratification and monitoring of decisions. With respect to ultimate decision rights, the strongest right, the right to veto, will rather rest with the tax department that serves as a controller rather than with a managing tax department.

Table 3.1: Predictions

	Tax Department acts more as a ...	Efforts	Ambitions	Temp. Inv.	Rights
high R&D intensity	... controller	-	-	-	+
low R&D intensity	... manager	+	+	+	-

Notes: + / - indicates the predicted direction of the effect of R&D intensity on each of the four dimensions, efforts, ambitions, temporal involvement and rights.

As stated above, we hypothesize that high R&D intensity leads the tax department to adopt more controlling tasks because the cost of coordination, particularly in the form of time delay, may be exorbitantly high. What that means for each separate dimension is shown in Table 3.1. We expect that a high R&D intensity is associated with less tax planning effort, less ambitions and a later involvement of the tax executives in the decision-making process. Therefore, the predicted effect of R&D intensity on efforts, ambitions and temporal involvement is negative.[9] On the other hand, we expect that R&D intensity is positively associated with rights, because this dimension is inversely related to the management-control-choice, i.e.

[9] We acknowledge that it may appear difficult to disentangle the effect that R&D intensity has on tax planning efforts and ambitions. We argue that the tax department is less involved in active investment decision management and planning both because it wants to avoid time delays and because it can much more efficiently shift profits after the investment took place by migrating mobile and firm-specific intangible assets to low-tax jurisdictions, i.e. through contract R&D agreements (for a more detailed discussion on different migration strategies see Section 4.2). Obviously, this ex post IP and profit migration requires some tax planning effort and ambition itself. In the empirical analysis, we will try to isolate the influences on the four dimensions associated with the management of IP.

tax departments that have more controlling tasks are more likely to have a veto right in the decision-making process. Consequently, the hypothesis that R&D intensive firms' tax departments act more as a controller rather than as a manager comes along with a predicted positive effect of R&D intensity on the rights of the tax department.

3.3 Research Method and Sample

3.3.1 Survey Approach

Many previous studies have investigated the effect taxes have on R&D investment and most of them have empirically tested their hypotheses by means of large archival data sets. Data that has commonly been used to study R&D investment is R&D expenditure (Bloom and Griffith, 2001; Bloom et al., 2002), royalty income (Mutti and Grubert, 2009), balance sheet data on intangible asset holdings (Dischinger and Riedel, 2011) or the number of patent applications (Ernst and Spengel, 2011; Karkinsky and Riedel, 2012; Boehm et al., 2012; Ernst et al., 2014). Instead, we conducted a survey in cooperation with the internationally operating tax consultancy firm PwC. A major advantage of surveys is the elicitation of otherwise unobservable data (Serita, 2008). As we are interested to gain a deeper understanding of how firm characteristics influence the role the tax department plays in the decision-making process, archival accounting databases would not help us to address our research question.

We designed the questionnaire and entered into a cooperation with PwC, who conducted the survey among preselected global client firms. The preselection of firms was done by PwC to compose a sample of large and multinationally operating firms. After we had designed a first draft of the questionnaire, we made several revisions to it based on feedback from academics in the areas of marketing, finance, accounting and economics. Moreover, three firms beta-tested the questionnaire and provided feedback on the length of the questionnaire and on the readability and comprehensibility of the content to us. Finally, we asked 39 questions, while the questions considerably differed in length and some questions comprised subsections.[10] The questionnaire is 20 pages long, where we assumed that it will take one minute per page to answer the questions. We divided the questionnaire in three subparts. The first part addresses the role of tax considerations in R&D-related business decisions. The second part contains questions regarding the organizational integration of the tax and R&D function. The last part asks for company characteristics of the respondent firm.

[10]This study analyzes selected questions from the questionnaire.

The questionnaire was sent out by PwC to its client firms in August 2012. The survey was closed in October 2013. Throughout this period, we sent several reminders to the contacted firms. Out of 321 questionnaires that were sent out, 47 firms returned the questionnaire properly filled out. Thus, the response rate was approximately 15%.

Survey data also entails some drawbacks. The major concern is measurement error caused by inappropriate answers. The answer a respondent gives can be inappropriate due to the lack of knowledge or that the respondent feels uncomfortable to openly and correctly answer the survey questions. Concerns on the part of respondents to honestly answer survey questions might be a problem in our context as international tax planning is generally not well received by public opinion. Respondents might therefore, consciously or subconsciously, be tempted to conceal the true role of tax considerations in their business decisions.

These potential difficulties have to be addressed carefully prior to conducting the survey, especially in the design of the questionnaire and in the way the survey is conducted. Following previous survey studies in the accounting and finance literature (Graham and Harvey, 2001; Graham et al., 2005, 2011) we dealt with these issues in several ways, which we discuss in the following. As we only asked tax experts to fill out the survey, we do not worry that the respondents randomly chose their answers. If the respondent was not motivated to fill out the survey, he could easily refuse to do it. Also, we rely on the expert knowledge of the respondents and believe that the questions we asked were understood correctly. Nevertheless, we included a question to indicate the job title of the person who filled out the form. From the 47 respondents, 29 respondents are head of the tax department, one respondent is the vice president of the tax department, four are CFO of the company, one respondent is the vice president of the CFO, six are local tax managers, one respondent is the CEO of the company, one the assistant to the CEO and another one the assistant to the CFO and, finally, three respondents did not report their job title.

We are aware that some of our questions are sensitive as we also focus on tax planning strategies. These questions are critical, because respondents might not want to answer such questions correctly. First, we made clear that we are only interested in legal tax planning schemes, which is distinct from illegal tax evasion. Second, we decided that PwC conducts the survey for us, because firms will probably have confidence in the integrity and discreetness of their consultancy firm. In the survey, we made clear that all answers will be forwarded to us, the researchers, in anonymous form. We also included a paragraph on data security and confidentiality in the introduction to the questionnaire. We assured our respondents that the data reported in the questionnaire would be treated confidentially and that results would be published in aggregate form only. Last, we pointed out that respondents may also return an uncompleted questionnaire in case they were unable to answer some of the questions. That information was also meant to ensure that respondents felt free to leave some questions unanswered if they were uncomfortable with them.

3.3.2 Survey Data and Sample

The following Tables 3.2 and 3.3 provide an overview of the characteristics of the 47 respondent firms. Half of respondents are located in Germany, followed by the US and Switzerland. Furthermore, the sample comprises firms from Australia, Austria, Finland, Hong Kong, Israel, Mexico, South Africa and the UK. Most firms are publicly traded (35 firms), but our sample also comprises eleven private firms and one firm that indicated some other ownership structure, although without specifying it any further. The majority of respondent firms are operating in heavy industries (16 firms), followed by the manufacturing industry (9 firms).

Table 3.2: Company characteristics of respondent firms

Group's parent country (N = 47)	# of firms	Industry (N = 47)	# of firms
Australia	1	Agriculture, forestry, fishing	1
Austria	1	Mining, construction	4
Finland	1	Manufacturing: food, textiles	
Germany	25	and chemicals	9
Hong Kong	1	Heavy industries	16
Israel	1	Transport and utilities	3
Mexico	2	Wholesale and retail trade	1
South Africa	1	Banking, finance, insurance,	
Switzerland	6	real estate	3
United Kingdom	1	Information technologies	4
United States	7	Health, pharmaceuticals,	
		biotechnologies	4
Ownership (N = 47)		Public administration	2
Public	35		
Private	11		
Other	1		

Notes: The group's parent country indicates the country of incorporation of the global ultimate owner company of the respective respondent firm. Industry classification is based on the US Securities and Exchange Commission's (SEC) standard industrial classification (SIC).

On average, our respondents have total assets of \$70,800 million, total liabilities of \$52,300 million and total sales of \$30,000 million. The average net income is \$1,830 million and the return on assets is 6.19%. The average respondent firm employs 61,537 people (full-time equivalents), where 5,537 of these are employed in R&D, and is approximately 87 years old. The average balance sheet amount of intangible assets is slightly more than one tenth of the total assets (\$7,960 million) and the average spending on R&D is \$1,240 million per year. The total R&D spending of all sample firms amounts to approximately \$53,400 million. This corresponds to approximately 30% of the total business R&D spending in the EU27 in 2012 or to 8% of the total business R&D spending within the OECD in 2012.[11] This share appears very high in view of the small number of firms we survey. However, the distribution of R&D expenditure across firms worldwide is highly skewed, meaning that the majority of R&D spending is concentrated in the hands of only a few firms. This is highlighted by the EU Industrial R&D Investment Scoreboard published by the European Commission (EC), which covers the top 2,000 investors in R&D worldwide. These 2,000 firms represent more than 90% of the total R&D expenditure by private businesses.[12] Our sample contains 30 firms that are among the top 2,000, and even 15 that are among the top 200 Scoreboard firms. In sum, our sample covers 7.7% of the top 2,000 firms' aggregate R&D expenditure in the year 2012. Moreover, we emphasize that 9 respondents are among the Top 50 applicant firms to the European Patent Office.

Table 3.3: Selected descriptive statistics of respondent firms

Variable	# Observations	Mean	Median	Minimum	Maximum
Total assets	47	70,800	22,800	113	685,000
Total liabilities	47	52,300	14,200	167	625,000
Total sales	47	30,000	18,000	140	147,000
Net income	46	1,830	662	-778	13,600
Return on assets	45	6.19%	6.10%	-34.64%	29.16%
Intangible assets	45	7,960	1,400	0	85,400
R&D expenses	43	1,240	193	0	6,790
Total employees	47	61,537	44,000	480	380,000
R&D employees	35	5,537	1,000	0	38,500
Firm Age	47	87	100	1	179

Notes: All financial statement information is in million US Dollars. Firm age is measured in years.

One limitation to survey research is selection bias in the answers due to self-selection of respondents (Dillman, 1978). Firms or managers may decide themselves whether to answer the survey or not and therefore, they select themselves into two groups, the group of respondents and the group of non-respondents. The concern of selection bias is related to the generalizability of the results and conclusions drawn from the survey. One form of selection bias is non-response bias that arises if the group of respondents is systematically different to the group of non-respondents in observable characteristics that influence the subject of interest in our study (i.e. R&D related tax planning behavior). Another form of selection bias

[11] The total business R&D spending in the EU27 in 2012 amounts to $176,744.85 millions and the total business R&D spending within the OECD in 2012 amounts to $649,214.01 millions. The figures are taken from the OECD database on business enterprise expenditure on R&D (BERD). The figures are measured at constant prices and PPP.

[12] See the European Commission's press release on November 18, 2013: http://europa.eu/rapid/press-release_MEMO-13-1000_en.htm.

arises if the group of contacted firms systematically differs from the population that is researched. Hence, we draw comparisons to address both of these concerns. First, we compare the sample of respondents to bigger populations, i.e. to the group of non-respondents and the group of firms that are part of the Standard & Poors (S&P) 1200 Index. Second, we compare our sample of contacted firms with the group of S&P 1200 firms. The S&P 1200 Index is a stock market index that covers the 1,200 worldwide biggest and publicly traded companies. It comprises approximately 70% of the world's stock market capitalization. Since the bigger part of R&D is concentrated in the hands of a few but very large multinational firms, we are interested to learn how our sample compares to this population of firms, and, therefore, use the sample of S&P 1200 companies as a comparison group.

Table 3.4: Non-Response Bias Tests

	S&P 1200 (1)		All Firms we Contacted with Available Data (2)		Survey Nonresponders with Available Data (3)		Survey Responders with Available Data (4)	
	N	Mean	N	Mean	N	Mean	N	Mean
RDINT	675	0.03	128	0.04	85	0.04	43	0.03
IPINT	1,197	0.19	147	0.20	102	0.21	45	0.17
SIZE	1,209	23,800	149	31,900	102	32,800	47	30,000
ROA	1,209	0.07	147	0.07	102	0.07	45	0.06
LEV	1,206	0.60	149	0.79	102	0.62	47	1.17
GROW	1,207	0.15	146	0.05	101	0.05	45	0.07
INVINT	1,189	0.08	147	0.12	102	0.11	45	0.13
CAPINT	1,186	0.28	145	0.21	101	0.22	44	0.20

	p-Value			
	1 vs. 2	1 vs. 4	2 vs. 4	3 vs. 4
RDINT	0.0573	0.7419	0.5462	0.3925
IPINT	0.0508	0.8792	0.2566	0.1199
SIZE	0.4426	0.1122	0.5241	0.3776
ROA	0.3641	0.8115	0.7779	0.6990
LEV	0.2773	0.4240	0.9342	0.9089
GROW	0.1006	0.7707	0.5527	0.4146
INVINT	0.0000	0.0005	0.4488	0.2992
CAPINT	0.0470	0.0888	0.6037	0.4780

Notes: Columns (1) to (4) represent different populations as stated. P-values are based on a two-tailed Wilcoxon test and indicate significant differences among the different populations in the variables observed. All variables are obtained from the Compustat Global and Compustat North America Database and are measured as of 2012. R&D intensity, abbreviated by RDINT, is R&D expenses (XRD) scaled by total assets (AT), IP intensity, abbreviated by IPINT is intangible assets (INTAN) to total assets (AT), size is measured by total sales (SALE) and is in million USD, ROA is the return on assets defined as net income (NI) scaled by total assets (AT), leverage, abbreviated by LEV, is calculated as liabilities (LT) over total assets (AT), asset growth is the percentage change in total assets to the one-year lag total assets (AT), inventory and capital intensity, abbreviated by INVINT and CAPINT respectively, is total inventories (INVT) and net property, plant and equipment (PPENT) respectively over total assets (AT).

Table 3.4 contains descriptive statistics of all samples and p-values from a Wilcoxon rank-sum test to indicate whether the samples are significantly different from each other. To test for possible selection bias we group firms into four different samples represented in columns (1) to (4) of Table 3.4. Column (1) comprises the set of firms that during January 2011 and December 2013 were at least once part of the S&P 1200 Index.[13] Column (2) comprises all contacted firms that were sent a questionnaire. Finally, this column is split in the group of non-respondents (column (3)) and the sample of respondents (column (4)).

Overall, with respect to most characteristics we evaluate, our sample of respondents is similar to the S&P 1200. The firms in the sample only differ from the S&P 1200 in terms of inventory and capital intensity. In other words, the S&P 1200 companies have similar distributions of R&D intensity, IP intensity, total sales, return on assets, leverage, and asset growth. Comparing all contacted firms with the S&P 1200 Index, our contacted firms differ significantly from the S&P 1200 in terms of R&D and IP intensity, in inventory and in capital intensity. Nonetheless, they are similar in terms of size, return on assets, leverage and asset growth. Comparing the characteristics of respondent firms to those of the firms we contacted and to those of non-respondents, we do not find that the respondent firms differ significantly from these two groups.

To sum up, contacted and responding firms are different from S&P 1200 firms along some few dimensions. Therefore, our results might not generalize to the whole sample of S&P 1200 firms. Nonetheless, there is no indication for systematic differences between firms that answered our survey and those that did not answer.[14]

3.4 Estimation Strategy

Our aim is to explore whether R&D intensity influences the coordination intensity of the tax department with other operational units within the firm. Since the tax department's management-control-choice is difficult to observe, we decided to measure specific characteristics of the tax department. Precisely, we assume that the tax departments' position on the continuum between management and control manifests itself in four dimensions. These are the tax departments' tax planning efforts, its

[13] The sample of column (1), therefore, contains slightly more than 1,200 firms.

[14] Generalizability requires a representative sample and, additionally, a sample size that is large enough to reduce the margin of error to conventional levels. Even if our sample of respondents was similar to the relevant comparison group in all characteristics, we would still be cautious about generalizing our findings to the whole population of firms due to our small sample. Limited generalizability is a general limitation of survey research in accounting and taxation and has been encountered by previous studies as well (e.g. Graham et al., 2011, 2014). Still, we believe that survey studies provide valuable contributions to unravel the black box of tax decision-making.

tax planning ambitions, its temporal involvement and its ultimate decision rights.

The data on these four dimensions comes from the questionnaire. While the first dimension - tax planning effort - is a proportion, the other three dimensions - ambitions, temporal involvement and rights - are ordinal variables measured on a five-point scale. *Tax planning efforts* are measured by the approximate time (in % of total workload) that is spent on tax planning activities, as opposed to activities linked to compliance and financial reporting, by tax executives. *Ambitions, temporal involvement* and *rights* are measured on a five-point scale respectively, ranging from 0 to 4. We ask *'How important is the minimization of the group's tax burden as an objective for your group's tax department?'* to measure the ambitions of the tax department. A 0 on the response scale indicates that minimization of the group's tax burden is not at all an important objective of the tax department, while 4 indicates that tax minimization is a very important goal. Furthermore, we ask *'Starting from which stage during the planning phase of an investment project are the tax executives involved in the decision-making?'* to measure the temporal involvement in the decision process. 0 again indicates the lowest parameter value, which we equate to a very late involvement of the tax executives and which we scenarize as *'The decision has been made; tax executives optimize given the target location'*. A value of 4 instead means that the tax department gets involved very early and preselects potential targets in the initiation phase of the decision process. Last, ultimate decision rights are measured by the question *'During the planning phase of an investment project, how would you characterize the role of the tax executives?'* and which ranges from 0, *No rights, the decision is made without consultation of tax executives*, to 4, *Tax executives have a veto right.*

To analyze the relationship between R&D intensity and each of these four dimensions, we will perform bivariate tests and regression analyses. Throughout the empirical analysis, we will take into account that our sample is small from a statistical point of view. Standard econometric methods used for hypothesis testing rely on sampling distributions that are approximately normal. The assumption of normality is without problems and justified by the central limit theorem if the sample size is large. However, given our sample size of slightly less than 50 observations, assuming a normal (approximate) sampling distribution may potentially be inaccurate. For our bivariate tests, we will therefore use the Wilcoxon rank-sum test[15] as a robust non-parametric alternative to the common Student's t-test (Wilcoxon, 1945; Mann and Whitney, 1947). However, the normal approximation to the sampling distribution can still be *accurate* in samples as small as 30 observations (p. 89 in Stock and Watson, 2012). We will therefore make statistical inferences on the basis of t-tests as well.

[15] Also known as the Wilcoxon-Mann-Whitney-Test, Mann-Whitney-U-Test, or U-Test.

The regression analysis will estimate an empirical model of the following form

$$\begin{aligned} DIM_i = \beta_0 + \beta_1 RDINT_i + \beta_2 SIZE_i + \beta_3 ROA_i + \beta_4 LEV_i \\ + \beta_5 GROW_i + \beta_6 INVINT_i + \beta_7 CAPINT_i + \beta_8 AGE_i + \epsilon_i \end{aligned} \tag{3.1}$$

where DIM_i abbreviates the four different dimensions and $RDINT_i$ represents R&D intensity, our variable of main interest.

Our hypothesis (see Section 3.2) predicts that with increasing R&D intensity it becomes more likely that the tax department takes the position of a controller rather than that of a manager. We measure R&D intensity (RDINT) by the firm's R&D expenses scaled by total assets. Furthermore, we include a number of control variables that likely co-determine the tax department's management-control-choice.

Previous literature substantiates the notion that tax planning opportunities and incentives influence the actual tax avoidance behavior of firms (Manzon and Plesko, 2002; Mills, 1998; Rego, 2003; Frank et al., 2009; Dyreng et al., 2008). Since the tax avoidance behavior of a firm is closely related to the nature of the tax department's tasks, we think that tax planning opportunities and incentives may also influence the management-control-choice of the tax department. Consequently, the first set of control variables capture real tax planning opportunities: Theoretically, it has been argued that the size of the firm increases complexity and, therefore, impacts negatively on the management-control-choice of a firm (Fama and Jensen, 1983b). The empirical evidence, however, reports mixed results. Early evidence by Zimmerman (1983) finds a positive effect of firm size on tax planning and documents that larger firms face higher tax payments. More recently, studies regarding the determinants of the ETR find negative (Boone et al., 2013; Chyz et al., 2013) as well as positive (Hope et al., 2013; Chyz et al., 2013) significant elasticities of firm size. Hence, the effect of firm size is a priori ambiguous. Our empirical analysis contains the logarithm of total sales (SIZE) to control for firm size. In line with Fama and Jensen (1983b), we expect that firm size likely increases complexity and consequently leads to less coordination intensity.

Furthermore, we include the return on assets (ROA) to capture the profitability of a firm, as the literature suggests that profitable firms might have more incentives for tax planning (Chen et al., 2010; Anderson and Reeb, 2003). Thus, we expect that high profitable firms make more effort on tax planning. In general, we suppose that profitability positively impacts on coordination-intensity. Furthermore, we include leverage (LEV) calculated as total liabilities divided by total assets to control for the debt tax shield benefit resulting from the deductibility of interest expenses. Lastly, we control for asset growth (GROW) by calculating the one-year percentage growth rate of total assets. Although the findings of Keating (1997) and Bankman (1994) suggest a negative impact of growth on tax planning efforts, more recent literature often does not find statistically significant effects of growth on firms' tax avoidance behavior as, for example, reflected in the reported GAAP ETR (Robinson et al., 2010; Chen et al., 2010; Phillips, 2003).

The second set of control variables capture book-tax planning opportunities. Contrary to real tax planning, where real activities are undertaken in a tax optimal way, book-tax planning refers to the tax optimal reporting in the financial as well as in the tax accounts. We include inventory intensity (INVINT) and capital intensity (CAPINT), because inventory and capital intensive firms are more affected by different valuation methods for tax and financial reporting purposes (Hope et al., 2013). Given that these firms have more tax planning opportunities, we could expect a positive effect on coordination intensity. On the other hand, the tax planning opportunities may also reduce the cost of autonomy and thus, cause the tax department to act more as a controller. This argument would substantiate a finding of a negative effect of inventory and capital intensity on coordination intensity. Taken together, the effects are a priori ambiguous. We calculate inventory intensity as inventory scaled by total assets and capital intensity as net property, plant and equipment divided by total assets. Last, we also control for the age of the tax unit. We do not have a prediction for the effect of tax unit age on coordination intensity, because tax unit age has not been studied in empirical analyses of tax planning behavior so far. On the one hand, older tax departments may have more routine and therefore coordinate more efficiently. Hence, one would expect a positive impact of age on coordination intensity due to lower coordination costs. On the other hand, a younger tax department may have to make higher efforts on tax planning as compared to compliance tasks, because it is not yet familiar with the task, which would result in a negative effect of tax department age on coordination intensity.

In sum, we include several firm specific characteristics to control for a potential systematic correlation between R&D intensity and firm specific characteristics. We control for firm size (SIZE) by including the logarithm of total sales, profitability (ROA) by including the return on assets, leverage (LEV) by including the quotient of liabilities over total assets, asset growth (GROW) by including the one-year percentage growth rate of total assets, inventory (INVINT) and capital intensity (CAPINT) by including the quotient of inventory over total assets and the quotient of plant, property and equipment over total assets and the age of the tax department (AGE).

For purposes of our regression analyses, we dichotomize the ordinal dimensions and estimate our regressions using OLS. The dichotomized variables take on the value 1 if the respondent's answer was 3 or 4, and takes on 0 otherwise. Thus, the value 1, respectively, stands for tax minimization being an important or very

Table 3.5: Cross-Correlation Table

Variables	RDINT	IPINT	SIZE	ROA	LEV	GROW	INVINT	CAPINT	AGE
RDINT	1.0000								
IPINT	0.1208	1.0000							
	(0.4402)								
SIZE	-0.1248	-0.0406	1.0000						
	(0.4253)	(0.7914)							
ROA	-0.0108	0.1452	0.0996	1.0000					
	(0.9453)	(0.3413)	(0.5150)						
LEV	-0.1363	-0.1770	**-0.3590**	0.1052	1.0000				
	(0.3835)	(0.2448)	(0.0132)	(0.4917)					
GROW	-0.0417	-0.0094	-0.0772	-0.0794	-0.1144	1.0000			
	(0.7908)	(0.9511)	(0.6142)	(0.6040)	(0.4544)				
INVINT	0.0463	-0.1283	-0.2678	-0.1183	0.0404	0.0426	1.0000		
	(0.7682)	(0.4010)	(0.0753)	(0.4391)	(0.7924)	(0.7813)			
CAPINT	-0.2293	-0.1337	0.1765	0.0768	-0.0453	0.1829	0.0932	1.0000	
	(0.1440)	(0.3868)	(0.2518)	(0.6205)	(0.7704)	(0.2346)	(0.5475)		
AGE	-0.1037	-0.0185	**0.5122**	-0.0927	**-0.3120**	0.2090	**-0.3513**	0.1626	1.0000
	(0.5083)	(0.9039)	(0.0002)	(0.5449)	(0.0328)	(0.1683)	(0.0180)	(0.2915)	

Notes: The table presents Pearson correlation coefficients for the variables used in the empirical analyses and reports p-values in brackets. Bold indicates that the Pearson correlation coefficient is statistically significant at $p < 0.05$.

important goal, tax executives being involved early or very early, tax executives having strong or even veto rights. We could also use non-linear response models to estimate the three regressions with qualitative dependent variables (ambitions, temporal involvement, decision rights). Indeed the linear probability model, which we prefer, is not beyond redemption. In particular, the predictions from the model cannot be constrained to the 0-1 interval (Greene, 2012).[16] Alternatively, some of the prominent problems associated with the linear probability model can be overcome by making the probability for one a non-linear, rather than a linear, function of the covariates. In contrast to the linear model, however, exact (small sample) properties of the Maximum Likelihood (ML) estimator of logit and probit models cannot be established (Aldrich and Nelson, 1984) and the literature on the small sample behavior of the ML estimator for binary regression models is rather limited (Chen and Giles, 2012). As outlined above, the central limit theorem can hold already in small samples of 30 to 50 observations and the normal approximation to the distribution of the OLS estimator should be appropriate. Thus, when using OLS we have more confidence in our inferences about the true empirical relationship between the explanatory variables of interest and the four dimensions of the tax department's role in the decision-making process. Nonetheless, we will check whether our results are sensitive to the choice of linear vs. non-linear estimation.

[16] For an exchange on the usefulness of the linear probability model, see Angrist (2001) and Moffitt (2001). Its shortcomings notwithstanding, the linear probability model is applied, among many others, by Caudill (1988), Heckman and MaCurdy (1985), and Heckman and Snyder (1997).

The data are primarily taken from the questionnaire. However, we also resort to data from Compustat Global and Compustat North America. When neither questionnaire data nor Compustat data is available, we also use the Worldscope database provided by Thomson Reuters. In addition, we always cross-checked the data obtained from the questionnaire with publicly available data from these alternative databases. Where we encountered any errors or even missing observations in all three data sources, we hand-collected the data from the consolidated financial statements directly. Nevertheless, we sometimes could not identify the necessary data in the financial statements and some firms did not even publish their reports, which leaves us with a few missing observations in our final sample. The consolidated financial statement information refers to the last publicly available financial statements from the date when the questionnaire was returned to us.

Table 3.5 presents cross correlations among our explanatory variables. R&D intensity is negatively correlated with capital intensity, size in terms of total sales is negatively correlated with leverage and inventory intensity and positively correlated with the tax department's age. The tax department's age is, moreover, positively correlated with asset growth and negatively correlated with leverage and inventory intensity. Most correlations, however, are small and, thus, rule out potential concerns about multicollinearity.

3.5 Results

3.5.1 Descriptive Analysis

The first part of our questionnaire is devoted to descriptive analyses. As Serita (2008) states, one advantage of survey analysis is that hypotheses can be directly checked without relying on inferential statistics. Furthermore, the relative importance of different influential factors can be identified.

As stated in Section 3.3.1, the literature on the interdisciplinary field of R&D and corporate taxation is mostly based on big data analyses. Partly, studies aim at identifying the effectiveness of R&D tax incentives (for example Hall and Van Reenen, 2000; Bloom et al., 2002; Arundel et al., 2008). More recently, the tax planning aspects in the context of R&D investments have been in the focus of researchers. Accordingly, questions on the location choice of R&D and IP have been studied in a number of papers (among others Dischinger and Riedel, 2011; Karkinsky and Riedel, 2012; Ernst and Spengel, 2011; Griffith et al., 2014). The general finding that has been substantiated in the cited studies is that the corporate tax rate exerts a negative effect on the holding of intangible assets. However, this finding leaves open questions as to how real R&D activity is affected by corporate tax rates. Moreover, it is not evident what kind of structures are set up by MNEs to achieve a tax optimal R&D investment. Therefore, we addressed these questions in a purely descriptive analysis.

This first part adds to the empirical analysis to come in that it draws a picture of the firms in our sample with respect to their views on R&D tax planning. It provides insights as to what considerations are important to them and what motives drive them to act like they do when investing in R&D and IP, respectively. In contrast to the regression analysis, the descriptive statistics do not aim to answer questions on the drivers of firm behavior, but rather like to describe general trends in firm behavior without relating it to firms' character traits. This is the focus of our regression analysis, which closer investigates the role of the tax department in R&D intensive firms (see Section 3.5.2 and 3.5.3).

All survey questions were measured on a five-point scale, ranging from 0 to 4. The respondents were asked to indicate agreement or disagreement with a given answer by checking the boxes on the scale, where we also indicated the highest and the lowest level of the scale. For example, when we ask for the importance of various factors in a business decision, we stated that a value of 4 indicates that the factor is '*very important*' and a factor of 0 is '*not at all important*'. For the purposes of the analysis of our results, we interpret a factor to be 'important' if the variable takes on the value 4 or 3 and to be 'not important' if it takes on the value 0 or 1. The value 2 lies in the middle of the five-point scale and since we do not indicate its meaning, we abstain from interpreting it.

Table 3.6: Importance of Factors Influencing the Amount of R&D Spending

Factor	# Obs.	Average Rating
The availability of internal funds.	42	2.95
The availability of external funds.	42	1.64
The tax rate on profits, including patent box regimes.	41	1.32
The availability of R&D tax incentives in the location(s) where your group conducts R&D activity.	42	1.83
The pressure your group faces to meet earnings benchmarks.	41	2.17

Notes: The table presents answers to the question: '*To what extent do the following factors influence the amount of your group's overall R&D spending?*', where respondents were asked to indicate whether a factor was 'not at all important' or 'very important' on a five-point scale.

According to Devereux and Maffini (2007) the investment decision of a firm can be theoretically divided into three separate decisions, which are the decision on the location of real activity, the amount of investment conditional on the investment location, and the location of the profits that stem from the investment. In line with this notion, the first set of survey questions addresses the business decisions regarding the amount of R&D spending, the location where real R&D activity should take place and the location where the arising IP rights should be hold. Table 3.6 presents results to the question '*To what extent do the following factors influence the amount of the group's overall R&D spending?*'. We listed five factors and asked respondents to indicate the importance of each factor as described in the previous paragraph. We are aware that many other factors may equally impact on the decision on the amount of R&D investment. However, the aim of our question is to learn about the relative importance of tax, accounting and financial concerns. The first two factors, the availability of internal and external funds, are financial concerns and relate to the common notion that R&D investments are financially constrained (see for example Hall, 2002; Harhoff, 1998; Hall et al., 1998). The last factor is an accounting factor. Previous research in the accounting literature has shown that managers cut R&D expenses to meet their earnings benchmarks (see for example Baber et al., 1991; Bushee, 1998; Roychowdhury, 2006).

We compare financial and accounting concerns with tax matters, which are represented by the second and third factors. Taken each factor by itself, only the first and last factor seems to be important for firms as both receive an average rating above 2. Thus, the availability of internal funds and the pressure to meet earnings benchmarks are important factors in the decision on how much resources are spent on R&D. Other factors, such as the availability of external funds, the availability of tax incentives and the profit tax rate on R&D output are of minor importance. The comparison shows that the availability of tax incentives is the third most important factor, followed by the availability of external funds and the profit tax rate. This result highlights that R&D investments seem to critically depend on equity capital and the liquidity of firms. Thus, tax incentives may induce R&D investment if firms are liquidity constrained.

Table 3.7: Importance of General Factors in R&D and IP Location Decision

Factor	# Obs.	R&D location decision	IP location decision	P-value
		Average Rating		
Wage costs	37	1.84	0.95	0.0000
Tax costs	37	1.46	1.92	0.0389
Skills and availability of workforce	35	3.63	2.09	0.0000
Country environment, infrastructure, culture	37	2.78	2.57	0.1276
Legal stability and security of IP	38	3.13	3.42	0.1111

Notes: The table presents answers to the questions: '*In general, what factors are important for your group when deciding whether to locate R&D activity (to hold patents) in one country or another?*', where respondents were asked to indicate whether a factor was 'not at all important' or 'very important' on a five-point scale. P-values are based on a Wilcoxon matched-pairs signed-rank test (Wilcoxon, 1945) and indicate significant difference in the rating of factors in the R&D and IP location decision.

Considering the location of R&D investments we ask firms about general country factors and their importance on the location choice. In a separate question we address the importance of general country factors for the location choice of IP. Hence, we are able to compare the factors with each other, but also to compare location choices, both the location choice of R&D investments and the location choice of IP holdings. The general factors are taken from A.T. Kearney's global services location index (A. T. Kearney, 2011) and are summarized to first wage costs, second tax costs, third skills and availability of a country's workforce, fourth the country's environment, its infrastructure and culture and fifth the legal stability and security of IP rights. Table 3.7 presents the results on the importance of general factors in the R&D and IP location decision. Not surprisingly, tax costs are among the less important factors in both R&D and IP location decision as compared to other country characteristics. For the location of R&D, tax costs are least important and for the location of IP tax costs are second least important. More interesting is the comparison of the two decisions with each other, since it reveals that the two decisions are significantly different from each other in many respects. As the p-values indicate, the average rating of three factors significantly differs in the two decisions, while only with respect to country environment, infrastructure and culture and with respect to the legal stability and security of IP the average rating does not significantly differ. Regarding the tax factor, the results indicate that for the location choice of IP taxes are slightly more important as they are for the location choice of R&D activity. We thus take a closer look at specific tax factors in two follow-up questions.

Table 3.8: Importance of Tax Factors in R&D and IP Location Decision

Factor	# Obs.	R&D location decision Average Rating	IP location decision Average Rating	P-value
The applicable tax rate on profits	38	1.82	2.16	0.0596
Tax regulations relating to R&D expenditure (tax credits, deductions)	38	2.42	2.21	0.1070
Imposition of exit tax upon the cross-border transfer of assets	38	1.97	2.26	0.0820
Loss-offset provisions	37	1.68	1.41	0.1186
Transfer pricing regulations	37	2.32	2.32	0.8749
Double tax treaty network	37	2.32	2.49	0.3061

Notes: The table presents answers to the questions: '*Relative to all other factors your group considers when deciding whether to locate R&D activity (to hold patents) in one country or another, how important are the following tax factors?*', where respondents were asked to indicate whether a tax factor was 'not at all important' or 'very important' on a five-point scale. P-values are based on a Wilcoxon matched-pairs signed-rank test (Wilcoxon, 1945) and indicate significant difference in the rating of factors in the R&D and IP location decision.

We asked our respondents: '*Relative to all other factors your group considers when deciding whether to locate R&D activity (to hold patents) in one country or* *another, how important are the following tax factors?*', where the question is asked twice, once regarding the location decision of R&D activity and once with respect to the location of IP rights. The questions are targeted to determine the relative importance of six specific tax factors as highlighted by Russo (2007). The average ratings of Table 3.8 cannot be compared with the results from Table 3.7. Due to concerns of salience, the average ratings of the specific tax factors are comparably high in contrast to the rating of tax costs among general country factors. This is, because only specific tax factors are compared with each other. If we had added more country characteristics to the list of choices, respondents had possibly rated tax factors lower as they did. However, the comparison of taxes and other country factors was addressed in previous questions (see Table 3.7), while the focus of this question is to compare only tax factors with each other. Following previous survey studies (Graham et al., 2011), we added the phrase 'relative to all other factors' to the question to ensure that we control for other factors, such as country environment, legal stability, workforce, etc.

The answers are presented in Table 3.8. Again, the p-values indicate whether the average ratings are significantly different in the location decision of R&D activity from the location decision of IP. Looking at the location decision of R&D activity, the most important tax factor is the regulation relating to R&D expenditure that includes also the regulations on R&D tax incentives, like additional allowances or tax credits. Contrary, the most important factor in the IP location decision is the double tax treaty network. Moreover, the applicable profit tax rate and the imposition of an exit tax upon the cross-border transfer of an asset are important factors in the IP location decision, while they are of less importance in the R&D location decision. In sum, we conclude that the R&D and IP location decision are two distinct decisions that are made separately. Two tax factors are rated differently in the two decisions at the 10% significance level, one tax factor is rated significantly different only at 10.7%. It seems that in the location decision of IP tax planning considerations are of higher importance as compared to the R&D location decision. However, this is only a conjecture and it will be examined in greater detail in the following.

Because it is not possible to draw conclusions from Table 3.8 as to why the IP location decision differs from the R&D location decision, we follow-up with a question on the considerations in the IP location decision. We investigate considerations in the decision to locate patents away from where R&D took place and motives why firms considered to locate patents at a low-tax affiliate. Last, we also ask how firms achieve to locate patents at a low-tax affiliate. Prior to our questions, we asked: '*Has your firm considered locating patents at an affiliate that is subject to comparably low tax rates?*' to avoid a downward bias caused by firms that never considered the opportunity to geographically separate the location of IP from the location of

Table 3.9: Specific Considerations in the IP Location Decision

How well do the following statements reflect your group's considerations in the decision to locate patents away from where R&D took place?	# Obs.	Average Rating
If exit taxes are in place, they pose an important obstacle to the cross-border transfer of patents within our group.	26	2.35
Our group uses contract R&D to locate patents in countries different from where the associated R&D activity took place.	27	2.74
By using cost-sharing agreements, patents may be spread across several countries.	26	1.65
Transferring patents is expensive. Therefore our group transfers R&D activity to countries that are attractive for holding patents.	26	1.73

How well do the following statements reflect why your group considered locating patents at an affiliate that is subject to comparably low tax rates?	# Obs.	Average Rating
Because the expected return related to a patent is high.	16	3.06
Because there is a large difference in tax rates between countries.	16	3.0
Because patents are internationally mobile assets that can be separated easily from other production affiliates in our group at low cost.	16	2.75
Because this reduces our group's overall tax burden.	16	2.88

How does your group achieve locating patents in low tax countries?	# Obs.	Average Rating
By conducting R&D in low tax countries.	15	1.47
By selling patents to affiliates in low tax countries.	15	2.4

Notes: The table presents answers to the questions stated in bold, where respondents were asked to indicate on a five-point scale whether they 'strongly disagreed' or 'strongly agreed' with a statement.

R&D.[17] Thus, the respondents to all follow-up questions that are presented in Table 3.9 have at least considered this opportunity.

On average, respondents agree that they considered the fact that contract R&D is a means to geographically separate the IP location from the location where the associated R&D activity took place. Moreover, they agree to the notion that exit taxes are an important obstacle to the cross-border transfer of patents within the group. These answers reveal that firms identified contract R&D as a tax planning structure to achieve a geographical separation of R&D activity and the ownership of the resulting IP rights. Moreover, the respondents on average disagreed with the statement that they transfer R&D activity to countries that are attractive for holding patents in order to avoid a costly transfer of patents. Thus, we conclude that our respondent's R&D activities are rather immobile factors. Last, our firms disagree having considered that cost-sharing agreements are used to spread patents across several countries indicating that cost-sharing agreements are less likely to be

[17]Note that this is also the reason why we observe only a reduced number of observations to the questions presented in Table 3.9.

considered as an alternative to contract R&D agreements.

Regarding the motives why firms considered to locate patents to low-tax affiliates, our respondents on average agree with all choices that were given. The most important motive to consider relocating patents to low-tax affiliates is that the expected return related to a patent is high. This result also confirms the notion that high-value patents are more likely to be relocated to low-tax locations as stated in Boehm et al. (2012) and Ernst et al. (2014). Furthermore, a large tax differential between countries is almost equally important, confirming first evidence by Dischinger and Riedel (2011) and Karkinsky and Riedel (2012). Third, the relocation of patents to low-tax affiliates reduces the overall tax burden of the MNE and fourth, can be achieved in a rather simple way, because patents are mobile assets. Last, we asked firms how they actually achieve to locate patents in low-tax countries. They answer that they rather sell patents to affiliates in low-tax countries than conduct R&D activity in a low-tax country to apply for patent protection afterwards. These insights suggest that firms indeed view IP to be more mobile than real R&D activity. Thus, tax planning is more simple and less costly when done with IP than with real R&D activity.

Table 3.10: Organization of R&D within the MNE

Form of organization	# Obs.	Total Points	Average Rating
In-house: Our group employs R&D affiliates that bear the costs and conduct R&D in-house.	39	73	1.87
Contract R&D: One or more affiliate(s) of our group contract(s) out R&D to other affiliates.	39	61	1.56
Pool-financing: One or more affiliate(s) of our group share the costs and undertake R&D activity in collaboration.	39	38	0.97
Outsourcing: R&D is contracted out to a third party, e.g. universities.	39	32	0.82

Notes: The table presents answers to the question: '*How do you organize R&D within your group?*', where respondents were asked to rank the top three forms of organization and leave the other forms blank.

More generally, we were also interested how R&D is organized within a multinational firm to get an idea what kind of structures are commonly implemented by firms. Table 3.10 presents results to the question '*how do you organize R&D within your group?*'. We enforced respondents to rank the top three forms of organization by entering a '1', '2' and '3' to avoid equal ratings of all available choices. The answers show that the most prevalent form of organization is in-house R&D, which refers to R&D that is carried out by the company who bears the costs of the investment and finally applies for patent protection, being the owner of the resulting IP. Contract R&D is the second most important form of organization of R&D. In this case, the R&D activities are contracted out to an affiliate company who carries out

Table 3.11: Attributes of R&D Tax Incentives

Attribute	# Obs.	Total Points	Average Rating
The tax incentive immediately impacts on liquidity.	44	83	1.89
The administration of the tax incentive is simple.	44	49	1.11
The tax incentive enables planning certainty.	44	59	1.34
The tax incentive is applied without restrictions on the location of R&D activity.	44	36	0.81
The tax incentive is applied without restrictions on the location of patents.	44	42	0.95

Notes: The table presents answers to the question: '*Which of the following makes a tax incentive most appealing to your group?*', where respondents were asked to rank the top three choices and leave the others blank.

the services on behalf of the financing company (for more discussion on tax planning issues with contract R&D see Chapter 5 Section 5.2). Third, pool-financing agreements are listed at rank three. Pool-financing or cost-sharing agreements are contracts among several affiliate firms to share costs and undertake R&D in collaboration. The resulting IP is also shared according to the contribution in the pool. Last, the least important form of R&D organization is contracting out R&D to third parties, like universities or research institutes. In sum, the results depict that the traditional form of R&D still prevails. Nevertheless, contract R&D and pool-financing agreements are ranked closely after traditional R&D revealing that these forms are likely to be considered or implemented by multinational firms.

Finally, we posed one question relating to traditional R&D tax incentives, like tax credits or additional allowances. We asked: '*Which of the following makes a tax incentive most appealing to your group?*'. As prior literature has suggested that these are effective in raising the overall amount of corporate R&D spending (for a review see Hall and Van Reenen, 2000),[18] we are interested in the attributes of a tax incentive. For example, Spengel et al. (2009) suggests that a tax credit that may be set off with the wage tax will be most effective in raising additional R&D activity, because it directly impacts on the liquidity of the firm. In fact, he claims a tax incentive that is also granted to firms if they are in a loss situation. Furthermore, Bloom (2007) suggests that complex incentives and incentives that are not granted continuously are less effective in raising corporate R&D activity. From a tax planning point of view, we are also interested how restrictions that relate to tax planning structures are evaluated by firms (see also Chapter 2 Section 2.1).

The results are presented in Table 3.11. Again, we enforced a ranking of the choices to establish an order of precedence of the attributes considered. In line with our conjecture, the most important attribute for a tax incentive is an immediate

[18]For a more detailed review and discussion of the evidence see Chapter 2 Section 1.3.2.

impact on liquidity. A continuous grant that enables planning certainty and the simplicity to administer the incentive are ranked second and third most important among the alternatives. Tax planning considerations as reflected by the fourth and fifth attribute (the tax incentive is applied without restrictions on the location of R&D activity and the location of patents, respectively) are ranked least important. The answers confirm previous findings in the literature that an immediate impact on liquidity, planning certainty and simplicity are among the most important drivers of the effectiveness of R&D tax incentives. Our finding that tax planning attributes are less important is in line with our previous findings, that tax planning considerations are less present in business decisions relating to real R&D activity.

To sum up, the descriptive analyses reveal that the firms we surveyed say that financial and accounting factors are important factors influencing the amount of R&D spending, but taxes are less so; as compared with other country characteristics, taxes are of less importance for the location decision of R&D as well as for IP; however, among various tax factors, the most important factor for the location of R&D activity is the regulation that determines the deductions for R&D expenditure and the most important factor for the location of IP is the double tax treaty network; they considered contract R&D agreements as a means to locate patents away from where the associated activity takes place; considered locating patents at a low-tax affiliate, because they expected the patent to yield a high return; and they achieve this primarily by selling the patent to the low-tax affiliate; overall, they most often engage in in-house R&D and that they view the impact on liquidity, planning certainty and simplicity to be the most important attributes of R&D tax incentives. In the analyses to come we go on to test, how tax considerations may be implemented the decision-making process of R&D intensive and IP intensive multinationals.

3.5.2 Bivariate Analysis

First, we present results from bivariate analyses. For each variable of interest, we split the sample into firms above and below the respective median value. For example, with respect to R&D intensity, we form one group of firms showing high R&D intensity and another group of firms displaying low R&D intensity, where high and low is defined by the median R&D intensity. We then use a Wilcoxon rank-sum test to figure out whether tax departments in the two groups of firms take different roles in the decision process, as reflected by their tax planning efforts, ambitions, the timing of involvement and ultimate decision rights. Remember that the first dimension - tax planning efforts - is a continuous variable, whereas all other dimensions - ambitions, temporal involvement and rights - are ordinal variables which are measured on a five-point scale ranging from 0 to 4. The bivariate analysis relies on this measurement. The ordinal indicator for tax planning ambitions takes on the value 0 if minimization of the group's tax burden is not at all important and thus, indicates the lowest parameter value. The highest parameter value is 4 and represents the highest level of importance of the minimization of the tax burden. Similarly, a 0 for temporal involvement indicates that the tax department is involved late, while a 4 indicates an early involvement. And last, tax executives have no rights in the decision process and are not consulted if the variable takes on the value 0, while they have a veto right if the variable takes on the value 4.

Table 3.12 presents findings from the Wilcoxon rank-sum test and shows, for each of the four dimensions of interest, the probability that a draw from the 'low' group, in terms of the seven distinct characteristics respectively, is larger than a draw from the corresponding 'high' group. Under the null hypothesis, the two groups do not systematically differ and the probability to draw a larger value from the first group as compared to the second is 50 percent.

Considering the results displayed in Table 3.12, the survey-based indicators for tax planning efforts, tax planning ambitions, the timing of involvement and the ultimate decision rights tend to show higher values for firms with low R&D intensity. In other words, the probability to draw higher values from the group of firms with low R&D intensity as compared to the group of firms with high R&D intensity is larger than 50 percent. More precisely, the probability that less R&D intensive firms exhibit more tax planning efforts than highly R&D intensive firms is 55.4%. Similarly, we find that the probability that less R&D intensive firms have higher tax planning ambitions is slightly above 50%, the probability that they are earlier involved in the decision-making is 64.1%. The probability that they have stronger ultimate decision rights is almost 60%. Although the differences between groups are, with the exception of what we find for the timing of involvement, not statistically significant, the observed tendencies regarding efforts, ambitions and temporal involvement are in line with our conjecture that increasing R&D intensity leads tax departments to act more as a controller than as a manager, with less tax planning efforts and ambitions and an involvement at a later stage of the decision process. In turn, the dimension of ultimate decision rights does not meet our expectation.

Interestingly, we find that low IP intensity is associated with lower tax planning efforts and ambitions. While the relationship between R&D intensity and tax planning efforts and ambitions appears negative, IP intensity thus has a positive impact on these dimensions. With respect to ambitions, the difference between less and highly IP intensive firms is statistically significant at 10% (Wilcoxon test) or 5% (t-test). We consider this finding in line with IP intensity being a more precise proxy for tax planning opportunities subsequent to the investment decision than R&D intensity which rather proxies for factors that prevents tax experts from getting actively involved in tax planning, i.e. high costs of delay and, accordingly, a strong focus on time to market.

Furthermore, results in Table 3.12 document that the conventional determinants of tax planning opportunities and tax planning behavior, which we take from previous literature (see Section 3.1), do significantly impact on the temporal involvement of the tax department but less so on the other dimensions of the tax department's role in the investment decision process. In particular, findings from the Wilcoxon test suggest that tax executives in relatively small firms and less leveraged firms get involved rather late in the decision process, i.e. the probability to draw higher values of our temporal involvement indicator (where high values stand for early involvement) is significantly reduced for these groups of firms. Moreover, in firms with low levels of inventory and capital intensity, tax departments get involved earlier. Finally, we find that younger tax departments tend to have weaker ultimate decision rights.

Table 3.12: Bivariate Analysis

		Efforts	Ambitions	Temp. Inv.	Rights
RDINT	low>high	55.4%	52.4%	64.1%*	59.5%
IPINT	low>high	38.7%	34.8%$^{*}_{\star\star}$	51.0%	54.8%
SIZE	low>high	46.0%	53.0%	35.6%$^{*}_{\star}$	37.9%
ROA	low>high	47.6%	55.3%	45.5%	44.3%
LEV	low>high	45.7%	47.4%	30.6%$^{**}_{\star\star\star}$	34.0%$^{**}_{\star\star}$
GROW	low>high	44.5%	49.7%	42.2%	41.8%
INVINT	low>high	53.7%	47.8%	65.1%$^{*}_{\star}$	56.9%
CAPINT	low>high	39.3%	48.4%	61.5%$_{\star}$	55.6%
AGE	low>high	49.9%	53.8%	42.3%	35.0%*

Notes: Respondents are split by the median into two groups according to each conditioning variable, listed on the left hand side of the table. It is then tested whether tax departments of one group and tax departments of the other group of firms take different roles in the decision process, as reflected by their tax planning efforts, ambitions, temporal involvement and ultimate decision rights. The probabilities that one group differs from the other group are shown in the table and are based on a Wilcoxon rank-sum test. Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Stars ($\star$, $\star\star$ and $\star\star\star$) indicate statistical significance at the 10%, 5% and 1% level based on a t-test. For example, with respect to R&D intensity, the probability that tax departments of less R&D intensive firms make more tax planning efforts than tax departments in high R&D intensive firms is 55.4%.

Overall, the picture from the bivariate analysis is mixed. On the one hand, some of the results support the view that coordination of the tax department with other operational units in R&D intensive firms is costly and may prompt tax experts in the firm to act less as managers in the investment process but more as merely ratifying controllers. On the other hand, only a few findings are statistically significant, an outcome which could however be attributable to the small sample size. Importantly, we find that significant differences between groups of firms according to the Wilcoxon rank-sum test are in most cases confirmed by the alternative t-test for the difference between the group means of the four dimensions considered. We conclude that inference based on conventional parametric procedures is accurate despite potential concerns arising from the small sample size.

3.5.3 Regression Analysis

The main results from the regression analyses are presented in Tables 3.13 and 3.14. Again, we are primarily interested in whether R&D intensity has an impact on the tax department's role in the business decision process, as reflected by its tax planning efforts, tax planning ambitions, the timing of involvement and ultimate decision rights. While tax planning efforts is measured as a proportion, the other dimensions - ambitions, temporal involvement and rights - are dichotomous variables as described in Section 3.4. They are measured as binary variables, where the variable takes on the value 1 if the original answer was 3 or 4 on the five-point scale and 0 otherwise. Column 1 of Table 3.13 shows the response of tax planning efforts, again measured by the approximate time (in % of total workload) that is spent on tax planning activities, as opposed to activities linked to compliance and financial reporting. Column 2 of Table 3.13 shows the response of tax planning ambitions, measured as a dichotomous variable, which is 1 if tax minimization is an important or very important objective of the tax department, and 0 otherwise. Column 3 of Table 3.13 shows the results for temporal involvement, again measured as a dichotomous variable, which is 1 if the tax department gets involved early or even very early in the initiation phase of the decision process, and 0 otherwise. Column 4 of Table 3.13 shows the results for ultimate decision rights, again measured on a dichotomous scale, where 1 reflects strong or even veto rights of the department.

Table 3.13 presents coefficient estimates from regressions of efforts, ambitions, temporal involvement and rights on R&D intensity and control variables. Standard errors robust to heteroscadasticity are given in parentheses. The coefficient estimate of R&D intensity on efforts (specification (1)) is -2.193 and statistically significant at 1%. This result means that an increase of R&D intensity by one percentage point leads to a 2.2 percentage point decrease of the proportion of workload spent on tax planning. The regression results from the dimension ambitions are reported in specification (2) and depict a different picture than the results from the effort-dimension. The coefficient estimate of R&D intensity is not significant indicating that R&D intensive firms are statistically not more or less ambitious to minimize their tax burden as compared to less R&D intensive firms. Furthermore, we investigate at which stage during the planning phase of an investment project tax executives are involved in the decision-making (see specification (3) of Table 3.13). We find that temporal involvement decreases in the R&D intensity. Precisely, an increase in R&D intensity by one percentage point is associated with a decrease in the probability

Table 3.13: Coordination Intensity in R&D Intensive MNEs

	(1)	(2)	(3)	(4)
	Efforts	Ambitions	Temp. Inv.	Rights
RDINT	-2.193***	-3.354	-4.362**	3.609
	(0.739)	(3.337)	(1.960)	(2.412)
SIZE	0.033**	-0.052	0.024	0.103*
	(0.016)	(0.063)	(0.056)	(0.058)
ROA	-0.058	-0.944	0.728	0.410
	(0.122)	(0.702)	(0.834)	(0.709)
LEV	-0.005	-0.040***	0.024*	0.054***
	(0.004)	(0.014)	(0.013)	(0.013)
GROW	0.384***	0.143	0.700**	0.893***
	(0.088)	(0.383)	(0.277)	(0.259)
INVINT	0.400	-0.685	-0.854	-0.205
	(0.335)	(1.163)	(0.699)	(0.794)
CAPINT	-0.047	0.771	-0.905	-0.216
	(0.190)	(0.605)	(0.568)	(0.606)
AGE	-0.073**	-0.057	0.100	0.136
	(0.033)	(0.095)	(0.089)	(0.087)
Constant	-0.252	2.212	0.046	-2.469*
	(0.311)	(1.444)	(1.291)	(1.435)
Observations	39	41	42	42
R-squared	0.410	0.208	0.333	0.319

Notes: All regressions are based on OLS estimation. While the dependent variable 'efforts' is a proportion, the variables 'ambitions', 'temporal involvement' and 'rights' are binary variables. The dependent variable 'efforts' (specification (1)) represents the workload spent on tax planning relative to total workload; 'ambitions' (specification (2)) is 1 if tax minimization is an important or very important objective of the tax department, and 0 otherwise; 'temporal involvement' (specification (3)) is 1 if the tax department gets involved early or even very early in the initiation phase of the decision process, and 0 otherwise; 'rights' (specification (4)) is 1 if the tax department has strong or even veto rights in the decision process. The four dimensions are regressed on firm characteristics, which are R&D intensity (RDINT), firm size (SIZE), profitability (ROA), leverage (LEV), firm growth (GROW), inventory and capital intensity (INVINT and CAPINT) and age of the tax department (AGE). Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Heteroscadasticity robust standard errors are in parentheses.

that tax executives are involved early in the decision-making by 4.36 percentage points. This finding supports our hypothesis that coordination costs are too high to involve tax executives early in the decision-making process. Last, we regress the dichotomous indicator for ultimate decision rights on R&D intensity and controls and present results in specification (4). Contrary to the other three dimensions efforts, ambitions and temporal involvement, R&D intensity has a positive estimated coefficient. This would indeed suggest that with increasing R&D intensity tax executives have stronger rights to oppose the decision made by other departments. However, the positive coefficient of R&D intensity is not statistically different from zero at all conventional levels of significance.

To sum up, we observe that R&D intensity seems to reduce the coordination intensity of the tax department with other departments in the firm, at least in terms of two of the four investigated dimensions. These two dimensions are the tax planning efforts measured as time of total workload attributed to tax planning and the temporal involvement of tax executives in the decision-making process. Tax executives indeed get involved at later stages of the investment decision and do not intervene in initial decisions such as investment location choices. With respect to the other dimensions, however, we find no evidence that R&D intensive firms have more or less tax planning ambitions and decision rights than less R&D intensive firms.

Table 3.14: Coordination Intensity in R&D and IP Intensive MNEs

	(1)	(2)	(3)	(4)
	Efforts	Ambitions	Temp. Inv.	Rights
RDINT	-2.670***	-6.435**	-3.860*	4.313*
	(0.651)	(2.719)	(2.166)	(2.407)
IPINT	0.279**	1.797***	-0.441	-0.619
	(0.125)	(0.512)	(0.505)	(0.408)
SIZE	0.031*	-0.069	0.032	0.115**
	(0.015)	(0.056)	(0.057)	(0.056)
ROA	-0.090	-1.146*	0.775	0.475
	(0.117)	(0.626)	(0.868)	(0.727)
LEV	-0.005	-0.039***	0.022*	0.052***
	(0.003)	(0.012)	(0.013)	(0.013)
GROW	0.390***	0.187	0.682**	0.868***
	(0.093)	(0.361)	(0.276)	(0.259)
INVINT	0.476	-0.210	-0.833	-0.176
	(0.307)	(1.015)	(0.712)	(0.804)
CAPINT	-0.089	0.533	-0.900	-0.209
	(0.170)	(0.555)	(0.582)	(0.592)
AGE	-0.080***	-0.100	0.099	0.135
	(0.024)	(0.103)	(0.086)	(0.085)
Constant	-0.196	2.586**	-0.097	-2.670*
	(0.324)	(1.243)	(1.330)	(1.368)
Observations	39	41	42	42
R-squared	0.474	0.439	0.347	0.345

Notes: All regressions are based on OLS estimation. While the dependent variable 'efforts' is a proportion, the variables 'ambitions', 'temporal involvement' and 'rights' are binary variables. The dependent variable 'efforts' (specification (1)) represents the workload spent on tax planning relative to total workload; 'ambitions' (specification (2)) is 1 if tax minimization is an important or very important objective of the tax department, and 0 otherwise; 'temporal involvement' (specification (3)) is 1 if the tax department gets involved early or even very early in the initiation phase of the decision process, and 0 otherwise; 'rights' (specification (4)) is 1 if the tax department has strong or even veto rights in the decision process. The four dimensions are regressed on firm characteristics, which are R&D intensity (RDINT), IP intensity (IPINT), firm size (SIZE), profitability (ROA), leverage (LEV), firm growth (GROW), inventory and capital intensity (INVINT and CAPINT) and age of the tax department (AGE). Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Heteroscadasticity robust standard errors are in parentheses.

Clearly, R&D intensive firms tend to hold more intangible assets as compared to less R&D intensive firms. A look at Table 3.5 documents a positive correlation (12.08%) between the R&D intensity and the IP intensity of our respondent firms.

As intangible assets are highly specific, their true value is hardly observable for national tax authorities, which provides leeway for transfer price distortions. As a consequence, a transfer of IP to low-tax affiliates may be attractive and require less planning efforts than direct intervention in initial decisions about the set-up and location of production facilities. If it is indeed easier for tax planners to tax-efficiently migrate IP within a multinational than it is for them to tax-efficiently structure real R&D investments, firms may accept forgone tax savings due to tax-inefficient R&D investments and will reverse part of those tax inefficiencies by means of tax-optimal transfers of their intangibles *ex post*. In other words, tax planning in R&D intensive firms takes place, but it takes place less with respect to R&D but with respect to IP location. In Figure 3.1 presented in Section 3.2, these ex post profit shifting opportunities by means of IP migration trigger a shift of the autonomy cost curve in Figure 3.1 to the left.

If IP intensity is indeed a determinant of the tax department's function in the firm, the coefficients for R&D intensity reported in Table 3.13 are actually 'biased' in the sense that they reflect the net effect of variation in R&D intensity *and* co-varying IP intensity. We now would like to disentangle the effect of R&D and the effect of IP on the tax department's role by additionally including a specific proxy for IP tax planning opportunities into our previous regression framework. We employ IP intensity (IPINT), calculated as the balance sheet item of intangible asset holdings scaled by total assets. As IFRS requires capitalization of both acquired *and* self-created intangible assets,[19] the IP intensity we extract from the consolidated accounts of the responding public[20] European multinational firms proxies well for the success of past innovative activity and arising actual profit shifting opportunities. Some countries allow for the capitalization of acquired intangibles only.[21] Still, even in these cases IP intensity reflects that part of profit shifting potential associated with acquired IP. The results of augmenting the empirical model with IP intensity are presented in Table 3.14.

Interestingly, we see that the effect of R&D intensity persists and is even stronger

[19]IAS 38.57 defines under which circumstances self-created IP has to be capitalized in the books. Accordingly, 'development costs are capitalized only after technical and commercial feasibility of the asset for sale or use have been established. This means that the entity must intend and be able to complete the intangible asset and either use it or sell it and be able to demonstrate how the asset will generate future economic benefits'.

[20]Note, that only publicly traded European firms are obliged to report their consolidated financial statements based on IFRS, see the Regulation (EC) No 1606/2002 of the European Parliament and of the Council of 19 July 2002. In our sample, these are 17 firms.

[21]According to US GAAP, Standard ASC 350, internal research and development costs are generally immediately expensed. There are a few exceptions for computer software or website development. Moreover, our dataset contains five publicly traded Swiss companies. In Switzerland, since 2005 most Swiss companies that are listed on the main board of the Swiss Exchange have an obligation to report either in IFRS or in US GAAP.

if we additionally control for IP intensity. Considering Column (1) of Table 3.14, a one percentage point increase in R&D intensity statistically significantly decreases the share of tax planning efforts in the tax department's total workload by -2.670 percentage points. At the same time, IP intensity shows a small but significant and positive impact on tax planning efforts. In particular, a one percentage point increase in IP intensity increases the share of tax planning efforts in the tax department's total workload by 0.279 percentage points. This finding supports our conjecture that efforts associated with IP tax planning do not outweigh the reductions in tax planning efforts associated with the tax experts' reduced intervention in real investment decisions. As shown in Column (1) of Table 3.13 already, the net effect of R&D intensity on tax planning efforts thus is negative. Looking at the dimension ambitions (Column (2) of Table 3.14), including IP intensity into the regression model turns both coefficients of R&D and IP intensity significant. While an increase in the R&D intensity by one percentage point leads to a decline in the probability that the respondent rates the minimization of the tax burden as important goal for the tax department by 6.44 percentage points, the same increase in the IP intensity leads to an increase in the probability to have an ambitious tax department by 1.8 percentage points. Interestingly, the effects are contrary to each other, which explains our previous finding in Column (2) of Table 3.13, where R&D intensity captures the net effect and therefore turned out insignificant. With respect to the dimension temporal involvement of the tax executives in the decision-making process (Column (3) of Table 3.14), the effect of R&D intensity persists when we include IP intensity. In particular, a one percentage point increase in R&D intensity is associated with a decline in the probability that the tax executives are involved early in the decision-making by 3.86 percentage points. Similarly, the effect of IP intensity is also negative, though insignificant. Nevertheless, this finding supports our conjecture that tax planning takes place only at a later stage in the R&D process. Consequently, R&D and IP intensive firms do not see the need for involving tax executives early in the decision-making on a new investment project. Rather, they optimize the legal structure given the target location of an investment, because the cost of autonomy is lower as compared to the cost of coordination. Last, we investigate the effect of R&D and IP intensity on the ultimate decision rights of tax executives. The first results in Column (4) of Table 3.13 did not show a significant impact of R&D intensity on rights. When including IP intensity though, we indeed find that R&D intensity exerts a significantly positive effect on rights (Column (4) of Table 3.14). Thus, a one percentage point increase in R&D intensity is associated with an increase in the probability that the tax experts have a veto right in the decision-making process by 4.31 percentage points.

Overall, our results reveal interesting insights in the decision-making of R&D and

IP intensive firms and suggest that tax planning activities take place at different stages in the R&D process. Coordination between the tax department and other operational units is negatively affected by R&D intensity. In other words, within R&D intensive firms coordination with the tax department is too costly and therefore, the tax department adopts more controlling than managerial tasks. If the tax department is less strongly involved in the management, the firm runs into the danger to incur costs by forgone tax savings. This, however, can be mitigated by tax planning opportunities that arise with respect to intangible assets. Overall, our findings reconcile previous evidence that taxes matter less for R&D intensive firms when it comes to investment choices (Overesch and Schreiber, 2010) while overall they have been shown to report lower ETRs on average (Graham et al., 2011; Robinson et al., 2010; Graham et al., 2014).

3.5.4 Robustness Checks

In this section, we document the results from a large series of sensitivity analyses assessing robustness of the results from our baseline estimations in Tables 3.13 and 3.14.

First, we include industry dummies as suggested by Wilson et al. (1993). Wilson et al. (1993) provides descriptive and qualitative evidence that the industry a firm operates in strongly determines the organizational and incentive structure of firms. For example, the pharmaceuticals and chemicals industry may be similar in many respects, but differ substantially with respect to gross margins. Pharmaceuticals have higher gross margins and, therefore, will incur higher losses if they fail to become the first patent applicant. Consequently, their costs of delay, which are part of coordination costs, are much higher than those of firms operating in other industries. Furthermore, the chemical industry differs from the pharmaceuticals industry in that transportation costs are substantially higher in the chemical industry. Hence, firms in the chemical industry face a higher pressure to locate their production facilities close to their major markets and suppliers to minimize transportation costs. The baseline regressions presented in Tables 3.13 and 3.14 are re-estimated with the inclusion of industry dummies. The results are shown in Table 3.15. Despite the reduction in degrees of freedom associated with the inclusion of industry dummies, the coefficients of RDINT again turn out significant and show expected signs. Quantitatively, the effects of R&D intensity on the four dimensions of the tax department's role within the business process are larger than without modeling of industry fixed effects. According to the results shown in Table 3.15, the effect of IP intensity is smaller in magnitude and is statistically significant only with respect to the ambitions of the tax department (specification (4) of Table 3.15).

As a second robustness check we extended our empirical model by a further variable that captures whether compensation contracts of tax executives are based on some kind of after-tax performance measure. The variable is drawn from our survey. We ask whether compensation of tax executives is based on some kind of performance measure and give four possible options, namely *yes, an after-tax measure*; *yes, a before-tax measure*; *yes, other* and *no*. We then dichotomize the variable to include it in our regression framework as compensation variable (COMP), where it takes on the value 1 if compensation of tax executives is based on some after-tax performance measure and 0 otherwise. Disregarding compensation contracts of tax executives could lead to omitted variable bias. Performance-based compensation typically aims at limiting agency costs as suggested by contracting theory (Jensen and Meckling, 1992). Performance measurement that is based on after-tax measures may motivate managers to care more about the tax consequences of their decisions. Consequently, managers may coordinate more intensively with the tax department. Thus, the four dimensions we use to measure the tax departments management-control-decision are likely influenced by compensation contracts. A common after-tax performance measure in this respect is the reported GAAP ETR of the firm, because it measures the total tax expense scaled by pre-tax profit. Empirical evidence suggests that indeed firms whose managers are compensated based on some after-tax performance measure report lower ETRs on average (Armstrong et al., 2012; Phillips, 2003). We therefore include the tax executives compensation into our modified model. The results are presented in Table 3.16. In general, the results support our hypothesis that the tax department in R&D intensive firms acts more as a controller than as a manager. Including compensation in the empirical model even renders the coefficient estimates of our variables of interest slightly larger in size. The compensation variable itself, however, stays mostly insignificant. Moreover, we considerably lose observations when including COMP in our regressions as it is missing for a number of firms. We therefore consider it as a robustness check and do not include it in our baseline analyses.

Furthermore, we re-estimate our baseline analyses using a non-linear probability model and present the results in Table 3.17. In our baseline model we decided to follow a linear approach, due to better small sample characteristics of OLS than non-linear probability models. To check robustness, we run the non-linear probit model using the dichotomized variables. The probit regression model is designed for estimation with a binary dependent variable and for capturing the non-linearity in the probabilities (Greene, 2012). Table 3.17 presents average marginal effects of the included covariates on the probabilities to show high tax planning ambitions, get involved early, and be assigned strong ultimate decision rights, respectively. Considering the results from the probit regression, the estimates of R&D intensity are significant and show the expected signs just as in the baseline model. For IP intensity we also find effects similar to our baseline results. However, according to column (6) of Table 3.17, IP intensity has a negative and significant effect on the ultimate decision rights of the tax department, whereas its effect was insignificant according to the baseline findings. With the exception of specification (2) of Table 3.17, estimated effect sizes of both R&D and IP intensity turn out quantitatively consistent to the baseline findings.

Thus, we conclude that our results are qualitatively, and mostly quantitatively, robust towards different estimation methods. Furthermore, the results also hold when estimating an ordered probit regression model using the original variables that range from 0 to 4.[22]

3.6 Conclusion

By locating intangible assets at low-tax affiliates, R&D intensive multinationals can reduce the tax burden on a relevant fraction of their economic rents. The corporate production process, however, does not only involve administration of intangible assets. These companies also have to decide on where to set up R&D facilities and final output production for consumers. This study contributes to better understand the particularities of tax decision-making in R&D intensive multinational firms. In particular, we focus on the allocation of management and control functions to the tax department, adding a new facet to the literature dealing with the interrelationship between tax decision-making and organizational architecture.

Using data from a confidential survey taken in 2012 of 47 top financial and tax managers of very large multinational companies, we develop and test a theory, based on the organizational design literature, for the intensity in which the tax department coordinates with managers from other business units to intervene with real investment decisions. According to organizational design theory, the optimal allocation of decision rights to managers inside the firm is determined by coordination costs that are incurred when centralization of management and control is high and the costs of autonomy that arise when management and control are exercised separately. We argue that this coordination problem also drives the choice of whether the tax department serves a controlling function or whether, instead, it acts more as a manager. We consider R&D intensity to be an important determinant of both the costs of coordination and the costs of autonomy. First, there is high pressure in R&D intensive industries to keep the time to market short and coordination costs in form of time delays associated with coordination between business units are very high.

[22] The results from the ordered probit estimation are not tabulated but available from the authors upon request.

Second, costs of autonomy are low in R&D intensive firms as tax-inefficiencies from autonomous decision-making without involvement of tax experts can be reversed by separating and tax-optimally allocating intangibles within the multinational group.

We indeed document supporting evidence that in R&D intensive multinational firms the tax department operates more as a controller than as a manager. In particular, tax departments of R&D intensive firms make less tax planning effort, are less ambitious to minimize the tax burden of the firm, are later involved in the decision-making process of a new investment project, but are more likely to have a veto right in the decision on a new investment project as compared to less R&D intensive firms. Conditional on R&D intensity, however, the level of intangible assets in the firm is associated with more tax planning efforts and ambitions. Our results are statistically significant and robust towards several sensitivity checks.

We acknowledge that our findings can only be considered a *first piece* of evidence due to the qualifications associated with small sample surveys. However, this first piece of evidence is important as it represents another illustration of the association between organizational design theory and the integration of the tax function in the hierarchical structure of firms. In this sense, we take another important step towards unraveling the black box of tax avoidance. Opening further parts of this black box is urgently required in view of the OECD's and the G20's major initiative to restrain what they call base erosion and profit shifting (BEPS) (OECD, 2013a,b). Understanding the intentional and unintentional consequences of profit shifting restrictions requires a good understanding of the tax planning mechanisms inside multinational firms and how these interact with business decision processes.

Table 3.15: Robustness Check: Industry Fixed Effects

	Efforts		Ambitions		Temp. Inv.		Rights	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RDINT	-3.519***	-3.549***	-9.327***	-9.663***	-6.157*	-6.254*	7.272***	7.375***
	(0.780)	(0.813)	(1.771)	(2.052)	(3.125)	(3.179)	(2.231)	(2.333)
IPINT		0.058		0.977*		0.282		-0.298
		(0.174)		(0.568)		(0.605)		(0.594)
SIZE	0.015	0.017	-0.089	-0.074	0.088	0.092	0.100	0.096
	(0.013)	(0.015)	(0.079)	(0.074)	(0.076)	(0.078)	(0.076)	(0.081)
ROA	-0.264	-0.262	-1.642**	-1.608**	0.822	0.832	0.642	0.632
	(0.172)	(0.179)	(0.733)	(0.697)	(0.913)	(0.911)	(0.842)	(0.877)
LEV	-0.008*	-0.008*	-0.046***	-0.043***	0.029	0.030	0.070***	0.069***
	(0.004)	(0.004)	(0.015)	(0.015)	(0.020)	(0.020)	(0.014)	(0.014)
GROW	0.306**	0.310**	-0.156	-0.095	0.549	0.567	1.275***	1.256***
	(0.116)	(0.121)	(0.310)	(0.303)	(0.359)	(0.357)	(0.346)	(0.347)
INVINT	0.200	0.241	-1.006	-0.391	0.517	0.694	-1.236	-1.424
	(0.509)	(0.560)	(1.074)	(1.180)	(1.623)	(1.609)	(1.460)	(1.567)
CAPINT	0.158	0.140	0.210	0.107	-1.275	-1.304	-0.377	-0.345
	(0.185)	(0.213)	(0.655)	(0.663)	(0.955)	(0.956)	(0.855)	(0.858)
AGE	-0.046	-0.050	0.042	-0.011	0.032	0.016	0.208**	0.224**
	(0.030)	(0.037)	(0.079)	(0.106)	(0.122)	(0.121)	(0.090)	(0.106)
Constant	0.158	0.128	3.322**	2.912*	-1.038	-1.156	-2.012	-1.887
	(0.345)	(0.383)	(1.600)	(1.539)	(1.695)	(1.750)	(1.674)	(1.777)
Industry Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Observations	39	39	41	41	42	42	42	42
R-squared	0.627	0.628	0.630	0.672	0.541	0.544	0.564	0.567

Notes: All regressions are based on OLS estimation. While the dependent variable 'efforts' is a proportion, the variables 'ambitions', 'temporal involvement' and 'rights' are binary variables. The dependent variable 'efforts' (specification (1) and (2)) represents the workload spent on tax planning relative to total workload; 'ambitions' (specification (3) and (4)) is 1 if tax minimization is an important or very important objective of the tax department, and 0 otherwise; 'temporal involvement' (specification (5) and (6)) is 1 if the tax department gets involved early or even very early in the initiation phase of the decision process, and 0 otherwise; 'rights' (specification (7) and (8)) is 1 if the tax department has strong or even veto rights in the decision process. The four dimensions are regressed on firm characteristics, which are R&D intensity (RDINT), firm size (SIZE), profitability (ROA), leverage (LEV), firm growth (GROW), inventory and capital intensity (INVINT and CAPINT), age of the tax department (AGE) and industry dummy variables. Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Heteroscadasticity robust standard errors are in parentheses.

Table 3.16: Robustness Check: Compensation

	Efforts		Ambitions		Temp. Inv.		Rights	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RDINT	-2.211**	-2.641***	-5.151	-7.251**	-4.553*	-4.020	4.915*	6.288**
	(0.820)	(0.699)	(3.305)	(2.762)	(2.612)	(2.890)	(2.844)	(2.769)
IPINT		0.306**		1.475**		-0.375		-0.964**
		(0.131)		(0.577)		(0.557)		(0.402)
SIZE	0.028*	0.026*	-0.031	-0.042	0.031	0.034	0.079	0.087
	(0.016)	(0.013)	(0.061)	(0.058)	(0.070)	(0.070)	(0.069)	(0.065)
ROA	-0.041	-0.068	-1.224*	-1.351**	0.733	0.765	0.354	0.437
	(0.119)	(0.107)	(0.639)	(0.578)	(0.903)	(0.930)	(0.783)	(0.781)
LEV	-0.006	-0.005*	-0.042***	-0.040***	0.023	0.022	0.061***	0.059***
	(0.004)	(0.003)	(0.013)	(0.012)	(0.015)	(0.015)	(0.013)	(0.013)
GROW	0.385***	0.392***	0.037	0.074	0.679**	0.670**	0.864***	0.841***
	(0.088)	(0.078)	(0.345)	(0.333)	(0.282)	(0.291)	(0.274)	(0.271)
INVINT	0.377	0.471*	-0.829	-0.387	-0.656	-0.768	-1.237	-1.526
	(0.345)	(0.232)	(1.200)	(1.065)	(1.118)	(1.157)	(1.181)	(1.217)
CAPINT	-0.050	-0.075	0.315	0.198	-0.962	-0.933	-0.026	0.050
	(0.213)	(0.206)	(0.618)	(0.616)	(0.728)	(0.731)	(0.660)	(0.603)
AGE	-0.072*	-0.076***	-0.099	-0.119	0.094	0.099	0.224**	0.237***
	(0.035)	(0.024)	(0.087)	(0.096)	(0.122)	(0.117)	(0.087)	(0.081)
COMP	0.004	-0.037	0.349**	0.151	-0.122	-0.072	-0.146	-0.016
	(0.062)	(0.071)	(0.146)	(0.165)	(0.233)	(0.241)	(0.250)	(0.276)
Constant	-0.122	-0.096	2.064	2.213*	-0.106	-0.143	-2.165	-2.262
	(0.293)	(0.270)	(1.399)	(1.274)	(1.472)	(1.498)	(1.607)	(1.514)
Observations	37	37	39	39	39	39	39	39
R-squared	0.440	0.513	0.325	0.473	0.292	0.301	0.345	0.399

Notes: All regressions are based on OLS estimation. While the dependent variable 'efforts' is a proportion, the variables 'ambitions', 'temporal involvement' and 'rights' are binary variables. The dependent variable 'efforts' (specification (1) and (2)) represents the workload spent on tax planning relative to total workload; 'ambitions' (specification (3) and (4)) is 1 if tax minimization is an important or very important objective of the tax department, and 0 otherwise; 'temporal involvement' (specification (5) and (6)) is 1 if the tax department gets involved early or even very early in the initiation phase of the decision process, and 0 otherwise; 'rights' (specification (7) and (8)) is 1 if the tax department has strong or even veto rights in the decision process. The four dimensions are regressed on firm characteristics, which are R&D intensity (RDINT), firm size (SIZE), profitability (ROA), leverage (LEV), firm growth (GROW), inventory and capital intensity (INVINT and CAPINT), age of the tax department (AGE) and compensation of tax executives (COMP). Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Heteroscadasticity robust standard errors are in parentheses.

Table 3.17: Robustness Check: Probit Estimation Model

	Ambitions		Temp. Inv.		Rights	
	(1)	(2)	(3)	(4)	(5)	(6)
RDINT	-3.692	-31.701***	-4.116**	-3.882**	5.354***	6.615***
	(2.348)	(11.304)	(1.927)	(1.957)	(2.072)	(2.325)
IPINT		11.073***		-0.388		-0.814*
		(3.448)		(0.389)		(0.489)
SIZE	-0.037	-0.331***	-0.006	0.008	0.023	0.044
	(0.062)	(0.107)	(0.052)	(0.055)	(0.051)	(0.055)
ROA	-2.082*	-5.264***	0.862	0.712	0.946	0.734
	(1.217)	(1.628)	(0.727)	(0.732)	(0.633)	(0.662)
LEV	-0.607	-0.727	0.542	0.378	0.723*	0.451
	(0.527)	(0.597)	(0.480)	(0.518)	(0.417)	(0.519)
GROW	0.677	1.859***	0.852	0.779	1.277**	1.150**
	(0.902)	(0.677)	(0.612)	(0.545)	(0.578)	(0.566)
INVINT	-0.693	0.307	-0.900	-0.975	-1.222	-1.345
	(0.918)	(0.748)	(0.590)	(0.628)	(0.910)	(0.847)
CAPINT	0.813	-0.376	-0.855	-0.934	0.371	0.514
	(0.658)	(0.382)	(0.523)	(0.578)	(0.438)	(0.453)
AGE	-0.039	-0.792***	0.084	0.086	0.180***	0.221***
	(0.090)	(0.296)	(0.068)	(0.065)	(0.060)	(0.073)
Observations	41	41	42	42	42	42

Notes: The table presents average marginal effects for non-linear probit estimations. The dependent variables 'ambitions', 'temporal involvement' and 'rights' are binary variables. The dependent variable 'efforts' (specification (1) and (2)) represents the workload spent on tax planning relative to total workload; 'ambitions' (specification (3) and (4)) is 1 if tax minimization is an important or very important objective of the tax department, and 0 otherwise; 'temporal involvement' (specification (5) and (6)) is 1 if the tax department gets involved early or even very early in the initiation phase of the decision process, and 0 otherwise; 'rights' (specification (7) and (8)) is 1 if the tax department has strong or even veto rights in the decision process. The four dimensions are regressed on firm characteristics, which are R&D intensity (RDINT), firm size (SIZE), profitability (ROA), leverage (LEV), firm growth (GROW), inventory and capital intensity (INVINT and CAPINT) and age of the tax department (AGE). Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Heteroscadasticity robust standard errors are in parentheses.

Chapter 4

Corporate Taxation and the Quality of Research and Development*

4.1 Introduction

In recent decades, corporate tax policies related to research and development have been high on governments' agendas in many countries. While, traditionally, tax incentives to foster R&D investment have been provided in the form of special tax allowances and tax credits, several countries recently also lowered their tax rates on patent income, including, among others, Luxembourg, the Netherlands and Belgium. Another addition to the list is the United Kingdom, which reduced its tax rate on patent income from 23% to 10% in April 2013 with the intention 'to strengthen the incentives to invest in innovative industries and ensure [that] the UK remains an attractive location for innovation'.[1]

The economic literature argues that R&D tax incentives, irrespective of their particular design, increase inefficiently low R&D investments in the private sector, as they internalize positive externalities of technological inventions on other agents in the economy (Nadiri, 1993).[2] On top, R&D tax incentives may be instrumental in

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[1] See paragraph 4.40 of Her Majesty's (HM) Treasury, Pre-Budget Report 2009, December 2009. The UK regime will be phased in over four years. In 2013, companies were only entitled to 60% of the full benefit, which will increase to 70%, 80%, 90% and 100% in subsequent years (Evers et al., 2014).

[2] Empirical evidence confirms that the social returns to R&D substantially outweigh their private returns (see for example Griliches, 1994; Jones and Williams, 1998; Griffith et al., 2004).

attracting internationally mobile R&D activities from abroad. A number of empirical studies assessed the effect of special tax provisions on the quantity of R&D activities, commonly reporting significant and sizable effects for both, R&D tax allowances/credits and low patent income tax rates (for example Hines and Jaffe, 2001; Bloom and Griffith, 2001; Bloom et al., 2002; Ernst and Spengel, 2011; Karkinsky and Riedel, 2012).

The purpose of this study is to analyze the impact of R&D tax incentives on the *quality* of R&D projects. We account for two quality dimensions: the project's profitability before taxes and subsidies and its degree of innovation. As will be shown, project profitability and innovativeness are positively correlated, i.e. high private returns go hand in hand with high levels of innovation, which in turn trigger high social returns through technological spillovers on other agents in the economy.

Our empirical analysis will account for the impact of R&D tax incentives, as captured by the average and marginal effective tax rates, on project quality. At the extensive margin (i.e. if MNEs are capacity constrained and decide on the location of a fixed number of R&D projects), MNEs have an incentive to distort the location of projects with a high expected profitability towards entities with a low average effective tax rate. In particular, conditional on the projects' expected future income and the expected corporate tax rates at potential hosting entities, MNEs may strategically distort the location of their new R&D projects. Changes in expected project value and corporate tax rates may also trigger relocations of ongoing R&D projects (although the latter may involve non-negligible relocation costs).[3] As R&D is well-known to earn above average returns (for example Hall et al., 2010), we will proxy for the average effective tax burden by the patent income tax rate (as the average effective tax converges to the patent income tax if profitability is high, see Devereux and Griffith (2003)).[4] Generous R&D tax credits and allowances are, in a very general sense, not expected to be instrumental in attracting a positive selection

[3]Note that recent survey evidence suggests that the average duration of R&D projects until the patent application is rather short, less than two man-years in the large majority of cases (see Nagaoka and Walsh, 2009). As tax reforms are commonly announced months or even years in advance, MNEs that decide on the location of R&D projects and form rational expectations on future tax rates likely obtain a quite precise predictor for the tax burden on the future income stream from the projects. The introduction of the UK patent box regime in 2013 was, e.g., announced in 2009 already. A number of companies declared to boost investment activity in the UK after the government announcement (see e.g. GlaxoSmithKline's press release on November 29, 2010: http://www.gsk.com/media/press-releases/2010/government-patent-box-proposals-transform-uk-attractiveness-for-investment.html). On top, besides the relocation channel spelled out in the main text, the quality of R&D projects may respond to changes in corporate taxation since high corporate taxes reduce the incentive to exert effort and may thus lower the quality of R&D. This applies for owner-managers as well as for dependent employees if the latter own shares or stock options in the company or owners adjust incentive contracts in response to tax changes.

[4]While most countries tax patent income at the statutory corporate tax rate, some implemented special low tax rates on patent income (see also Section 4.2.3).

of highly profitable projects since their value to the firm depends on the size of R&D expenditures instead of expected earnings.[5]

At the intensive margin, low patent income taxes and special R&D tax allowances/credits may induce a genuine increase in the R&D activity undertaken in a country by reducing project costs. With a downward sloping marginal product curve, the new projects have a lower profitability though and thus the average profitability (and in consequence also the average innovativeness) of the project pool is expected to decrease. Our empirical analysis will model the marginal effective tax burden on R&D by the so-called B-index which accounts for R&D tax credits/tax allowances as well as for the country's corporate income tax rate.

The theoretical considerations show that low patent income taxes and generous R&D tax allowances/tax credits may exert very different effects on the average profitability and innovativeness of R&D projects. Taken together, we expect that an expansion of R&D tax allowances/credits reduces the average profitability of projects undertaken in a country, while effects related to low patent income tax rates are theoretically ambiguous. As project profitability and innovativeness are positively correlated, the argumentation furthermore carries over to the R&D's degree of innovation. See also our theoretical discussion in an earlier working paper version (Ernst et al., 2013).

To empirically assess the link between R&D tax incentives and R&D quality, we exploit information on the universe of patent applications to the EPO between 1995 and 2007 which is drawn from the PATSTAT data base. To proxy for the earnings potential and innovativeness of the technology protected by the patent, we follow previous research and exploit three indicators: the patent's number of forward citations, its family size (i.e. the number of countries in which the corporation filed for patent protection) and the number of industry classes stated on the patent. The patent information is moreover linked to data on multinational firms in Europe that allows us to control for observed and unobserved heterogeneity across patent inventing affiliates. On top, the data is augmented by information on national R&D tax incentives. We further include information on the effective patent income tax rate, which accounts for taxes levied on patent income in the royalty receiving country as well as for withholding taxes levied in the royalty paying country in case of cross-border royalty streams and the unilateral and bilateral method to avoid double taxation. Moreover, we follow the existing literature and construct the B-index that accounts for special R&D tax allowances and R&D tax credits.

[5] Since tax authorities commonly do not grant tax refunds, this holds true as long as affiliate profits are high enough to ensure the affiliate can exploit the full value of the tax allowance/credit. If the value of the tax allowance/credit exceeds profits, incentives to select high-value R&D projects to countries with attractive R&D tax credit and allowance schemes may prevail. See Ernst et al. (2013).

Our results suggest that patent income taxation exerts a significantly negative effect on average patent quality. Quantitatively, we find that a decrease in the patent income tax rate (which proxies for the average effective tax rate) by 10 percentage points raises patent quality by around 1-5%. This result prevails in a number of sensitivity checks which control for observed and unobserved heterogeneity in patent quality across industries, countries and firms. The B-index (which captures the tax burden on marginal investment) in turn exerts a negative effect on patent quality. Consequently, while both R&D tax allowances/credits and low patent income taxes raise R&D quantity (as shown by previous research), our analysis suggests that their impact on project quality differs substantially: while low patent income taxes raise average project quality, generous R&D tax allowances/credits tend to reduce it.

The study contributes to several strands of the economic literature. First, it directly relates to papers which assess the impact of R&D tax incentives on R&D expenditure. For the US, Hall (1993) and Hines (1994) study the responsiveness of corporate R&D to the Research and Experimentation Tax Credit and find significant R&D price elasticities. Similarly, Hines and Jaffe (2001) determine how US R&D expense deduction rules affect the location of R&D by US multinationals. Bloom et al. (2002) confirm a significantly positive effect of R&D tax credits on the level of R&D expenditures using macro data for major OECD countries (for survey papers on the topic see also Hall and Van Reenen, 2000; Arundel et al., 2008).[6] Second, Griffith et al. (2014), Ernst and Spengel (2011) and Karkinsky and Riedel (2012) find a negative effect of patent income taxes on the number of corporate patent applications.

Our study adds to the sketched literature by stressing that tax provisions for patent income may not only impact on the quantity of R&D and patent holdings but also on their quality. In this sense, the study is related to recent contributions that emphasize the importance of quality aspects in assessing the welfare consequences of corporate taxation. Becker and Fuest (2007) and Becker and Riedel (2012) criticize that conventional studies solely focus on the effect of corporate taxes on the quantity of capital investment. The welfare effects of the investment, however, critically depend on the number of jobs created, the associated profit and tax revenue base, and the project's innovativeness. Our results confirm the importance of this argumentation.

The Chapter is structured as follows: Sections 4.2 and 4.3 describe our data set and estimation methodology. The results are presented in Section 4.4 and Section 4.5 concludes.

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[6] In a recent paper, Ernst and Spengel (2011) report some impact of R&D tax incentives on the number of corporate patent applications. Buettner and Wamser (2009) find positive effects of R&D tax incentives on the volume of FDI of German multinationals.

4.2 Data

In order to assess the link between R&D tax incentives and project quality, the empirical analysis merges information on corporate innovative activities as captured by patent data to information on R&D tax incentives in Europe.

4.2.1 Patent and Firm Data

To proxy for R&D activity, we will make use of the universe of patent applications to the EPO drawn from the PATSTAT data base. Firms seeking patent protection in a number of European countries may file an application directly at the EPO and designate the relevant national offices in which protection is sought.[7] Filing a patent with the EPO firstly enables a firm to make a single application, which is cheaper than filing separately in each national office, and, secondly, allows the firm to delay the decision over which national states to further the application in.

The data includes information on the patent applicant and inventor, the technology of the patent and patent citations. The right to patent an invention belongs to the inventor or to anyone who by law or contract is entitled to file the application (Muir et al., 1999). Commonly the employer is entitled to file an application for an invention made by an employee. In these cases, the employer is the applicant and legal owner of the technology and consequently also the relevant subject for taxation (Quick and Day, 2006; Ernst and Spengel, 2011)[8] while the employee has to be listed as the inventor on the application.[9]

Note that in most cases (more than 90% of the patent applications), inventor and applicant are located in the same country. As recent papers suggest that multinational firms can set up structures which allow them to geographically split the location of inventor and patent applicant in order to shift income to low-tax countries (see for example Boehm et al., 2012), we drop the according patents from our analysis and focus on the 'standard' case where the inventing unit and the patent owner are located in the same country.

The PATSTAT data base comprises patent applications for the years 1978 to 2007. In the analysis to come, we will account for patent applications from 1995 onwards

[7]The EPO is not a body of the European Union and, as a result, the states which form part of the European Patent Convention (the legal basis for the EPO) are distinct from those in the European Union. See: http://www.epo.org/about-us/epo/member-states.html.

[8]Note, however, that in some countries the principle of economic ownership applies, implying that legal and economic owner may diverge. In such cases, information on the legal owner can be used as a proxy for the party that will eventually be subject to taxation only.

[9]The employer can also transfer ownership of the invented technology to the employee who may then file for patent protection. We consider these cases to be rare events though as firms do not have an incentive to waive ownership of a technology that is expected to earn positive income.

Table 4.1: Country Statistics

Country	Number of Patents	Country	Number of Patents
Austria	3,127	Hungary	166
Belgium	2,217	Ireland	331
Bulgaria	9	Italy	11,886
Switzerland	8,495	Lithuania	1
Czech Republic	75	Netherlands	8,080
Germany	74,620	Norway	969
Denmark	2,536	Poland	53
Spain	1,453	Portugal	70
Finland	3,788	Romania	2
France	23,842	Sweden	6,805
Great Britain	12,145	Slovenia	50
Greece	60	Slovakia	10
Total			160,790

Notes: The table shows the country coverage for our sample of EPO patent applications, which we obtained from the PATSTAT database.

as our tax and firm data is restricted to that period and limit the sample to patents that were eventually granted. Furthermore, we merge the patent information to the European firm-level data base AMADEUS provided by Bureau van Dijk. The link between the data bases is achieved through standard name matching procedures.[10] Success rates of that procedure are comparable to previous studies (Thoma et al., 2010). On average around 67% of the patents in our data are matched over all sample years and countries. For more details on the matching procedure, see Ernst and Spengel (2011). The match rates for the five largest EU countries by population are 47% for Spain, 55% for France, 68% for Germany, 63% for Italy and 72% for the United Kingdom. Table 4.1 presents host country statistics for the patent applications in our data.

4.2.2 Construction of the Patent Quality Indicators

As described above, the purpose of this study is to assess the effect of the design of the corporate tax system on the quality of R&D projects. In the following, project quality is proxied by the quality of patents invented in a country (see Section 4.4 for a discussion of this approach) as determined by a factor analysis.[11] In line with previous research, the factor model accounts for three separate indicators of the patent's underlying, latent quality: the patent's forward citations, its family size and the number of technical fields. The estimates of the factor model can be used

[10]Following previous efforts (Abramovsky et al., 2008), the name of the AMADEUS firm was matched to the name of the applicant on the patent application. Note that corporations may take on the role as patent applicant, while patent inventors are necessarily non-corporates.

[11]See Hall et al. (2007). We are grateful to Grid Thoma for providing us with this data.

to construct an estimator for patent quality conditional on the indicators. In the following, we will give a brief description of the information employed to derive the quality index. For more details on this approach see Lanjouw and Schankerman (2004) and Hall et al. (2007).

Following previous studies, we consider the patent's family size, i.e. the number of jurisdictions in which the firm has filed for patent protection, to be a good proxy for the patent's expected earnings potential. In particular, as filing for patent protection involves considerable costs (Helfgott, 1993), it only pays for a firm to protect its invention in many markets if the expected earnings potential is sufficiently large. The number of forward citations received by a patent within the five year period from the publication date, in turn, serves as a proxy for the invention's innovativeness as it indicates whether the technology is the basis for future inventions.[12] Last, the construction of the patent quality index also accounts for the number of technological classes named on the patent which have been shown by previous research to be an indicator of technological quality (Lerner, 1994).[13]

Several authors have also stressed that the value of patents varies across industries and across time. To account for that, we follow previous studies (Hall et al., 2007) and use quality measures that control for technology and year fixed effects (which is not decisive for our results though). Descriptive statistics for the quality measures are presented in Table 4.2. The composite quality index (CQI) accounts for all three quality dimensions (forward citations, family size and industry classes) and controls for technology and year fixed effects. The average index is approximately 0, varying strongly between -2.5 and $+7.3$. There is also substantial cross-sectional and longitudinal variation of the average patent quality across countries and firms as can be seen from Table 4.2.[14] Accordingly, the average quality index varies across countries from $-.3561$ to $.1471$ with a standard deviation of 0.1707. The average variation within countries as measured by the standard deviation of the composite quality index within a single country is approximately 0.6791. On average, 5.9

[12]Forward citations have an important legal function in the sense that they limit the scope of property rights which are awarded to a patent. In the case of EPO patents, inventors are not required to cite prior technology used in the development of their patent but the references are added by patent examiners. On the one hand, this implies that not necessarily all innovations which draw on an existing patent in fact acknowledge the reference. On the other hand, an external patent examiner has the benefit of following a consistent and objective patent citation practice.

[13]For the purpose of guaranteeing a reasonable level of precision, the construction of the quality measures accounts for an eight-digit international patent classification (IPC) reported in the patent document.

[14]Note that we do not observe any changes in the quality of a particular patent over time. The analysis, in turn, will focus on changes in the average quality of the *pool* of patent applications. Furthermore note that our data allows us to identify the location of the technology inventor at the time of the patent application only. If an ongoing R&D project was relocated (in response to tax incentives), we do not observe the original location in our data.

Table 4.2: Descriptive Statistics

Variable	# Obs.	Mean	Median	Min.	Max.
Composite Quality Index	160,790	-.1958	-.2494	-2.5289	7.2887
Mean - Between Countries	24	-.1076	-.1629	-.3561	.1471
Mean - Between Countries-Years	245	-.0818	-.0509	-1.2632	.6923
Mean - Between Affiliates	38,832	-.2913	-.3263	-2.3226	5.4258
Stand. Dev. - Within Countries	23	.6791	.6889	.3450	.8585
Stand. Dev. - Within Countr.-Y.	233	.6496	.6574	.0235	1.387
Stand. Dev. - Within Affiliates	14,501	.4329	.4070	.000	2.5738
Quality Index - Forward Citations	160,790	-.2769	-.3026	-2.3566	7.2058
Quality Index - Family Size	160,790	-.0801	-.1349	-1.7970	5.2683
Patent Income Tax	160,790	.3904	.3829	.0	.59
B-index	112,058	.9944	1.029	.428	1.069
GDP	160,790	1.55e+12	1.80e+12	1.27e+10	2.90e+12
GDP pC	160,790	26,128.32	25,913.16	5,365.83	51,862.42
Polity2	160,790	9.8513	10	8	10
TPI Corruption Index	160,790	7.6987	7.9	2.9	10
Total Assets (in million US dollars)	25,896	6,732.671	232.1615	0.001	128,568

Notes: The Composite Quality Index is a measure for patent quality derived from a factor model accounting for the patent's forward citations, its family size and the number of industry classes (conditional on industry and year fixed effects). The Forward Citations (Family Size) Index is an analogous measure which accounts for the number of forward citations (family size) of the patent only. Patent Income Tax stands for the statutory tax rate on patent income. The construction of the B-index follows Equation (2) in Section 3. GDP and GDP pC depict the host country's gross domestic product and gross domestic product per capita respectively in US dollars. The polity2 index captures information on concomitant qualities of democratic and autocratic authority in governing institutions. The polity2 index varies from -10 (strongly autocratic) to +10 (strongly democratic). TPI Corruption Index stands for the Transparency International corruption perception index which ranges from 0 (high corruption) to 10 (absence of corruption). Total assets depicts the total assets of the patent-filing firm in in millions of US dollars.

patents are held per affiliate. Where an affiliate holds more than one patent, the average variation of the quality index within one affiliate is 0.4329.

The separate quality indices for forward citations and family size exhibit a similar distribution. Furthermore note that the family size and forward citation indices are positively correlated (correlation coefficient 0.34, statistically significant at 1% level), which suggests that, on average, a high level of innovativeness (as measured by the forward citation index) goes along with a high earnings potential (as measured by the family size index).

4.2.3 Corporate Taxation

As described above, our analysis will assess the effect of the corporate tax system on patent applications, accounting for two types of tax incentive instruments: the (output-based) patent income tax rate and (input-based) tax credit and allowances measures.

Information on the patent income tax in the host country of the patent applicant is obtained from Ernst and Young's corporate tax guides, the International Bureau of Fiscal Documentation's country analyses and other sources. Most countries tax patent income at the same rate as other corporate income. In recent years, a growing number of countries have, however, introduced special low tax rates on patent income (e.g. Belgium, Luxembourg and the Netherlands). While many of these special provisions were introduced after 2007 and are, thus, not reflected in our data, our tax measure accounts for special tax provisions where applicable. In particular, during our sample period France implemented a special low tax rate on patent income of 19% in 2000 (standard corporate tax rate: 33%) which was then, in a second reform, lowered to 15% in 2005. Ireland furthermore exempted patent income altogether during our whole sample period and Hungary enacted a patent box regime in 2003 which reduced the tax rate on patent income to 9.5%. Finally, the Netherlands enacted a special low patent income tax rate of 10% in 2007 (see also Evers et al., 2014). Since the analysis to come will account for the sketched cases, we refer to the tax parameter as *patent income tax rate* instead of corporate income tax rate.

The average tax rate applicable to the patents in our data is 39%, varying strongly between 0% and 59%. The high average rate reflects that many patents in our data are filed from large economies, like Germany, which also charged high tax rates on corporate income within our sample period. Furthermore note that the patent income tax rate exhibits significant variation over time (within standard deviation of .062). Precisely, our sample period saw 15 major reductions in the patent income tax rate (or corporate income tax rate respectively) of 5 percentage points or more (in the countries of Austria (2005), Belgium (2003), Bulgaria (2007), Germany (2001), France (2000), Hungary (2003), Italy (1998), Lithuania (2002), Netherlands (2007), Poland (2004), Portugal (2004), Romania (2000 and 2005) and Slovakia (2000 and 2004)). There were moreover numerous smaller adjustments in the patent income tax rate.

Yet, using this statutory tax rate as a measure for the tax burden on patent income disregards that several countries additionally levy a so-called withholding tax on royalty payments from their border. In case of cross-border royalty streams, patent income is, thus, not only taxed in the country that receives the royalty income but may also be taxed in the royalty paying country. Withholding tax rates are commonly determined in bilateral double taxation agreements between countries. The according information is retrieved from recent and historic bilateral tax treaties and from Ernst and Young's corporate tax guides. To avoid double taxation, royalty receiving countries commonly grant a tax credit for withholding taxes paid on the royalty income.[15] Thus, the effective tax rate t_e on a cross-border royalty stream is the maximum of the royalty income tax rate t_k in the patentee's host country k and the royalty withholding rate tw_{jk} charged on royalty streams from a country j to country k: $t_e = max(t_k, tw_{jk})$.

To determine the average tax on royalty income related to a particular patent, we have to make assumptions on the structure of royalty streams received by a patent owner. In a first step, we assume that the pattern of the royalty stream corresponds to observed aggregate bilateral royalty payments. However, as the quality and earnings potential of a patent may impact on the structure of royalty payments, using bilateral royalties for the construction of the effective tax measure may give rise to endogeneity concerns in the empirical analysis to come. We will therefore alternatively assume that the relative size of the royalty streams corresponds to the countries' size distribution as measured by the countries' GDP. This assumption reflects that production and sales activities are plausibly positively correlated with market size and, thus, trigger higher payments for the use of the protected invention. Alternatively, we will proxy for the pattern of royalty streams related to a patent by exploiting information on the patent offices where the firm filed for patent protection for the technology. The underlying rationale is that sales through affiliates in these markets will trigger royalty and license payments to the patent owner. Formally, the definition of the effective tax rate reads

$$t_e = \sum_{j=1}^{J} W_j \cdot max(t_k, tw_{jk}) \tag{4.1}$$

where j indicates the host country of the royalty paying party and tw_{jk} depicts the respective royalty withholding rate charged on royalty income paid from country j to the patentee's host country k. W_j stands for the weighting matrix. If W_j is constructed based on the relative size of aggregate bilateral royalty payments and the countries' GDP distribution respectively, the effective tax measure accounts for partner countries in EU27 and major non-EU countries, namely Australia, Canada, China, Switzerland, Japan and the US.[16] If royalty streams are modelled by information on the patent family, W_j is a uniform weighting scheme and the number of partner countries accounted for in the construction of t_e is the subset of the EU27 and major non-EU countries named above where the firm filed for patent protec-

[15] There were a few exceptions to the credit method. If no double tax treaty was in force for a specific country in a specific year (especially in the 1990ies) the unilateral method to avoid double taxation was applied to calculate the effective income tax rate, e.g. deduction of the foreign withholding tax.

[16] The information on annual bilateral royalty payments used for the construction of the index was obtained from the International Monetary Fund. Information on countries' GDP was obtained from the World Development Indicators Database.

tion.[17]

Another alternative way to construct the effective tax measure is to exploit information on the structure of multinational corporations in our data. Precisely, inventions protected by corporate patents are often exploited within the boundaries of the multinational firm only to avoid knowledge dissipation to competitors (Zuniga and Guellec, 2009). We thus reconstruct t_e assuming that royalties are paid to the patentee from all other firms belonging to the multinational group. Ideally, following the above logic, one might want to weigh the information by affiliate size. As size information is missing for a relatively large number of cases in the AMADEUS data base though,[18] we follow previous studies (Dischinger and Riedel, 2011) and construct an unweighted average $t_e = \sum_j \frac{1}{J} \cdot max(t_k, tw_{jk})$ where j indicates each of the J other affiliates within the multinational group (apart from the patenting affiliate), including the parent firm, and tw_{jk} again denotes the withholding tax rate charged by their host country on royalty payments to the patentee. As sketched in the introductory section, for highly profitable investments, the effective tax rate on patent income converges against the average effective tax rate.

Following previous work, we moreover construct the so-called B-index which captures the tax component in the costs of an R&D investment (Warda, 2002; Guellec and van Pottelsberghe de la Potterie, 2003), accounting for special tax allowances and credits, and serves as a measure for the tax burden on marginal R&D investment. Formally,

$$B_k = \frac{1 - Z_k \cdot t_k}{1 - t_k} \tag{4.2}$$

where t_k stands for the corporate income tax rate in country k and Z_k represents a measure for the deductibility of R&D expenditures, including tax allowances or tax credits granted for R&D investments. The numerator reflects the after-tax cost of one unit of expenditure in R&D and the B-index consequently captures the minimum pre-tax earnings required for the project to break even and to go ahead. If an R&D

[17] Note that, as our main data set comprises patent applications to the European patent office, the construction of t_e assumes that the firm filed for patent protection in all countries that were members of the European Patent Office in the year of the patent application. For our first sample year 1995, this comprises the countries of Austria, Belgium, Switzerland, Germany, Denmark, Spain, France, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Sweden. Countries that became members during our sample period are: Bulgaria (2002), Cyprus (1998), Czech Republic (2002), Estonia (2002), Finland (1996), Hungary (2003), Island (2004), Lithuania (2004), Latvia (2005), Malta (2007), Poland (2004), Romania (2003), Slovenia (2002) and Slovakia (2002). Furthermore note that royalties paid from parties in the host country of the patentee itself are also accounted for in the construction of t_e, in the cases where the weighting matrix reflects the country size distribution and the construction is based on the patent offices where the firm filed for patent protection. It holds $tw_{jk} = 0$ if $j = k$.

[18] Note that AMADEUS contains ownership information on a worldwide basis. For most subsidiaries and parents outside Europe, accounting information which allows to proxy for subsidiary size is not available though.

investment can be fully expensed in a fiscal year, the B-index is equal to one since Z_k equals one. A tax incentive, granting for example an additional deduction on top of the normal deduction of R&D expenditures, reduces the value of B_k below one, as Z_k is then larger than one. Consequently, the lower the B-index the more attractive is the tax system for R&D investments and vice versa (see also Ernst and Spengel, 2011). The average B-index in our sample is .99 (comprising information for the years 1998 to 2006). The variable furthermore exhibits relevant variation over time (within standard deviation of .028). Precisely, our sample countries experienced 10 major adjustments in the B-index by more than 0.05 through the introduction or reform of R&D tax credit and allowances schemes (in the Czech Republic (2005), Spain (2000), France (2004 and 2006), UK (2002), Italy (2004), Portugal (2002, 2004, 2006) and Slovenia (2006)). Moreover, the sample period has seen numerous smaller adjustments in R&D tax incentive schemes.

4.2.4 Control Variables

Last, we augment our data by information on other country characteristics, like GDP per capita (as a proxy for economic development), the size of population (as a proxy for country size) and a corruption perception index obtained from the World Development Indicator Database and Transparency International respectively. We furthermore include information on the concomitant qualities of democratic and autocratic authority in a country's governing institutions using the so-called Polity2 Index. Note that Transparency International's corruption perception index ranges from 0 (high corruption) to 10 (absence of corruption), while the Polity 2 Index varies from -10 (strongly autocratic) to +10 (strongly democratic).

4.3 Estimation Strategy

As described above, the aim of our analysis is to identify whether the structure of the corporate tax system affects the quality of R&D projects undertaken in a country. To do so, we proxy for project quality by the patent quality indicators described in the previous section and estimate a model of the following form

$$q_{ikat} = \beta_0 + \beta_1 \tau_{kt} + \beta_2 X_{ikat} + \phi_a + \mu_t + \epsilon_{iat} \tag{4.3}$$

where q_{ikat} indicates the quality of patent i filed at time t by multinational affiliate a located in country k. The explanatory variable of main interest is τ_{kt}, which is the vector of corporate tax parameters comprising the statutory tax rate on patent income levied by the host jurisdiction of the patenting firm and the effective tax rate on patent income (which proxy for the average effective tax rate) and the B-index described in the previous section (which captures the tax burden on marginal R&D investment).

To control for time-constant heterogeneity in average patent quality across firms and industries, we moreover include a full set of affiliate fixed effects and industry fixed effects (as determined by the first industry class named on the patent) in the estimation.[19] The set of regressors is furthermore augmented by a full set of year fixed effects to absorb common shocks to patent quality which simultaneously affect all patents in the data. Additionally, we include time-varying country controls for market size (as measured by the host country's GDP), the degree of development (as measured by the host country's GDP per capita) and the country's political and governance situation (as measured by the Transparency International corruption index and the Polity2 Index). Last, we augment the vector of control variables by firm size information as measured by the affiliate's total assets to control for a potential systematic correlation between corporate taxation, firm size and patent quality.

4.4 Results

The estimation results are presented in Tables 4.3 to 4.8. The tables display the coefficient estimates and heteroskedasticity robust standard errors which are adjusted for clustering at the country-year level.

4.4.1 Baseline Results

In Specification (1) of Table 4.3, we regress the composite quality measure on the statutory tax rate levied on patent income in the host country of the patent applicant, controlling for country and year fixed effects. The coefficient estimate is negative and statistically significant, suggesting that an increase in the patent income tax rate by 10 percentage points reduces the quality index by 0.035. Evaluated at the sample mean, this corresponds to a decline by 1.5%.[20]

Specifications (2) and (3) reestimate specification (1) augmenting the vector of regressors by a full set of industry fixed effects and time-varying country controls. The inclusion of the additional control variables leaves the qualitative and quantita-

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[19] As ownership information is only available in cross-sectional format in the AMADEUS database, affiliates are assumed to not change their host location over time. Consequently, affiliate fixed effects nest host country fixed effects.

[20] As the composite quality index may take on negative values, the semi-elasticity is evaluated at the sample average of the variable plus the absolute value of the variable's minimum: $|min(CQI)| + avg(CQI) = 2.5289 - 0.1958 = 2.3331$, see Table 4.2. It follows that $0.035/2.3331 = 1.5\%$.

Table 4.3: Patent Income Tax and Patent Quality

	Composite Quality Index					Family Size		Forward Citation		Composite Quality Index		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Patent Income Tax	-0.346***	-0.377***	-0.315***	-0.448***	-0.947***	-0.333***	-0.711***	-0.316**	-0.700***			
	(0.076)	(0.074)	(0.080)	(0.110)	(0.212)	(0.073)	(0.180)	(0.136)	(0.230)			
$GDP/10^{14}$			0.594***	0.123	1.620***	0.153	1.410***	0.014	0.934*			
			(0.221)	(0.204)	(0.385)	(0.143)	(0.330)	(0.258)	(0.482)			
$GDPpC/10^{4}$			-0.119***	-0.169***	0.076	-0.071	0.112	-0.232***	-0.016			
			(0.046)	(0.065)	(0.098)	(0.046)	(0.080)	(0.080)	(0.121)			
Polity2			-0.003	0.164**	0.131**	0.134**	0.152***	0.089	-0.055			
			(0.080)	(0.081)	(0.065)	(0.053)	(0.049)	(0.102)	(0.115)			
TP Corruption Index			0.003	0.002	0.048**	-0.005	0.035**	0.015	0.044*			
			(0.010)	(0.012)	(0.020)	(0.008)	(0.017)	(0.016)	(0.025)			
Log Total Assets					-0.020**		-0.023***		-0.008			
					(0.010)		(0.007)		(0.011)			
France, year>1999										0.041**	0.083***	0.074**
										(0.016)	(0.018)	(0.031)
Industry Fixed Effects		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Country Fixed Effects	✓	✓	✓			✓		✓		✓	✓	
Affiliate Fixed Effects				✓	✓		✓		✓			✓
# Observations	160,790	160,790	160,790	116,913	25,896	116,913	25,896	116,913	25,896	113,830	30,196	22,161
R Squared	0.0720	0.1298	0.1300	0.4111	0.4657	0.5064	0.5617	0.2578	0.3233	0.1243	0.1226	0.3953

Notes: *, **, *** indicate significance at the 10%, 5% and 1% level. Heteroscedasticity robust standard errors adjusted for country-year clusters in parentheses. The dependent variable is the composite patent quality index (specifications (1) to (5) and (10) to (12)) and the family size and forward citations index respectively (specifications (6) to (9)). For details on the variable definition, see the notes to Table 4.2. Specifications (10) to (12) estimate a difference-in-difference model, compare equation (4). All specifications include a full set of year fixed effects.

tive results largely unaffected. Specification (4), furthermore, includes a full set of affiliate fixed effects which absorb any time-constant heterogeneity in the quality of R&D projects across patent inventing firms. The sample is moreover restricted to patents filed by firms that are part of a multinational group.[21] Specification (5) adds firm size as measured by the logarithm of the firm's total assets as an additional control variable. Both specifications confirm our previous findings and suggest a significantly negative impact of the patent income tax rate on patent quality. Quantitatively, specification (5) indicates that an increase in the statutory tax rate on patent income by 10 percentage points decreases the patent quality index by 0.095. Evaluated at the sample mean, this corresponds to a decline by 4.1%.[22]

As a robustness check, we further reran the analysis using the patent's number of forward citations and family size as proxies for its degree of innovation and earnings potential. The results are presented in specifications (6) to (9). Similar to the previous estimates, we find that patent taxation reduces the quality measure. An increase in the tax rate by 10 percentage points lowers the family size index and the forward citation index by around 0.07. Evaluated at the sample mean, this corresponds to a decrease by 4.1% (3.4%) (see specification (7) and specification (9) respectively of Table 4.3). To the extent that the patent's family size and forward citations serve as a proxy for the earnings potential and the degree of innovation of the underlying R&D project, the estimates thus suggest a significant reduction in the two welfare components.

As sketched in Section 4.2, our sample period saw a number of large patent income tax adjustments. Specifications (10) to (12) separately assess the effect of the largest adjustment in the patent tax rate within our sample frame which was the introduction of a special low patent income tax rate of 19% in France in 2000 (statutory corporate tax rate: 33.3% plus surcharges). Precisely, we implement a

[21]Precisely, a firm is defined to be part of a multinational group if it owns a foreign affiliate with more than 50% of the ownership shares, or is owned by a foreign parent with more than 50% of the ownership shares or is owned by a parent firm in the same country which in turn owns at least one foreign affiliate with more than 50% of the ownership shares.

[22]Note that the sample size is reduced when we restrict the sample to MNEs and augment the model by affiliate fixed effects in Specification (4) and the total asset control in Specification (5). The sample reduction in Specification (4) on the one hand reflects that not all patent applicants can be matched to firms in the Amadeus data base and on the other hand that some of the matched patents are filed by national firms. The sample reduction in Specification (5) reflects that the total asset information is missing for a relevant number of firm-year-cells. Note that the restriction to multinational firms in Specification (4) increases the absolute coefficient estimate, while the inclusion of the affiliate fixed effect reduces it. Running the model on the sample in Specification (4) but without affiliate fixed effects yields a coefficient estimate of -0.91 (significant at the 1% level). The absolute increase in the coefficient estimate in Specification (5) relative to Specification (4) is moreover driven by the sample restriction. The coefficient estimate for the sample in Specification (5) without the inclusion of the total asset control is -0.96 (significant at the 1% level).

differences-in-differences model of the following form:

$$q_{ikat} = \alpha_0 + \alpha_1 FRXPOST_{kt} + \alpha_2 X_{ikat} + \phi_k + \mu_t + \epsilon_{ikat} \tag{4.4}$$

where $FRXPOST_{kt}$ indicates patents filed in France after the reform year 2000. The definition of the other variables corresponds to Equation (4.3). Note that country and year fixed effects are included and the sample is limited to patent applications filed between 1997 and 2003, i.e. three years prior and after the reform. Specification (10) of Table 4.3 uses all other countries in our sample as control group, while specification (11) limits the control group to countries that did not experience a major adjustment in their patent income tax rate (i.e. corporate tax rate if no special tax applies for patent income) or adjusted their tax credit or tax allowance scheme. The latter control group comprises the countries of Finland, Ireland, Netherlands and Sweden. Both specifications suggest that patent quality in France increased after the year 2000 relative to the countries in the control group. As Specification (10) includes a number of countries that substantially reduced their corporate income tax rates within this period as well, it is not surprising that the coefficient estimate for the treatment effect increases when the control group is reduced to countries without a major reform in Specification (11). Quantitatively, Specification (11) suggests that average patent quality increased by 0.083, or, evaluated at the sample mean, by 3.6%. Augmenting the model by affiliate fixed effects in Specification (12) leads to a slight drop in the coefficient estimate which remains statistically significant though.

Moreover, the effective tax burden on patent income does not only depend on the statutory tax on patent income charged by the host country of the royalty recipient but may, in case of cross-border payments, be equally determined by royalty withholding taxes charged by the royalty paying country. As laid out in Section 4.3, we account for this by constructing an effective tax rate on patent income which takes both rates into account. The results are presented in Table 4.4. Specifications (1) to (6) employ an effective tax rate measure which is constructed based on the assumption that the patentee receives royalty payments from other EU and non-EU countries and that the relative size of the royalty streams matches aggregated observed bilateral royalty streams. The effective tax rate measure in specifications (7) to (12) (specifications (13) to (18)) assumes royalty payments to be determined by partner country size (the patent family). Finally, Specifications (19) to (24) employ an effective tax rate measure which is constructed based on the assumption that the patentee receives royalties from all other affiliates within the same multinational group. The results confirm our qualitative and quantitative baseline findings for the statutory patent income tax rate, irrespective of whether the composite patent quality index is used as the dependent variable or the indices reflecting forward citations or patent family size.

Table 4.4: Effective Patent Income Tax and Patent Quality

	Effective Patent Income Tax - Weights: Royalty Flows						Effective Patent Income Tax - Weights: GDP					
	Comp. Qual. Index		Family Size		Forward Citation		Comp. Qual. Index		Family Size		Forward Citation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Effective Patent Income Tax	-0.260***	-0.365***	-0.217***	-0.265***	-0.136**	-0.271**	-0.260***	-0.366***	-0.218***	-0.266***	-0.137**	-0.271**
	(0.070)	(0.096)	(0.054)	(0.064)	(0.067)	(0.118)	(0.069)	(0.096)	(0.054)	(0.064)	(0.067)	(0.119)
Country Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Industry Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Country Fixed Effects	✓		✓		✓		✓		✓		✓	
Affiliate Fixed Effects		✓		✓		✓		✓		✓		✓
# Observations	160,790	116,913	160,790	116,913	160,790	116,913	160,790	116,913	160,790	116,913	160,790	116,913

	Effective Patent Income Tax - Weights: Patent Family						Effective Patent Income Tax - Weights: MNE Group					
	Comp. Qual. Index		Family Size		Forward Citation		Comp. Qual. Index		Family Size		Forward Citation	
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Effective Patent Income Tax	-0.262***	-0.368***	-0.219***	-0.269***	-0.136**	-0.266**	-0.414***	-0.252***	-0.336***	-0.142**	-0.310***	-0.308**
	(0.069)	(0.096)	(0.054)	(0.064)	(0.069)	(0.119)	(0.090)	(0.102)	(0.072)	(0.070)	(0.105)	(0.140)
Country Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Industry Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Country Fixed Effects	✓		✓		✓		✓		✓		✓	
Affiliate Fixed Effects		✓		✓		✓		✓		✓		✓
# Observations	159,821	116,408	159,821	116,408	159,821	116,408	86,284	86,284	86,284	86,284	86,284	86,284

Notes: *, **, *** indicate significance at the 10%, 5% and 1% level. Heteroscedasticity robust standard errors adjusted for country-year clusters in parentheses. The dependent variable is the composite patent quality index (specifications (1)-(2), (7)-(8), (13)-(14), (19)-(20)) and the family size (specifications (3)-(4), (9)-(10), (15)-(16), (21)-(22)) and forward citations index respectively (specifications (5)-(6), (11)-(12), (17)-(18), (23)-(24)). For details on the variable definition, see the notes to Table 4.2. All specifications include a full set of year fixed effects and the country control variables GDP, GDPpC, Polity2 and TP Corruption Index.

Table 4.5: Clustering of Standard Errors at Different Levels

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Composite Quality Index					
Patent Income Tax	-0.315**	-0.315***	-0.372***	-0.448**	-0.448***	-0.448***
	(0.151)	(0.112)	(0.121)	(0.197)	(0.155)	(0.129)
Cluster	Ctry	Ind	Firm	Ctry	Ind	Firm
	Panel B: Family Size					
	(1)	(2)	(3)	(4)	(5)	(6)
Patent Income Tax	-0.245*	-0.245***	-0.289***	-0.333**	-0.333***	-0.333***
	(0.125)	(0.077)	(0.092)	(0.142)	(0.094)	(0.100)
Cluster	Ctry	Ind	Firm	Ctry	Ind	Firm
	Panel C: Forward Citations					
	(1)	(2)	(3)	(4)	(5)	(6)
Patent Income Tax	-0.213*	-0.213***	-0.251***	-0.316	-0.316*	-0.316**
	(0.133)	(0.141)	(0.135)	(0.190)	(0.189)	(0.144)
Cluster	Ctry	Ind	Firm	Ctry	Ind	Firm
# Observations	160,790	160,790	128,101	116,913	116,913	116,913
Country Controls	✓	✓	✓	✓	✓	✓
Industry Fixed Effects	✓	✓	✓	✓	✓	✓
Country Fixed Effects	✓	✓	✓			
Affiliate Fixed Effects				✓	✓	✓

Notes: *, **, *** indicate significance at the 10%, 5% and 1% level. Heteroscedasticity robust standard errors adjusted for country clusters ('ctry'), industry clusters ('ind') and firm clusters respectively in parentheses. The dependent variable is the composite patent quality index (Panel A) and the family size (Panel B) and forward citations index respectively (Panel C). For details on the variable definition, see the notes to Table 4.2. All specifications include a full set of year fixed effects and the country control variables GDP, GDPpC, Polity2 and TP Corruption Index.

Note, moreover, that our results are robust to adjusting standard errors for clusters at different levels. While our baseline specifications report standard errors that allow for correlation of residuals in the same country and year cell, we reran our specifications calculating standard errors that account for correlation within country clusters, industry clusters and firm clusters respectively. Panel A of Table 4.5 presents the results of specifications which reestimate the models presented in columns (3) to (4) of Table 4.3 (which use the composite quality index as dependent variable). The modification leaves the statistical significance of the coefficient estimates for the patent income tax variable unaltered. Analogous results are found if the family size index or the index for the number of forward citations is used as the dependent variable in Panels B and C.

The specifications presented in Table 4.6 furthermore test for a potential link between the B-index and patent quality. Specifications (1) to (3) regress the composite patent quality index on the B-index and the host country's patent income tax rate. The coefficient estimate for the tax variable, again, shows a negative sign, indicating a statistically significant and economically relevant impact of patent income taxes on patent quality. Quantitatively, an increase in the tax rate by 10 percentage points reduces patent quality by 0.92 or 3.9% (see Specification (3)). The coefficient estimate for the B-index is positive and turns out statistically significant in Specifications (2) and (3), indicating that reductions in the marginal tax burden on R&D investment, as e.g. induced by an expansion of R&D tax allowances/credits, reduce the average quality of R&D projects undertaken in a country.[23] Quantitatively, a reduction in the B-index by 0.10 (implying that a 1 Euro investment in R&D has to earn 10 cent lower pre-tax income in order to break even) lowers the average patent quality by 0.059 and thus by 2.5%. This result is in line with the theoretical notion that, with a downward sloping marginal product curve, marginal R&D projects induced by generous tax allowances/credits or low patent income taxes, reduce the average profitability of the project pool. We furthermore reran the regressions using the patent's family size (see specifications (4) to (6)) and its forward citations (see specifications (7) to (9)) as the dependent variable. While the coefficient estimates for the patent income tax rate remain statistically significant and large in all specifications, the B-index loses in terms of size and significance in the specifications which employ the number of forward citations as the dependent variable. The results thus suggest that, while project profitability as proxied by the family size of the patent decreases with a reduction in the marginal effective tax burden, the degree of innovation as proxied by the number of forward citations is not significantly affected.[24]

Furthermore note that the construction of the B-index also accounts for the tax burden on R&D income. To separate out effects related to the policy instruments of low patent income taxes and generous R&D tax credits/allowances, we also ran specifications with a modified B-index variable, which captures the *after-tax* income required for a project to break even and corresponds to the numerator of the B-index defined in Equation (4.2). The results are presented in Specifications (10) to (12). Qualitatively, they resemble our baseline findings. The coefficient estimate for the patent income tax somewhat drops in size. Specification (3) suggests that an increase in the patent income tax rate by 10 percentage points reduces the patent quality by 0.038 or 1.6%.

[23]Recall that higher tax credits/allowances reduce the B-index.

[24]As a robustness check, we also ran specifications which included the B-index as the only tax measure, which does not change our results.

Table 4.6: B-index and Patent Quality

	Comp. Qual. Index			Family Size			Forward Citation			Comp. Qual. Index		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Patent Income Tax	-0.290***	-0.562***	-0.917***	-0.209***	-0.380***	-0.661***	-0.269***	-0.535***	-0.737***	-0.223*	-0.201	-0.376*
	(0.0794)	(0.140)	(0.192)	(0.0553)	(0.0857)	(0.170)	(0.0861)	(0.188)	(0.232)	(0.133)	(0.196)	(0.225)
B-index	0.137	0.519***	0.590**	0.180	0.533***	0.652***	0.027	0.316	0.071			
	(0.176)	(0.196)	(0.283)	(0.129)	(0.133)	(0.244)	(0.172)	(0.309)	(0.370)			
B-index, Numerator										0.099	0.480***	0.788***
										(0.138)	(0.158)	(0.276)
GDP/10^{14}	0.613*	0.940**	3.000***	0.512**	0.739***	2.710***	0.447	0.905	1.680**	0.588*	0.846**	2.990***
	(0.317)	(0.399)	(0.674)	(0.219)	(0.280)	(0.523)	(0.392)	(0.555)	(0.837)	(0.326)	(0.419)	(0.681)
GDPpC/10^{4}	-0.218***	-0.268***	0.024	-0.102***	-0.146***	0.053	-0.303***	-0.354***	-0.009	-0.206***	-0.212**	0.066
	(0.052)	(0.082)	(0.098)	(0.037)	(0.052)	(0.068)	(0.061)	(0.114)	(0.147)	(0.055)	(0.083)	(0.096)
Polity2	-0.013	-0.039	-0.033	0.091	0.150***	0.136***	-0.252**	-0.449	-0.392	-0.008	-0.013	-0.025
	(0.076)	(0.099)	(0.111)	(0.060)	(0.035)	(0.049)	(0.114)	(0.350)	(0.363)	(0.076)	(0.097)	(0.107)
CPI	0.041***	0.048**	0.026	0.030***	0.026**	0.018	0.040**	0.054*	0.027	0.043***	0.055**	0.031
	(0.014)	(0.021)	(0.023)	(0.010)	(0.013)	(0.019)	(0.019)	(0.031)	(0.029)	(0.015)	(0.022)	(0.022)
Log Total Assets			-0.018*			-0.020***			-0.006			-0.018*
			(0.009)			(0.007)			(0.011)			(0.009)
Industry Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Country Fixed Effects	✓			✓			✓			✓		
Affiliate Fixed Effects		✓	✓		✓	✓		✓	✓		✓	✓
# Observations	112,058	80,936	25,642	112,058	80,936	25,642	112,058	80,936	25,642	112,058	80,936	25,642

Notes: *, **, *** indicate significance at the 10%, 5% and 1% level. Heteroscedasticity robust standard errors adjusted for country-year clusters in parentheses. The dependent variable is the composite patent quality index (specifications (1)-(3) and (10) to (12)) and the family size (specifications (4)-(6)) and forward citations index respectively (specifications (7)-(9)). For details on the variable definition, see the notes to Table 4.2. All specifications include a full set of year fixed effects.

4.4.2 Robustness Checks and Discussion

The analysis so far has accounted for corporate tax incentives in the year of patent application. Two issues are important to discuss in this context. Firstly, as described in the introductory section, MNEs may have an incentive to distort the location of valuable R&D projects to affiliates with a low corporate tax rate. Thus, the decision on the R&D location is, in most cases, made several months prior to the patent application and to the income flow related to the R&D. Note that, for the average R&D project, the time of the project until patenting is rather short though, in 75% of the cases less than 24 man-months (see a recent survey of US and Japanese firms, Nagaoka and Walsh (2009) and footnote 3 in this Chapter).[25] Consequently, MNEs have to form expectations on the future patent income tax rate that will apply to income from the project at the time when it makes its location decision. As corporate tax reforms are commonly announced and enacted months or even years in advance, uncertainty on the taxation of the income stream may be small for projects with a short (scheduled) project horizon. For projects with a longer (scheduled) project horizon, the MNE has to form expectations on the development of the corporate income tax rate in potential host countries. With extrapolative expectations, expectations depend on the history of the corporate tax rate, in the easiest case agents assume the future corporate tax rate to correspond to today's corporate tax rate. With rational expectations, the expected corporate tax rate in turn corresponds to the mathematical expectation of the future tax rate given the available information today. Modeling the tax incentives by the patent income tax rate and R&D tax allowances/tax credits in the year of the patent application, as we did in the baseline analysis, assumes rational expectations of MNEs which have enough information at hand to predict future corporate tax rates at potential hosting locations (at the time when the income stream arises, presumably the year of the patent application) when deciding upon the location of R&D projects. Extrapolative expectation would in turn suggest to include lagged values of the tax variables to proxy for tax incentives at the time when the MNE makes the R&D location decision.

Following this notion, Specifications (1) and (2) in Table 4.7 rerun our baseline specifications replacing the patent income tax rate in the year of the patent application with the first lag of the patent income tax. The coefficient estimates turn out negative and statistically significant, indicating quantitatively slightly smaller effects than the baseline model. Specifications (3) and (4) simultaneously account

[25] Man-months of course do not necessarily directly correspond to the actual length of the project until patenting. On the one hand, the project period in months may be shorter since more than one employee may be assigned to the project. On the other hand, the period may be longer as employees may work on several projects simultaneously. In any case, the survey suggests that the time span between the kick-off of the R&D project and the application for patent protection is rather short.

Table 4.7: Lagged Information on Tax Incentives

	Composite Qual. Index				Family	Forward	Comp. Qual. Index	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Patent Income Tax			-0.261***	-0.243**	-0.195**	-0.086	-0.378***	-0.293***
			(0.097)	(0.100)	(0.084)	(0.112)	(0.109)	(0.102)
Patent Income Tax, First Lag	-0.258***	-0.529***	-0.374***	-0.268***	-0.161**	-0.349**	-0.351**	-0.161
	(0.083)	(0.134)	(0.126)	(0.095)	(0.064)	(0.145)	(0.143)	(0.115)
Patent Income Tax, Second Lag				-0.344***	-0.216***	-0.398**		-0.114
				(0.120)	(0.077)	(0.182)		(0.147)
B-index							0.047	0.241
							(0.206)	(0.206)
B-index, First Lag							0.414	-0.079
							(0.282)	(0.253)
B-index, Second Lag								0.805*
								(0.482)
Industry Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Country Controls	✓	✓	✓	✓	✓	✓	✓	✓
Country Fixed Effects	✓							
Affiliate Fixed Effects		✓	✓	✓	✓	✓	✓	✓
# Observations	147,308	107,085	107,085	96,517	96,517	96,517	70,038	58,125

Notes: *, **, *** indicate significance at the 10%, 5% and 1% level. Heteroscedasticity robust standard errors adjusted for country-year clusters in parentheses. The dependent variable is the composite patent quality index (specifications (1)-(4) and (7) to (8)) and the family size (specification (5)) and forward citations index respectively (specification (6)). For details on the variable definition, see the notes to Table 4.2. All specifications include a full set of year fixed effects and the country control variables GDP, GDPpC, Polity2 and TP Corruption Index.

for the patent income tax in the application year as well as the patent income tax in the year(s) prior to the application. The results suggest that deeper lags of the patent income tax do have explanatory power and exert a statistically significant effect on the quality of R&D projects. Specifications (5) and (6) rerun the model in Specification (4) using the family and forward citation index as the dependent variable respectively. Again, the pattern of the results remains unchanged. Specifications (7) and (8)) augment the set of regressors by information on the B-index in the year of the patent application as well as in prior years. The estimates suggest that marginal project costs as modelled by the B-index impact on project quality particularly strongly in years indicated by deeper lags, i.e. the years when the decision on the implementation and (initial) location of the R&D is made. This is intuitive as the size of the B-index is decisively driven by tax allowances and tax credits granted for R&D investments whose benefits largely accrue at the start of the project.

Table 4.8 furthermore assesses the sensitivity of our results to controlling for transfer pricing legislations that aim to limit multinational profit relocations to low-tax countries. As technologies resulting from R&D are an important input in the production process of modern MNEs, a significant fraction of intra-firm trading activities is related to patented innovations. In general, MNEs have an incentive to distort prices on royalty payments for high- and low-value R&D alike. High-value R&D may, however, be used more intensely within the multinational group and may thus offer more opportunities for price distortions. The implementation of transfer pricing regulations and the associated limitation of profit shifting opportunities (for empirical evidence see Lohse and Riedel, 2013) may thus in particular drive high-value R&D from the country. If changes in transfer pricing laws and R&D tax incentives are correlated, our coefficient estimates of interest may be biased. To assess this possibility, we collected information on transfer pricing legislations in our sample countries. In particular, we defined a dummy variable which takes on the value 1 if transfer pricing requirements are implemented into national tax law.[26] The specifications in Table 4.8 augment our baseline models by this transfer pricing indicator. While we do not find a statistically significant impact of transfer pricing rules on the average quality of R&D projects located in a country, the impact of the patent income tax and the B-index resemble the baseline findings.

Moreover, as described in Section 4.2, the analysis disregards patents where applicant and inventor are located in different countries to avoid findings that reflect tax-motivated international profit shifting through patent relocations to low-tax

[26] In doing so, we follow Lohse et al. (2012) and code the dummy as 1 if the country's national tax law requires intra-firm transfer prices to be set according to the arm's length principle and if the tax law provides further details on the applicability of the principle (e.g. specifies methods which MNEs are allowed to pursue to determine arm's length prices).

Table 4.8: Transfer Pricing Rules

	Comp. Qual. Index		Family	Forward	Composite
	(1)	(2)	(3)	(4)	(5)
Patent Income Tax	-0.308***	-0.451***	-0.348***	-0.242*	-0.548***
	(0.0812)	(0.120)	(0.0808)	(0.139)	(0.142)
B-index					0.515***
					(0.196)
Transfer Pricing Rules	-0.007	-0.023	-0.005	-0.070***	-0.014
	(0.015)	(0.020)	(0.015)	(0.024)	(0.035)
Industry Fixed Effects	✓	✓	✓	✓	✓
Country Controls	✓	✓	✓	✓	✓
Country Fixed Effects	✓				
Affiliate Fixed Effects		✓	✓	✓	✓
# Observations	160,790	116,913	116,913	116,913	80,936

Notes: *, **, *** indicate significance at the 10%, 5% and 1% level. Heteroscedasticity robust standard errors adjusted for country-year clusters in parentheses. The dependent variable is the composite patent quality index (specifications (1)-(2) and (5)) and the family size (specification (3)) and forward citations index respectively (specification (4)). For details on the variable definition, see the notes to Table 4.2. All specifications include a full set of year fixed effects and the country control variables GDP, GDPpC, Polity2 and TP Corruption Index.

countries. Geographical splits of patent applicant (i.e. the owner of the technology who is subject to tax) and the inventor can e.g. be implemented through contract research schemes, where an R&D unit undertakes research for a group affiliate in a tax-haven country which finances the project and bears its risk. The R&D unit earns a small fixed profit margin on its costs, while the residual income accrues with the contracting entity in the low-tax country.[27] In contrast, relocating ownership of the technology after patent protection was granted tends to be unattractive from a profit shifting perspective as tax authorities in high-tax countries would require that a transfer price corresponding to the patent's true value is charged for the transaction.

Another issue that merits discussion is the use of the patent quality measure to proxy for the quality of R&D projects. In particular, strategic patenting may involve that different subparts of one innovation are protected by a number of interconnected patents. This directly implies that increases in the quality of an R&D project may partly show up through increases in the number of patents filed by a corporation. Using the number of patent applications as the main regressand, like done in previous research (see for example Ernst and Spengel, 2011; Karkinsky and Riedel, 2012; Griffith et al., 2014), might thus capture both, responses in the quality and quantity

[27] Boehm et al. (2012) analyze patent applications to the EPO and find that geographical patent splits are partly motivated by tax considerations.

of R&D projects to corporate taxation. The merit of our approach is in turn that it allows for an isolated identification of the quality effect by investigating the impact of patent income taxation and R&D tax incentives on the quality of patents filed by a corporation, conditional on the number of patent applications.

To sum up, the findings suggest that, in line with our theoretical considerations, low average tax rates on patent income (as proxied by the statutory patent income tax rate) raise the average quality of R&D projects undertaken in a country (by attracting a positive selection of high-value patents to the economy). Low marginal effective tax rates are in turn found to decrease the average patent quality (by triggering new R&D investments with lower quality). This also implies that different R&D tax instruments exert a very different impact on the average quality of R&D projects undertaken in a country. While input-based measures like R&D tax allowances and credits (that influence the marginal tax burden on R&D) exert a negative impact on average project quality, low patent income taxes turn out to be instrumental in raising R&D quality.

4.4.3 Welfare Consequences

Finally note that the welfare consequences of generous R&D tax credits/allowances and low patent income tax rates are theoretically unclear. From an individual country's perspective, granting special tax incentives may decrease national welfare if the quantitative response of private sector R&D to the incentive is weak and the policies therefore only generate windfall gains to the corporate sector, while overall tax revenues decline. The sign and size of the welfare consequences moreover critically depend on the existence and structure of technological spillovers to other firms in the economy.

The patent quality effects discussed in this study decisively affect the welfare assessment of the policy instruments. Precisely, our analysis suggests that R&D tax credits and allowances reduce the average project quality (by expanding marginal R&D investments). Any positive welfare consequences of increases in R&D quantity induced by generous R&D tax credits and allowances are thus counteracted by a reduction in average project quality (i.e. lower profitability (and thus a lower contribution to the country's corporate tax base) and lower innovativeness (and thus less spillovers on other firms in the economy)). In terms of low patent income tax rates, the welfare assessment is positive from a national perspective as low patent income taxes do not only expand R&D activity (as suggested by previous work) but also trigger the inflow of R&D activity with above average quality. The picture looks less optimistic from an international perspective though. Precisely, as countries compete for internationally mobile R&D projects, projects gained by one country are lost by another. As governments do not account for the consequences of their policy choices on other countries, patent income tax rates are set inefficiently low from a global perspective. Accounting for the quality effects of low patent income taxes discussed in this study further fuels this race-to-the-bottom.

4.5 Conclusion

In recent years, a large and growing empirical literature has shown that corporate taxation negatively impacts on corporate investment behavior at the extensive and intensive margin. Most existing papers, however, restrict their view on testing for corporate tax effects on investment *quantity*. The welfare implications of corporate taxation in turn critically depend on the effects of corporate taxation on investment *quality*, e.g. the profitability and innovativeness of R&D activity (see Becker and Riedel, 2012). The aim of this study was to empirically assess the effect of the design of the corporate tax system on the quality of innovations resulting from R&D activity.

The analysis uses data on patent applications to the EPO between 1995 and 2007 which is linked with firm level information. Proxying for a project's earnings potential and innovativeness by patent quality measures constructed from information on the patent's family size, its number of forward citations and the number of industry classes, we find that low tax rates on patent income tend to increase average patent quality. The effect also turns out to be economically relevant. A decrease in the patent income tax rate by 10 percentage points raises patent quality by around 1-5%. Tax allowances and tax credits for R&D investment are in turn found to exert a negative impact on observed project quality.

These results may have important implications for the design of tax instruments related to innovation policy. In recent years, several governments in Europe significantly reduced their tax rates on patent income. Policy makers justified the tax adjustment with the aim to attract innovative R&D activities. Our findings confirm this notion and suggest that low patent income tax rates are indeed instrumental in attracting R&D projects with an above average earnings potential and innovativeness. Interestingly, an analogous effect does not exist for R&D tax allowances and R&D tax credits as their deduction value is unrelated to project quality. Thus, while both tax policy measures may help to attract and increase the size of R&D projects (i.e. R&D quantity), only low patent income taxes are found to exert a positive effect on project quality.

Chapter 5

Tax Effects on R&D Location Decisions

5.1 Introduction

This study addresses the question how taxes influence R&D location decisions. The reduction of trade barriers has led to an increase in international trade and cross-border activities of firms. In an environment of competition among states for the settlement of firms, firms can choose where to locate their business activities in a cost minimizing way. Taxes play a non-negligible role in these decisions and a vast strand of literature has investigated this issue (for a review of the literature see De Mooij and Ederveen, 2006; Devereux and Maffini, 2007). R&D investments differ from other investments in that they involve higher uncertainty and risk on the one hand, but also in that they render higher economic rents if the project was a success, on the other hand. These specialties of R&D investments may provide a different incentive structure to firms and may trigger different reactions with respect to taxes. Previous studies have focused on the high profit potential of R&D investments and emphasized that this is a strong incentive to locate the output from R&D activities, such as patents, trademarks and other intellectual property, to low-tax countries (see among others Dischinger and Riedel, 2011; Karkinsky and Riedel, 2012; Griffith et al., 2014). I, in turn, focus on the effect of taxes on the decision where real R&D activity - the input side of R&D - is located and contribute to the existing literature by presenting a more complete picture of both, the location decision of R&D input and R&D output. Investigating the input side to R&D is equally important to studying the output side, as it reflects where real R&D activity with all its positive side effects, such as employment and technological spillovers, is located. As the movement of intellectual property does not necessarily reflect the move of real R&D activity (Clausing, 2010), it is important to closer examine how real R&D activity reacts to various tax regulations.

The analysis of this paper is twofold. In a first step, I examine whether taxes can distort the location choice of firms with respect to their real R&D activity. In a second step, I draw my attention to the location decision on where the applicant and owner of the patent resides. To do so, I exploit information on worldwide patent applications that reveals country information about where the patent inventor resides and country information about where the owner of the patent resides. Patent inventor information is used to measure where real R&D activity took place. To analyze whether the location of real R&D activity is distorted by tax factors, I estimate a conditional logit model where the dependent variable is location choice. Furthermore, location choice is regressed on tax factors and several control variables. On the other hand, I use patent owner information in a similar way to investigate whether tax factors exert an impact on the location choice of the patent owner country.

The results suggest that tax factors do impact on R&D location decisions, but they exert different effects in different location choices. With regard to the inventor country, taxes impact positively on location choice indicating that a country with a higher tax rate is more likely to be chosen as an inventor location than a country with a lower tax rate. This finding can be explained by the fact that deductible costs are most valuable in high-tax countries. As during the phase of invention only costs occur, the firm primarily benefits from deducting these costs against a high tax rate. On the contrary, the effective tax burden does not significantly impact on the location choice of a patent owner country. However, the exit tax rate of a country negatively and statistically significantly impacts on the owner country decision. Together these findings suggest that while the effective tax burden in the owner country does not play a significant role for the firm, the firm anticipates adverse tax effects from cross-border relocations of patents caused by an exit taxation regime and thus, is less prone to locate a patent in a country with a high exit tax rate.

Sensitivity checks reveal that patents of high quality react more sensitive to high tax rates than patents of lower quality. While the findings for the inventor location choice also hold for high-quality patents, the results of the owner location choice suggest that high-quality patents are less likely to be owned in countries that trigger a high tax burden for the firm. This finding confirms the notion that taxes negatively distort the location choice for patents towards countries with lower tax burdens, if patents are expected to yield high returns on investment (for previous evidence see Ernst et al., 2014; Boehm et al., 2012).

The findings presented in this study compare to previous literature in that they complement earlier findings with respect to the inventor country choice in R&D

location decisions. So far, many studies have investigated the location choice of the ownership of intellectual property rights. Dischinger and Riedel (2011) rely on balance sheet data and document an above average amount of intellectual property rights held in low-tax subsidiaries. Their results are evidence that R&D tax planning takes place, but it is still unclear what kind of structures firms implement to lower their overall tax burden. According to Clausing (2010) the literature leaves open to what extent geographical relocations of intellectual property rights reflect the move of real R&D activity. Thus, the findings of Dischinger and Riedel (2011) can be explained either by a move of intellectual property rights or a move of real R&D activity cross-border to low-tax locations. The answer to this question is of high economic relevance, because different welfare effects may be caused by the move of intellectual property rights only or the move of real R&D activity as a whole. In this context, Bloom and Griffith (2001) document first evidence for 'footloose' R&D. They investigate the amount of research activity that is conducted in the UK and focus on who finances the R&D activity. They find that there is a trend towards an increase in private R&D that is conducted by a foreign owned firm and/or financed from abroad but takes place within the UK. Furthermore, they find evidence that this internationalization of R&D activity is partly motivated by tax reasons. Specifically, they show that domestic R&D responds not only to the domestic but also to the foreign user cost of R&D, which incorporates also tax aspects like tax allowances and tax credits. In the same direction, Wilson (2009a) and Paff (2005) report a tax induced shift of existing R&D activities to tax favorable jurisdictions.

Following up on these studies, Ernst and Spengel (2011) and Karkinsky and Riedel (2012) presented evidence on tax planning considerations in the context of R&D investments using patent data in order to proxy for R&D. Both studies find that patent applications negatively respond to taxes indicating that a low corporate tax rate attracts firms to own intellectual property rights and apply for patent protection in that country. Both Karkinsky and Riedel (2012) and Ernst and Spengel (2011) estimate a negative binomial model by counting the number of patent applications in a country and regressing them on the statutory tax rate and controls. They report a negative and statistically significant coefficient estimate of the corporate statutory tax rate, suggesting that the likelihood for patent applications decreases in the corporate tax rate. The negative binomial model, which is a poisson model with a different assumption about the error term, is closely related to the conditional logit model. In fact, the more sophisticated conditional logit model results in a poisson model if the regressors are not alternative-specific. Nevertheless, the two models differ in their basic assumptions such that Schmidheiny and Bruelhart (2009) argue that the coefficient estimates from the conditional logit model and the poisson model denote the boundaries with regard to location choice models in applied research. In this sense, this study presents evidence that, in terms of the size of the coefficient, is at the lower bound on the range of coefficient estimates resulting from the poisson model, the nested logit and the conditional logit model.

Two more recent studies also present evidence on the location choice of the patent applicant based on conditional logit estimations (Boehm et al., 2012; Griffith et al., 2014). Boehm et al. (2012) concentrate their analysis on patents that observe a geographical split between the country where the patent was invented and the country where the patent applicant resides and the patent is owned. The authors report that these kinds of patents make up only 8% of all patents they observe in the universe of patent applications to the EPO. However, they suspect tax planning activities behind these structures and indeed find statistically significant evidence that low-tax countries attract ownership of foreign invented patents. The most closely related study by Griffith et al. (2014) similarly examines the location choice for patent ownership, though in a mixed logit framework allowing for random coefficient estimates (Train, 2009). They find that lower tax rates are likely to exert significant effects on the location of patent ownership.

This study extends the existing literature by investigating the location choice for real R&D activity exploiting patent data. So far, most studies have concentrated on the location of patent ownership, because that is also the location where the profits stemming from intellectual property are subject to tax. Hence, tax planning activities may be detectable where profits accrue. For example, Altshuler and Grubert (2006) emphasized that intangible assets play an important role in allowing firms to structure their activities in a tax favorable manner. As intangible assets often do not have a market equivalent, there is no possibility to establish a transfer price that is at arm's length according to comparable market prizes. This opens up room to maneuver and to set a transfer price that is beneficial to the multinational's overall tax position (for more detailed evidence on this topic see Klassen et al., 2013). Indirect evidence has been provided by Grubert and Mutti (1999) and Hines (1994) in that they document that firms in low-tax locations show a relatively high profitability.

Nevertheless, from a welfare perspective it is also of interest whether the location where innovative activity takes place is distorted by the tax system. As welfare consequences from R&D are not only tax revenues from profitable investment projects, but also technological spillovers and positive effects on employment, it is crucial to understand the tax effects on innovative behavior of firms. Specifically, it is not fully evident from the literature to what extent taxes impact on the location choice of firms regarding their real R&D activities. This gap in the existing literature should be addressed by this study. Bloom et al. (2002) have addressed the question whether the size of R&D investments is affected by taxes and find that R&D tax incentives have the potential to raise the investment volume of firms in R&D. Regarding, however, the question of location choice only few evidence exists so far. Most closely related is a study by Hines and Jaffe (2001) for the US. The authors document that taxes do impact on the location where innovative activity takes place within US multinational enterprises. They focus, however, on the specific impact of tax incentives for R&D in the US and abroad and calculate a measure that captures the tax deductibility of R&D expenses. Hines and Jaffe (2001) find that R&D expense deductibility has a positive effect on location choice for innovative activity.

The research question of this study is whether adverse tax regulations on the profit from an R&D investment impact on the location choice on where the real activity of the R&D investment should be carried out. Theory claims that the presence of tax haven countries and multinational engagement in profit shifting activities might actually increase the welfare of well-developed high-tax countries as the possibility to relocate income refrains firms from relocating the real activity itself (Hong and Smart, 2010). I hypothesize that firms anticipate tax regulations that hit the profits that accrue from an investment already at an earlier stage in the decision-making process. Thus, I investigate the effect of the corporate tax rate that is imposed on patent income on the location of innovative activity. Furthermore, the analysis of the statutory corporate tax rate is extended by incorporating the mark-up into the analysis. The mark-up - as some kind of anti-avoidance mechanism - determines how much profit remains in the country where the real activity takes place in the case of cross-border structures. Following previous studies, I investigate the choice of a patent ownership location and extend the analysis by the exit tax rate, which is also an anti-avoidance regulation that aims at securing a jurisdiction's taxing rights. In this sense, the study also adds to previous literature on anti-avoidance tax regimes (Lohse and Riedel, 2013; Buettner et al., 2014).

The remainder of the Chapter is structured as follows: Section 5.2 discusses the tax considerations of multinational enterprises regarding investments in R&D in more detail and summarizes the tax factors that are incorporated in the empirical analysis of this study. Section 5.3 presents the data I use to estimate the empirical model that is closer described in Section 5.4. The results from the analysis are presented in Section 5.5, while Section 5.6 is attributed to a robustness check on the issue of high-quality patents. Finally, Section 5.7 concludes.

5.2 Tax Considerations of R&D Intensive Firms

This section summarizes tax aspects that are important for location decisions of R&D investments from the point of view of a multinational enterprise. For this purpose, I consider a company that has subsidiaries in several countries and has to decide where to locate a new R&D investment. A theoretical model of this decision problem is introduced by Dischinger and Riedel (2011). According to their model, the location decision of a new R&D investment can be disentangled into two separate decisions: the decision on the location of real R&D activity and the decision on the location of profits stemming from that activity.[1] Consequently, the firm can either locate both real activity and profits in the same country or geographically separate the locations of real activity and profits. For the purposes of my analysis, I consider both decisions of the firm. On the first stage, the firm may decide on the country where it wants to conduct its R&D activity. Subsequently, it decides where the patent should be owned and will be subject to tax. The problem is solved by backward induction. Thus, the firm will first consider its payoffs in the second stage and take the result as given when it decides on the first stage.

Broadly speaking, the firm can structure its R&D activity in two different ways. First, the firm can do research in the country where it is established and let any arising intellectual property remain in the same country. This concept is known as 'traditional R&D'. Second, it could engage in a 'contract R&D' agreement. In this case, the firm contracts out the research activity to an affiliated company in a country abroad and pays a remuneration for the costs that occur at the research company. Effectively, contract R&D leads to a geographical separation of patent inventor and ownership location.[2] The fee paid as remuneration is commonly based on the costs incurred by the R&D company and usually entails a mark-up at arm's length. The inventor is therefore located at the affiliated research company abroad, while any arising intellectual property rights will be located at the firm who contracted out the research.[3] This is, because the ownership of intellectual property belongs to the financer who bears all risks and chances from the investment.

[1] According to Dischinger and Riedel (2011), a firm who decides to relocate the patent away from where it has been created has to explicitly transfer the patent after its creation. That is, the firm in a first stage decides where it creates the intangible assets. After its creation, the firm observes the value of the patent and may then decide to relocate it to another jurisdiction. Moreover, in a third stage the firm also decides on the transfer price that is charged for the relocation of the intangible asset. In their paper, Dischinger and Riedel (2011) focus on the decision on the location of patent ownership and on the transfer price. On the contrary, I assume that the firm may anticipate the value of the patent and thus, decide on the separation of inventor and patent owner country at an earlier stage. In the case the firm wants to invent the patent at a different location than where it owns the patent, the firm will engage in a contract R&D agreement. A later transfer of the patent after it has been applied for patent protection is not addressed in this study.

[2] Alternatively, the firm could transfer the arising intellectual property to an affiliated company abroad after it has been created. This would also lead to a geographical separation of IP invention and ownership, but only after IP already arose. The cross-border transfer may, however, cause the imposition of an exit tax that might partly or on the whole set off any tax savings from the transfer.

[3] A subcase of contract R&D is to set up a pool financing agreement (Jacobs et al., 2011). This involves several researching companies who jointly participate in the financing and conducting of the research. Consequently, all participants will also jointly own the arising intellectual property stemming from the investment. Alternatively, all participants of the research pool can contract out the research activity to a separate R&D company, who will be remunerated similarly to the contract R&D agreement described above (Russo, 2007).

From a tax planning point of view, the main questions are where costs are deducted and profits are taxed. In the case of a traditional R&D investment, costs are deducted in the same jurisdiction where profits later arise. Similarly, in the case of a contract R&D agreement the costs are deductible in the hands of the financing company as a fee paid to the research company. As the IP also arises in the hands of the financing company, the profits are liable to taxation in the same country. The major difference between the two concepts is a mark-up paid to the research company, which constitutes a small profit liable to taxation in the jurisdiction of the research company. The mark-up has to be at arm's length and is commonly based on the application of some kind of cost-plus method (Russo, 2007). The Guidance of the OECD regarding transfer pricing aspects of intangibles (OECD, 2014) set forth the determination of the mark-up at arm's length and establish that '*the analysis of this issue requires an assessment of (i) the obligations and rights implied by the legal registrations and agreements between the parties, (ii) the functions performed, the assets used, and the risks assumed by the parties, (iii) the intangible value anticipated to be created [...], and (iv) the compensation provided for the functions performed [...]*'. They go on to clarify that '*one relatively clear case is where a [...](research company) acts merely as an agent, being reimbursed for its [...](research) expenditures and being directed and controlled in its activities by the owner of the [...] intangibles. In that case, the [...](research company) ordinarily would be entitled to compensation appropriate to its agency activities alone. It would not bear or control the risks associated with the further development of the [...] intangibles, and would therefore not be entitled to additional remuneration in that regard.*'[4] As a result, the size of the mark-up depends on the circumstances of the case, but also on the strictness of a jurisdiction regarding the interpretation and application of the OECD Guidance.

Ideally, the costs incurred by an R&D investment are deductible against a high tax rate, while the profits are taxed at a low rate. This cannot be achieved in fact, because countries employ anti-avoidance legislation that counter such structures. In the case of traditional R&D, an ideal structure would be to conduct R&D in a high-tax country, where costs would be deductible against the high tax rate, and later transfer the IP to a low-tax country, where profits will ultimately be subject to tax. However, any tax savings are set off by an efficient exit taxation regime in the country where the research was conducted. The exit tax is regularly imposed upon the transfer of an asset to a foreign jurisdiction. The mere transfer cross-border is

[4]OECD (2014), p.54, para.6.74. The words in brackets were added by the author. The original case applies to a marketing company. However, para. 6.76 states that '*the principles set out in the foregoing paragraphs also apply in situations involving the performance of research and development functions by a member of an MNE group under a contractual arrangement with an associated enterprise that is the legal owner of any resulting intangibles.*'

deemed to be an alienation of the asset such that all hidden reserves of the asset are subject to taxation in the high-tax country. An exit taxation regime works efficiently, if the deemed value equals the discounted future cash flows and thus, any tax saving will be compensated for by the exit taxation upon the cross-border transfer.

In the case of contract R&D, the geographical split of inventor and owner does not mean that costs can be deducted against a high tax rate in the one country and profits are liable to a low tax rate in the other country. However, the firm has an incentive to pay a low mark-up in the inventor country, if the inventor country is a high-tax jurisdiction. Vice versa, the firm aims to pay a high mark-up in the inventor country, if the inventor country is a low-tax country. In this regard, the mark-up determines how much profit is split from the corresponding costs and subject to a different tax rate. Nevertheless, one has to mention that the determination of the mark-up is not incumbent upon the taxpayer, but rather upon the tax authorities of the involved jurisdictions. Consequently, the firm can choose between deducting the research expenses against a high tax rate and accepting that also profits will be subject to that high tax rate or benefiting from a low tax rate on profits while the expenses are deductible only against that low tax rate. Both alternatives can be achieved via traditional R&D and contract R&D.

In the analysis to come, I investigate both the inventor country and the owner country decision. Summing up the tax factors that impact on these decisions, I consider two countries, the inventor country i and the owner country o and a multinational enterprise, the firm, that has to decide upon where to allocate its research activity (the inventor country) and where to finance this activity from (the owner country). Further, I denote the statutory tax rate τ, the mark-up applied in an inventor country m_i and the exit tax rate applied in an owner country e_o. In a first step, I examine the choice of an inventor country by taking the owner country as given. In the case the firm decides for traditional R&D, the owner country equals the inventor country and the relevant tax rate payable on the profits from the R&D activity will be the statutory tax rate of the owner country. On the contrary, if the firm sets up a contract R&D agreement, taxes are to be paid in both the inventor and the owner country. The mark-up determines how much of the profit will be taxed in the inventor country. The full costs including the mark-up are fully deductible in the owner country and any exceeding profits will be subject to tax in the owner country. Formally, the effective tax payable in the inventor country T_i is

$$T_i = \left(\frac{m_i}{p}\right) \times \tau_i \tag{5.1}$$

where p denotes the profit margin earned on the whole R&D investment by the firm and τ_i the statutory tax rate in the inventor country. Correspondingly, the remaining profit is taxed in the country, where the intellectual property is owned. Formally, the definition of the effective tax payable in the owner country reads

$$T_o = \left(1 - \frac{m_i}{p}\right) \times \tau_o \tag{5.2}$$

where τ_o is the statutory tax rate in the owner country. When a firm chooses the inventor country, it decides whether the inventor country is the same country as the owner country and thus, whether it conducts its R&D in the traditional form or whether it contracts out R&D activity to any other country. Precisely, the crucial tax rate in this choice is a composite tax rate T_c, which is formally defined as

$$T_c = \begin{cases} \tau_o = \tau_i & \text{if traditional R\&D is chosen} \\ \left(\frac{m_i}{p}\right) \times \tau_i + \left(1 - \frac{m_i}{p}\right) \times \tau_o & \text{if contract R\&D is chosen} \end{cases} \tag{5.3}$$

where p is unknown. In order to calculate T_c, an assumption about the size of p has to be made. It is assumed that p is 20% for all investments (Spengel et al., 2012a).[5] The same considerations apply to the choice of an owner country. On the second stage a firm learns about the outcome of the decision on the first stage, i.e. where it is conducting its R&D activity. Thus, a firm will choose the location of an owner country and will decide between traditional and contract R&D, where the composite tax rate defined in equation (5.3) is determining. After the firm has decided on inventor and owner country, it could still move the resulting IP to a low-tax country by accepting the imposition of an exit tax e_o upon the cross-border transfer of the asset. The profit arising from that IP would still be fully taxed in the owner country - provided that the tax authority can determine the true value of the asset - but instead of τ_o the exit tax rate e_o would be levied. One drawback of the data is that I do not observe any transfers of patents away from the owner country once the owner has applied for patent protection. However, I argue that the exit tax e_o may already have an impact on the decision of the owner country, as firms might anticipate that IP can only be transferred to any other country by

[5] I follow previous work on the calculation of effective tax rates that also assumes a constant rate of return of 20%. In a related analysis for the calculation of effective tax rates at the industry level, Spengel et al. (2012b) also apply different return rates for different industries, though merely in a sensitivity analysis. A vast strand of literature addresses the determination of the returns to R&D and has been surveyed by Hall et al. (2010). This literature finds rates of returns that strongly vary between less than 5% to rates above 100% (note the distinction between social and private rates of returns). As there are many different approaches to determine the returns to R&D, I decided to follow a fixed rate of return throughout my analysis. Assuming a rate of return of 20% seems reasonable as Hall et al. (2010) argue that the private returns to R&D will range between 10% and 30% (see also Chapter 2 Section 2.3.1). Moreover, in a sensitivity analysis that is not presented in this paper I find that the results are robust towards assuming alternative rates of return of 5%, 10% and 15%.

being charged an exit tax in the owner country.

In the following, the various tax factors discussed above will be empirically assessed in the inventor and the owner country decision of R&D intensive multinational enterprises. To the best of my knowledge, there is only one empirical study by Hines and Jaffe (2001) that investigates the location choice for real R&D activity with respect to tax effects. Hines and Jaffe (2001), however, focus on the effects of investment incentives for R&D. The expected effects of profit taxes on the inventor country choice are therefore a priori ambiguous. However, as already sketched above, two arguments will be central to firms: the argument of the deductibility of expenses incurred with the R&D investment - as emphasized by Hines and Jaffe (2001) - and the argument of profit taxation regarding profits stemming from intellectual property - as emphasized by Griffith et al. (2014) among others. As the beneficial treatment of one aspect comes at the cost of a disadvantage regarding the other aspect, it is unclear which argument weighs stronger on average. With respect to the location decision about an owner country, prior literature has shown that the statutory tax rate exerts a negative effect (Ernst and Spengel, 2011) as well as the tax rate differential among affiliated companies (Karkinsky and Riedel, 2012). Similarly, Griffith et al. (2014) find that recently introduced preferential tax regimes for intellectual property attract the ownership of patents. In line with these findings, I expect that the statutory tax rate negatively impacts on the location decision of patent ownership. The newly introduced composite tax rate T_c is a more precise measure of the tax burden payable on the R&D investment and thus, might exert a similar effect as the statutory tax rate. On the other hand, one could follow the same line of argumentation as in the inventor country decision that the firm has one good reason in favor of a low-tax country and one good reason in favor of a high-tax country. Hence, it would be unclear whether the tax rate exerts a negative or a positive effect on the owner country decision. With respect to the exit tax rate e_o I already argued that a negative effect is expected. The exit tax rate is an anti-tax avoidance measure that harms firms in their free movement of assets cross-border. Consequently, firms might anticipate that once patent ownership is located in a country with a high exit tax rate future profits stemming from that patent will be taxable at the high rate upon the cross-border transfer of the patent. Furthermore, the interaction effects of the exit tax rate and the statutory and the composite tax rate are investigated.

5.3 Data

To analyze the effect of the corporate tax system on the location of real R&D activity as well as the location of patent ownership I use a comprehensive dataset on worldwide patent applications. This data contains information on the inventor country of patents, which I use to measure real R&D activity, and information about the location of the patent applicant, which I use to measure patent ownership. I augment this data with tax rate information, data on firm characteristics of the patent owner and country controls.

5.3.1 Patent and Firm Data

I collect information on worldwide patent applications at national patent offices from the Orbis Bureau van Dijk database over a time span of 24 years (1990-2013), which is linked to micro data about the patent applicant. For each patent I observe the country where the patent was invented and the country where its applicant resides and is liable to taxes. From a legal perspective, the person who bears all risks and chances from an investment in R&D, i.e. the person who finances an R&D investment, is allowed to apply for patent protection at a patent office. This person is the legal owner of the patent (Muir et al., 1999). For tax purposes, most countries follow the concept of beneficial ownership to identify the economic owner relevant for tax purposes. Accordingly, legal and economic ownership may sometimes be separated. However, since economic ownership is unobservable to the econometrician, I use the legal ownership as a proxy in the analyses to come. Information on the firm structure, also contained in Orbis, allows us to identify the multinational enterprise (global ultimate owner) to which the patent applicant belongs. This information is crucial, because the parent company ultimately decides which affiliate carries out R&D (inventor) and which one finances the R&D project and applies for patent protection (owner and patent applicant). Hence, I am able to control for firm characteristics of the decision maker, the parent company.

I first identified all patent families within the data and removed all duplicates in order to avoid any double counting of inventions.[6] Ultimately, each observation is a patent which represents an invention. I remain with a sample of 1,187,258 patents that belong to 24,123 parent companies. The choice set of potential location countries comprises 42 countries, for which I collected detailed tax information. Each of these can be chosen by the parent company as a location for R&D activity and as location for patent ownership.[7] Moreover, a patent can have multiple applicants and

[6]Secondary filings can be identified if they carry a priority number. The priority number equals the application number of the first filing. The applicant has the possibility to extend patent protection to other countries by using the priority date to determine the novelty of the invention. For further reference see OECD (2009).

[7]Note that the country where the applicant resides may not be confused with the country where patent protection is sought. Patent protection can be sought in various countries, but only one country is the country where the owner of the patent resides and is liable for taxes.

multiple inventors. With respect to both applicants and inventors, I only use the first one named in the application and follow previous studies in doing so (Karkinsky and Riedel, 2012; Boehm et al., 2012; Ernst and Spengel, 2011; Ernst et al., 2014; Hines and Jaffe, 2001).[8]

The dataset allows to observe patents, whose inventor country equals its owner country, and patents, where the inventor is geographically split from the owner. The first case constitutes the traditional form of conducting R&D, while the geographical split of inventor and owner country is interpreted as contract R&D.[9] The vast majority of patents was invented following the concept of traditional R&D. Only in 10.6% of all cases contract R&D was chosen.[10] What remains unobservable in the sample are any cross-border transfers of patents that would trigger the application of an exit tax. The patent owner that I observe is the patent applicant, who financed the R&D investment, but after the application the patent could have possibly changed its owner several times. However, the patent is only observed once in time, at the date of application.

Table 5.1 shows descriptive statistics of the sample. The top applicant and inventor countries are the US, Germany and Japan. Moreover, the table provides a breakdown of patents to inventor and owner country. For example, in Germany only 6% of German-owned patents were invented abroad and 5.2% of German-invented patents are owned abroad.[11] On the other hand, in France 10.5% of France-owned patents are foreign-invented, but even 35.8% of France-invented patents are owned abroad. This highlights that in a high-tax country, like France, home-invented patents are taxed in some foreign country. However, in the US, which is another high-tax country, this descriptive statistic does not fulfill the hypothesis. In the US, 11.4% of US-owned patents are foreign invented and only 5.6% of US-invented patents are owned abroad. Thus, in the case of the US, the percentage of foreign-invented patents that are owned and taxed in the US is higher than the percentage of patents that are home-invented but taxed abroad. In contrast, in lower tax countries like Ireland or The Netherlands, the percentage of patents that were invented abroad

[8]The application procedure for a patent requires to name a main applicant, the first one, in the case of multiple applicants. With respect to multiple inventors, Hines and Jaffe (2001) already argue that in over 90% of all patents the other inventors reside in the same country as the first inventor and hence, no added value is contained in using this additional information. This also holds true for my sample, where 93% of patents with multiple inventors have inventors of one country only.

[9]In this interpretation I follow previous studies (see for example Karkinsky and Riedel, 2012; Boehm et al., 2012).

[10]This compares well to EPO data analyzed by Boehm et al. (2012), who identify 8% of geographically split patents.

[11]Foreign-invented and home-owned patents for Germany are calculated as (391,683 - 368,047)/391,683 = 6%. Foreign-owned and home-invented patents are calculated as (388,231 - 368,047)/388,231 = 5.2%.

Table 5.1: Overview of Patent Data

country of inventor	owner AT	BE	BG	BR	CA	CH	CL	CN	CY	CZ	DE	DK	EE	EG	ES	FR	HK	HU	IE	IN	IT	JP
AT	7,438	12	0	0	9	434	0	0	0	1	4,436	12	0	0	4	12	1	2	1	1	6	0
BE	4	5,227	1	1	19	157	0	0	0	0	984	11	0	0	12	50	2	0	66	0	8	9
BG	0	1	42	0	0	1	0	0	0	0	61	1	0	0	1	1	0	0	0	0	0	0
BR	1	4	0	314	7	25	0	0	0	0	122	1	0	0	6	7	0	0	0	0	8	3
CA	13	17	0	1	10,954	125	0	6	0	0	282	8	0	0	1	44	55	0	62	0	3	10
CH	104	34	0	1	21	20,403	0	1	0	1	1,569	18	0	0	6	82	2	0	21	0	54	7
CL	0	6	0	0	0	6	9	0	0	0	12	0	0	0	2	0	0	0	0	0	0	0
CN	6	15	0	0	26	90	0	42,804	0	0	244	21	0	0	3	26	159	0	1	0	1	27
CY	0	0	0	0	4	0	0	0	3	0	2	0	0	0	0	0	0	0	0	0	1	0
CZ	8	6	0	0	1	35	0	0	0	3,460	183	3	0	0	1	6	0	1	3	2	3	1
DE	821	451	0	1	83	3,886	0	11	0	16	368,047	144	1	0	72	361	0	3	64	0	73	74
DK	2	9	0	0	3	153	0	0	1	0	561	5,728	0	0	23	5	1	0	3	0	2	1
EE	0	0	0	0	0	0	0	0	0	0	14	0	29	0	0	0	0	0	32	0	0	0
EG	0	0	0	0	0	1	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	1
ES	2	39	0	0	2	74	0	0	0	0	778	8	0	0	9,748	61	1	0	4	0	12	1
FR	16	242	0	4	108	1,449	0	2	3	0	2,195	34	0	0	90	16,630	0	0	54	0	68	25
HK	0	0	0	0	2	2	0	0	0	0	12	0	0	0	0	2	378	0	0	0	0	2
HU	18	5	0	0	0	0	0	0	0	3	223	1	0	0	2	7	0	581	0	0	3	0
IE	0	0	0	0	2	22	0	0	0	0	19	0	0	0	0	3	0	0	800	0	2	1
IN	5	4	1	0	5	88	0	0	0	1	205	3	0	0	3	12	0	1	21	592	9	2
IT	45	378	0	0	2	555	0	3	0	2	752	11	0	0	69	115	0	1	70	0	11,218	8
JP	4	14	0	0	55	154	0	1	0	1	520	22	0	0	4	49	8	0	2	0	14	46,665

	KR	LT	LU	MT	NL	NZ	PL	PT	RO	RU	SE	SG	SK	TH	TR	TW	UA	US	VE	ZA	other	**total**
AT	0	0	2	4	151	0	1	0	0	0	36	5	0	0	0	1	0	208	0	1	128	**12,906**
BE	0	0	48	0	345	0	2	0	0	0	14	0	0	0	0	0	0	1,891	0	2	151	**9,004**
BG	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	3	**116**
BR	0	0	1	0	7	0	0	1	0	0	13	0	0	0	0	0	0	211	0	0	12	**743**
CA	6	0	23	0	43	0	1	0	0	0	475	34	0	0	0	14	0	4,745	0	1	183	**17,106**
CH	0	0	5	3	152	0	4	1	0	0	54	12	1	0	0	3	0	1,197	0	0	196	**23,952**
CL	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	15	0	0	6	**59**
CN	7	0	1	1	56	0	0	0	0	0	82	26	0	0	0	194	0	1,743	0	0	237	**45,770**
CY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**12**
CZ	0	0	0	0	24	0	3	0	0	0	0	0	11	0	0	0	0	202	0	0	14	**3,967**
DE	123	0	196	6	713	3	15	0	0	0	1,618	275	0	3	2	4	0	10,029	0	4	1,133	**388,231**
DK	0	0	0	0	20	0	0	0	0	0	95	7	0	0	0	1	0	430	0	0	306	**7,351**
EE	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	6	**87**
EG	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	43	0	0	0	**49**
ES	0	0	0	0	35	0	1	6	0	0	128	2	0	0	0	0	0	589	0	1	142	**11,634**
FR	3	0	74	0	534	0	1	0	0	0	377	4	0	0	1	2	0	3,460	0	0	523	**25,899**
HK	0	0	0	0	1	0	0	0	0	0	2	5	0	0	0	3	0	131	0	0	32	**572**
HU	0	0	3	0	1	0	0	0	0	0	140	0	0	0	0	0	0	109	0	0	74	**1,170**
IE	0	0	1	0	3	1	0	0	0	0	54	2	0	0	0	0	0	584	0	6	62	**1,562**
IN	1	0	0	0	79	0	1	0	0	0	16	6	0	0	0	0	0	2,402	0	0	167	**3,624**
IT	1	0	19	0	92	0	4	6	0	0	218	2	4	0	4	0	0	1,713	0	0	181	**15,473**
JP	17	0	0	0	109	0	0	0	0	0	125	39	0	0	0	20	0	3,103	0	0	226	**51,152**

Table 5.2: Overview of Patent Data - Continued

country of inventor	AT	BE	BG	BR	CA	CH	CL	CN	CY	CZ	DE	DK	EE	EG	ES	FR	HK	HU	IE	IN	IT	JP
KR	0	11	0	0	0	10	0	0	0	0	74	0	0	0	0	3	3	0	0	0	3	24
LT	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
LU	0	0	0	1	0	0	0	0	0	0	22	0	0	0	1	4	0	0	0	0	4	0
MT	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
NL	13	112	0	0	169	252	0	0	0	5	1,186	62	0	0	12	52	0	0	30	0	10	18
NZ	4	1	0	0	0	7	0	0	0	0	13	0	0	0	0	0	0	0	1	1	1	1
PL	2	1	0	0	0	74	0	0	0	0	91	2	0	0	2	3	0	0	0	0	1	0
PT	1	2	0	0	2	2	0	0	0	0	105	3	0	0	12	1	0	0	0	0	1	0
RO	1	1	0	0	1	3	0	0	2	0	49	0	0	0	0	1	0	0	25	0	0	0
RU	2	15	0	0	30	36	0	0	0	1	156	7	0	0	2	13	0	1	0	0	7	9
SE	13	57	0	0	4	636	0	29	0	0	423	86	0	0	0	17	0	0	24	0	1	1
SG	4	1	0	0	2	33	0	3	0	0	226	42	0	0	0	19	0	0	0	0	9	8
SK	6	0	0	0	1	4	0	0	1	36	67	0	0	0	0	7	0	1	0	0	3	0
TH	0	0	0	0	0	4	0	0	0	0	6	1	0	0	0	1	0	0	1	0	0	2
TR	1	2	0	0	0	2	0	0	0	0	74	3	0	0	2	1	0	0	0	0	2	0
TW	0	1	0	0	0	24	0	44	0	0	44	0	0	0	1	2	99	0	0	0	1	12
UA	0	3	0	0	0	1	0	0	0	0	13	0	0	0	0	0	0	1	0	0	1	0
US	53	709	0	8	2,179	4,196	1	72	0	0	5,591	303	0	0	56	830	37	5	396	4	172	776
VE	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0
ZA	0	1	0	0	0	11	0	0	0	0	37	0	0	0	0	7	0	0	1	0	1	0
other	54	139	0	7	388	1,078	0	5	2	5	2,277	184	0	0	60	155	23	0	177	9	62	99
total	**8,641**	**7,520**	**44**	**338**	**14,079**	**34,034**	**10**	**42,981**	**12**	**3,532**	**391,683**	**6,719**	**30**	**1**	**10,197**	**18,589**	**769**	**597**	**1,859**	**609**	**11,764**	**47,787**

country of inventor	KR	LT	LU	MT	NL	NZ	PL	PT	RO	RU	SE	SG	SK	TH	TR	TW	UA	US	VE	ZA	other	total
KR	22,371	0	0	0	3	0	0	0	0	0	228	3	0	0	0	6	0	375	0	0	7	**23,124**
LT	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	2	**28**
LU	0	0	300	0	1	0	0	0	0	0	1	0	0	0	0	0	0	210	0	0	0	**544**
MT	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	7	**13**
NL	0	0	1	3	12,974	1	2	1	0	0	391	4	0	0	0	2	0	1,571	0	3	393	**17,267**
NZ	1	0	1	0	3	476	0	0	0	0	23	2	0	0	0	0	0	118	0	0	59	**712**
PL	1	0	0	0	3	0	3,868	0	0	0	19	0	0	0	0	9	0	71	0	0	38	**4,185**
PT	0	0	0	0	4	0	0	167	0	0	1	0	0	0	0	0	0	21	0	0	29	**351**
RO	0	0	0	0	4	0	0	0	76	0	1	0	0	0	0	0	0	44	0	0	6	**214**
RU	9	0	0	0	26	0	7	1	0	186	2	0	0	0	0	6	1	377	0	0	47	**941**
SE	1	0	0	0	91	0	2	0	0	0	11,933	1	0	0	0	2	0	872	0	4	435	**14,632**
SG	0	0	0	0	27	0	0	0	0	0	11	913	0	0	0	9	0	509	0	0	46	**1,862**
SK	0	0	1	0	0	0	0	0	0	0	0	0	156	0	0	0	0	14	0	0	11	**308**
TH	0	0	0	0	2	0	0	0	0	0	2	0	0	1	0	0	0	32	0	0	12	**64**
TR	0	0	0	0	4	0	0	0	0	0	0	2	0	0	308	0	0	54	0	0	5	**460**
TW	1	0	1	0	7	0	1	0	0	0	6	10	0	0	0	10,142	0	423	0	0	33	**10,852**
UA	0	0	0	0	2	0	7	0	0	1	0	0	0	0	0	0	38	43	0	0	7	**117**
US	68	0	39	0	1,599	15	3	2	1	1	1,447	466	0	0	6	284	0	394,187	0	8	4,023	**417,537**
VE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	5	**30**
ZA	0	0	0	0	11	1	0	0	0	0	1	0	0	0	0	0	0	45	0	470	34	**620**
other	4	0	13	3	1,044	7	5	2	0	3	1,314	107	1	0	1	20	0	13,017	0	29	52,664	**72,859**
total	**22,614**	**15**	**729**	**22**	**18,175**	**504**	**3,929**	**187**	**77**	**191**	**18,830**	**1,930**	**173**	**4**	**322**	**10,722**	**39**	**444,824**	**0**	**529**	**61,647**	**1,187,258**

Notes: The table contains an overview of the sample of patents I use in the empirical analysis, drawn from the Orbis Bureau van Dijk database. All patents are broken down to inventor and applicant country. For example, a total of 388,231 patents were invented in Germany throughout the period from 1990 to 2013, while 368,047 (94.8%) of these patents are also owned in Germany. The rest is owned in other countries, e.g. 821 patents are owned in Austria, 451 in Belgium, etc. Overall, 391,683 patents are owned in Germany, but 23,636 of these were invented in other countries than Germany.

but then are owned in the low-tax country is much higher than in high-tax countries. In Ireland, for example, 57% of Irish-owned patents were invented abroad, while in The Netherlands 28.6% of Dutch-owned patents were invented in a foreign country. These countries also observe a higher percentage of home-invented and foreign-owned patents though (48.8% in Ireland, 25% in The Netherlands), which means that they observe a higher degree of internationalization in general.

5.3.2 Corporate Taxation

To measure the relevant corporate tax regulations applying to the R&D investment decision, I cooperated with the internationally operating tax consultancy PwC in collecting the data.[12] I designed a questionnaire that was sent to 50 PwC country offices and received 42 responses. The questionnaire was filled out by a tax practitioner in the respective country office and sent back to PwC Frankfurt, who coordinated the survey. By this means, I was able to collect relevant tax information about the regulations that apply to cross-border R&D investments in 42 countries.

The questionnaire was structured in two parts that addressed R&D relevant tax aspects. The first part addressed contract R&D while Part II addressed tax consequences of a transfer of an intangible asset cross-border. In Part I, I sketched the scenario of a contract R&D agreement to make sure that all respondents know the case I refer to in the questions. Specifically, I have a multinational enterprise in mind with an R&D performing company in country A. The group's IP company located in country B enters into a contract R&D arrangement, whereby the R&D company performs R&D activities on behalf of the IP company. the IP company, in turn, will legally own the IP rights developed and pays an arm's length compensation to the R&D company. The respondents were then asked to answer all questions from the perspective of country A, the R&D company's country. First, I asked whether the concept of contract R&D is generally accepted in their jurisdiction. All countries answered that *contract R&D is always accepted* (40.5%) or is *accepted given certain requirements are met* (59.5%). There is no country in the sample, where contract R&D is not accepted at all. Furthermore, I went on to ask for the mark-up that is part of a fee paid by a firm contracting out its research activities to a foreign affiliate. I first asked, whether '*a cost-plus method will apply in determining the arm's length compensation*' for a contract agreement. 22% answered '*Yes, always*' and the majority of about 78% said that '*It depends, but yes under certain conditions*'. Also, there is no country where the cost-plus method never applies to a contract R&D agreement. In a follow-up question I asked for the average mark-up applied by a jurisdiction in the years from 1990 to 2013. Precisely, tax practitioners were asked

[12] Especially, I want to thank Manuel Imhof from PwC Frankfurt for his great support.

Table 5.3: Country Coverage

Country	mark-up	exit tax	Country	mark-up	exit tax
Austria	✓	2005-2013	Latvia	-	2013
Belgium	✓	✓	Lithuania	-	✓
Brazil	✓	✓	Malta	-	✓
Bulgaria	✓	✓	Netherlands	-	-
Canada	-	✓	New Zealand	✓	✓
Chile	-	✓	Poland	-	2013
China	✓	✓	Portugal	-	✓
Cyprus	✓	✓	Romania	-	✓
Czech Republic	✓	✓	Russia	-	✓
Denkmark	-	✓	Singapore	-	-
Egypt	✓	✓	Slovakia	2004-2013	2004-2013
Estonia	✓	✓	South Africa	2001-2013	2001-2013
France	✓	✓	Spain	✓	✓
Germany	✓	1990-2010	Sweden	2013	2008-2013
Hong Kong	-	✓	Switzerland	-	-
Hungary	-	-	Taiwan	-	-
India	-	✓	Thailand	-	-
Ireland	-	✓	Turkey	-	2004-2013
Italy	-	✓	Ukraine	✓	✓
Japan	-	✓	United States	✓	-
Korea	✓	✓	Venezuela	-	2008-2013
Total				19	35

Notes: This table provides an overview of the countries for which I have information about their average mark-up and their exit tax rate. The information has been collected within a survey in collaboration with PwC. ✓indicates full coverage for the period from 1990 to 2013.

'*What is the most common mark-up accepted by the tax authority of your jurisdiction? Please indicate the most common mark-up m if the taxpayer has real costs of 100 so that revenues are taken to be 100 + m.*' Column 1 in Table 5.3 depicts which countries answered to this question.

Column 2 of Table 5.3 presents the countries for which I collected data about their exit tax rate. Similarly to the section on contract R&D, I first sketched the case to establish a common ground of understanding in Part II. I imagine a multinational enterprise with an IP company located in country A. This IP company transfers an intangible to a foreign affiliate of the same multinational enterprise that is located in country B. Again, tax practitioners were asked to fill out the questions from the perspective of country A. I asked them, whether the cross-border transfer of the legal and/or beneficial ownership of a patent constitutes a taxable event in their jurisdiction. 95.2% answered with '*Yes*', while only two countries negated the question. Hong Kong stated that '*In Hong Kong, generally capital gains are not taxable under profits tax. However, particular facts and circumstances should be considered for each case and if the transfers are considered trading profits, it will be taxable under profits tax*'. Hence, the cross-border transfer out of Hong Kong may be subject to tax in certain cases only. On the other hand, in Singapore, '*the* *transfer of intangible assets, if considered to be a capital asset, is not taxable in Singapore as it does not tax capital gains. However, post IP transfer transactions need to be documented appropriately*'. Regarding the amount of tax imposed on such a transfer, I went on to ask: '*If the transfer of the IP constitutes a taxable event, what will be the tax imposed? Please indicate the tax t that is imposed if the transferred asset had a value of 100.*' All other questions are descriptive in nature and are therefore not used in the empirical analysis.

With respect to the typical caveats in survey research (see Section 3), I believe that they are of minor relevance in my case. As I do not survey on the level of the observational unit (which is the patent in this study) but on the aggregate level of a country, I compare the number of responses to the number of countries that have been investigated in related studies that use similar estimation methods. For example, Griffith et al. (2014) analyze 14 countries, Buettner and Ruf (2007) analyze 18 countries, Feld et al. (2013) compare 20 countries and Barrios et al. (2012) 33 countries. Although the response rate is high and 42 countries (84%) sent back the questionnaire, not all questions were answered properly. Therefore, with respect to the mark-up variable I only have information about 19 countries, while with respect to the exit tax rate I am able to include 35 countries in the estimations. Moreover, I do not fear any measurement error from inappropriate answers, because I conducted the survey only among tax experts. In this respect, I am convinced that I even receive the best possible data as I rely on the expert knowledge from practitioners.

5.3.3 Control Variables

To allow for country- and firm-specific heterogeneity, I include several control variables into the regression framework. First, I control for several country characteristics that likely have an impact on the decision on where to conduct R&D activities or to hold intellectual property rights. I include market size as measured by GDP, since it has been shown that it significantly impacts on location choice (Boehm et al., 2012; Griffith et al., 2014). In line with prior literature, I expect that market size exerts a positive effect on the probability that a country is chosen as investment location. Next, I control for the wage level in a country by additionally including GDP per capita. This variable should capture the costs of the labor force in a country, which is especially relevant for R&D investments as these are typically labor intensive. However, the effect of the wage level on the probability of location is a priori ambiguous, as has been shown in prior literature (Kimino et al., 2007). On the one hand, higher wages might signal high skilled workers, which may be crucial for the success of an R&D project. On the other hand, lower wages provide a cost advantage to the firm. Another factor that is important in the location decision of

Table 5.4: Descriptive Statistics and Correlations

Panel A: Definitions and summary statistics for variables in main regressions

Variable	Definition	Source	# Obs.	Mean	Std. Dev.	Min	Max	Median
Tax factors								
statutory tax rate τ	corporate income tax	ZEW	15,874,749	29.49	8.51	10	57.25	30
composite tax rate T_c	takes on the value of the statutory tax rate for traditional R&D and the effective tax payable in the inventor and owner country for contract R&D, see equation (5.3)	own calculation	6,371,481	36.5	5.79	0	57.25	36.15
mark-up m_i	determinant of transfer price based on cost-plus method	PwC	5,528,464	7.52	4.09	0	17.5	7.5
exit tax rate e_o	tax upon cross-border transfer of an asset	PwC	6,036,071	20.22	14.27	0	57.25	25
eff.tax inventor c. T_i	tax payable in inventor country for contract R&D, see equation (5.1)	own calculation	5,496,416	11.6	7.19	0	28.88	11.63
eff.tax owner c. T_o	tax payable in owner country for contract R&D, see equation (5.2)	own calculation	5,496,416	25.32	9.22	0	57.25	25.41
Location factors								
market size	Natural logarithm of GDP, current prices	World Bank	15,874,749	25.9	1.77	22.11	30.07	25.86
wage level	GDP per capita in thousand USD, current prices	World Bank	15,874,749	15,373.22	12,419.64	387.74	53,628.23	12,455.57
tech. innovat.	Number of researchers scaled by population	World Bank	15,874,749	.06	.15	0	1.05	.01
rule of law	Index variable based on nine dimensions	World Justice Project	15,874,749	.86	.85	-1.38	1.99	.98
Location-specific firm factors								
distance to MNE	simple distance between most populated cities, in thousand kilometers	CEPII	15,874,749	5,596.15	3,996.46	6.69	19,586.18	6,160.56
MNE presence	Natural logarithm of one-year lagged tangible assets of all subsidiaries of an MNE located in a country	Orbis Bureau van Dijk	15,874,749	-2.82	4.63	-4.61	19.93	-4.61

Panel B: Correlation matrix for variables in main regressions

Variable	τ	T_c	m_i	e_o	T_i	T_o	market size	wage level	tech.innovat.	distance	presence	rule of law
τ	1.0000											
T_c	0.6325	1.0000										
m_i	-0.0378	-0.2650	1.0000									
e_o	0.4450	0.1545	0.1635	1.0000								
T_i	0.3551	0.0190	0.9104	0.3278	1.0000							
T_o	0.1552	0.6572	-0.8636	-0.1577	-0.7410	1.0000						
market size	0.4389	0.2684	-0.0392	0.2106	0.1898	0.0261	1.0000					
wage level	0.1409	0.0735	0.1948	-0.0919	0.2963	-0.1788	0.3341	1.0000				
tech. innovat.	-0.0575	-0.3203	0.3179	-0.1980	0.0892	-0.2931	-0.3604	0.4494	1.0000			
distance to MNE	-0.0895	-0.1633	0.3001	-0.0936	0.2603	-0.3014	0.0332	-0.1666	-0.0626	1.0000		
MNE presence	-0.0724	-0.1507	-0.0305	0.1151	-0.0724	-0.0517	0.1411	0.1093	-0.0405	-0.1212	1.0000	
rule of law	0.0500	-0.0248	0.3546	0.0451	0.3738	-0.3135	0.0723	0.7687	0.3060	-0.1015	0.1038	1.0000

Notes: Panel A provides an overview and descriptive statistics of the variables incorporated in the empirical analysis. More details on the geographical data from the CEPII (Centre d'Etudes Prospectives et d'Informations Internationales) Database are provided in Mayer and Zignago (2011). The corporate income tax rates are obtained from the Centre for European Economic Research (ZEW) in Mannheim. Panel B presents Pearson correlation coefficients for all variables of the main regressions. All correlations are statistically significant at the 1% significance level.

R&D investments is the technological innovativeness of a country, which I measure as the number of researchers proportional to the population. I expect that the higher technological development of a country is positively associated with probability of location choice. Last, I control for the country's legal environment which is captured by an index known as the rule of law provided by the World Justice Project. This factor contains nine dimensions which are constraints on government powers, absence of corruption, open government, fundamental rights, order and security, regulatory enforcement, civil justice, criminal justice and informal justice. Rule of law is expected to exert a positive effect on the probability of location.

In addition, I control for two firm-specific characteristics. First, I include the bilateral variable distance between the potential location and the country where the decision maker, the MNE, resides. The distance is calculated between the most populated cities of the respective countries and is measured in thousand kilometers. It has been shown that distance has an impact on location choice of FDI (Shatz, 2010). I argue, that the closeness of an R&D location to the headquarter company could make a location more attractive, because of lower costs of knowledge transfer. Second, I include a variable that captures whether the MNE is already present in the potential country for a new R&D investment. The historical presence of the MNE might have some agglomeration effect and attract further investments in that country, as has been established by previous literature on agglomeration economies (Bobonis and Shatz, 2007; Head et al., 1995). Hence, I control for the one-year lag of tangible assets that are attributed to the MNE in the respective location and expect a positive effect on the probability of location. In order to calculate this figure, I extract information from the Orbis company account's database and data about the ownership structure of the MNE. This allows me to identify all subsidiaries of the MNE. For my purposes I only consider subsidiaries where the MNE's interest exceeds the threshold of 50%. Next, I collect information from the unconsolidated company accounts from each subsidiary about its reported tangible assets. Ultimately, I aggregate the one-year lagged tangible assets figure across all subsidiaries belonging to the same MNE in a respective country.

Table 5.4 Panel A presents descriptive statistics for all variables included in the empirical analysis. Panel B documents Pearson correlation coefficients on tax, location and location-specific firm factors. The statutory tax rate and the composite tax rate are positively correlated, which is not surprising due to the definition of the composite tax rate. Also the statutory tax rate is positively correlated with the exit tax rate. This is, because in most countries the tax rate upon the hidden reserves of the transferred asset is just the statutory tax rate itself, because the income is deemed to be ordinary business income. In a few countries, though, a lower tax rate than the statutory tax rate is levied, for example the capital gains tax rate or a similar type of taxation (Kroppen and Silva, 2011). Furthermore, the statutory tax rate is positively associated with market size and the wage level, indicating that bigger economies and economies with a higher wage level tend to levy higher corporate tax rates. On the other hand, technological innovativeness is slightly negatively associated with the statutory tax rate. This suggests that economies with a relatively high number of researchers are not necessarily high-tax countries. The composite tax rate reveals similar correlations as the statutory tax rate. On the contrary, the exit tax rate is only positively correlated with market size, but negatively associated with wage level and technological innovativeness.

5.4 Empirical Model

Following previous literature (Boehm et al., 2012; Griffith et al., 2014) I analyze the location choice of a multinational enterprise with respect to its R&D investment in a conditional logit model framework introduced by McFadden (1974, 1976). I assume that the firm plans to invest in R&D to generate a patent and earn an economic rent on this patent. Therefore, it has to decide in which country it will locate real R&D activity and the ownership of the patent. Both, the decision where to locate real R&D activity and second, the decision where to legally own the patent are determined partly by tax factors and also by other factors like the economic and political landscape in the respective country or special attributes of the firm relating to that country. Some of these factors are observable, others may be unobservable to the econometrician.

The empirical model assumes that the multinational firm f realizes a payoff from locating the real R&D activity (the legal ownership, respectively) of patent p in country i which is given by

$$\pi_{pit} = \boldsymbol{\alpha}^\top \mathbf{T}_{it} + \boldsymbol{\beta}^\top \mathbf{T}_{pit} + \boldsymbol{\gamma}^\top \mathbf{X}_{it} + \boldsymbol{\delta}^\top \mathbf{X}_{fit} + \epsilon_{pit} \tag{5.4}$$

where T is the vector of tax factors, X the vector of observable country- and firm-specific characteristics and subscript t indicates the time period. While the statutory tax rate, the mark-up and the exit tax rate are country-specific variables, the composite tax rate as well as the effective tax rate in the inventor country and the effective tax rate in the owner country vary across both, countries and patents. Similarly, the vector of control variables X contains variables that vary across countries only and variables that vary across countries and firms. Unobservable country-specific effects are controlled for by the inclusion of country dummy variables. Consequently, the firm aims to maximize its payoff function and therefore chooses one location over the other if

$$\pi_{pi^*t} > \pi_{pit} \; \forall \; i^* \neq i. \tag{5.5}$$

The probability that location i^* is the one chosen from all alternatives is given by

$$\begin{aligned} &Pr(\pi_{pi^*t} > \pi_{pit} \mid T_{1t}, T_{p1t}, X_{1t}, X_{f1t}) = \\ &= \frac{exp(\boldsymbol{\alpha}^\top \mathbf{T}_{it} + \boldsymbol{\beta}^\top \mathbf{T}_{pit} + \boldsymbol{\gamma}^\top \mathbf{X}_{it} + \boldsymbol{\delta}^\top \mathbf{X}_{fit})}{\sum_{n=1}^{N} exp(\boldsymbol{\alpha}^\top \mathbf{T}_{nt} + \boldsymbol{\beta}^\top \mathbf{T}_{pnt} + \boldsymbol{\gamma}^\top \mathbf{X}_{nt} + \boldsymbol{\delta}^\top \mathbf{X}_{fnt})} \; \forall \; i \in (1, ..., N). \end{aligned} \tag{5.6}$$

In the following, the parameters α, β, γ and δ will be estimated.

5.5 Results

This section presents results from regressions of a binary choice variable on factors influencing the decision among the alternatives. The dependent variable is a dummy variable indicating the alternative that has been chosen from the choice set. The observational unit is a patent that may be invented and owned in 42 potential countries.

In a first step I examine the decision where to locate real R&D activity, the results of which are presented in Table 5.5. In Specification (1) I regress location choice on the statutory tax rate in the inventor country and control variables. The coefficient estimate is not significant, indicating that taxes are of minor or no relevance in the decision on an inventor country. In a next step, I investigate the impact of the composite tax rate variable, as introduced in Equation (5.3), see Specification (2). The composite tax rate variable measures the effective tax burden that will be payable by the multinational firm upon the profits stemming from the investment in R&D. In contrast to regressing location choice merely on the statutory tax rate, the composite tax rate better represents the trade-off a firm faces in this decision. Surprisingly, the composite tax rate exerts a positive effect on location choice, statistically significant at 1%. The positive coefficient estimate indicates that an increase in the composite tax rate in one country leads to an increase in the probability that this country is chosen and a decrease in the probability that any other country will be chosen. The average marginal effect for Germany, for example, is 0.003385 or 0.002480 for the US.[13] This means that an increase in the tax rate in Germany (US) that causes an increase in the composite tax rate by 1% increases the probability that Germany (the US) is chosen as an inventor country by 0.003385 (0.002480), for

[13] I calculate the average marginal effect as suggested by Cameron and Trivedi (2010).

a fictional observation with all control variables set to sample mean. On the first glance, this result is surprising, because it suggests that the firm chooses an inventor country that is associated with a higher tax burden over an inventor country with a lower one. However, the investment in R&D activity comes along with high costs and these are most valuable if they can be deducted against a high tax rate.

I, therefore, closer investigate this argument in Specifications (3) to (6). In Specification (3) I regress location choice on the statutory tax rate of the inventor country and the mark-up separately. While the statutory tax rate now exerts a significantly negative effect on location choice, the coefficient estimate on mark-up is significantly positive. The mark-up determines the tax base that remains taxable in the inventor country in case the firm chooses to engage in contract R&D. The positive estimate on mark-up indicates that the firm prefers to invent in a country that demands a higher mark-up. This makes sense only, if the firm contracts out research to a low-tax country. The mark-up may not be confused with the final tax burden the firm faces in the inventor country and thus, I regress location choice on the separate factors that form part of the composite tax rate variable in Specifications (4) to (6).

The composite tax rate variable consists of the tax T_i a firm has to pay in the inventor country, as given in equation (5.1), and the tax that is payable on the remaining part of profit in the owner country, as given in equation (5.2), if the firm contracts out research to a foreign affiliate. Specification (4) regresses location choice on T_i and controls. The coefficient estimate on T_i turns out to be negative and statistically significant, indicating that an increase in the tax that has to be paid in the inventor country decreases the probability that this country will be chosen as an inventor location. This result is reasonable, because the researching company will never incur a loss, but will always receive a remuneration for the costs it incurs and in most cases also a small amount of profit. Therefore, the costs will not be deducted against the tax rate that is applicable in the inventor country and, thus, the argument of deductibility does not apply. Specification (5), on the other hand, regresses location choice on the tax burden that the firm would face in the owner country if the firm engages in contract R&D. The significantly positive coefficient estimate suggests that a location is more likely to be chosen as an inventor country, if the tax payable in the owner country thereby increases. The tax payable in the owner country is partly determined by the inventor country, because only profits exceeding the mark-up are taxable in the owner country. All else equal, the tax burden in the owner country decreases in the mark-up of the inventor country, and vice versa. That is, a decrease in the mark-up of a country leads to an increase in the tax burden in the owner country and a higher probability that the country is chosen as an inventor location. Again, this result seems to be counter-intuitive at first sight. However, the firm will deduct the costs incurred by the R&D investment in the country where the patent is owned. Hence, the firm prefers to deduct costs against a high tax rate, at the expense that profits are subject to a higher tax rate. Last, I regress location choice on both, T_i and T_o, and find that the positive coefficient estimate on T_o remains significantly, while the estimate on T_i is not significant anymore.

Overall, the findings confirm the notion that the argument of deductibility of costs against a high tax rate is more important than the argument of a low profit tax rate. As outlined in Section 5.2, the firm may choose between financing the R&D investment from a high-tax location which means deductibility of costs against a high tax rate and a high profit tax rate, on the other hand. Or the firm may choose to finance the investment from a low-tax location which would result in a low profit tax rate, but also in the deductibility of costs against the low rate. Consequently, it is not surprising that the statutory tax rate in the inventor country does not impact significantly on the decision on where to locate real R&D activity, because it does not necessarily determine the deductibility of costs nor the taxation of profits. Much more important is the composite tax rate variable that better represents the relevant tax criterion in this decision. The argument of deductibility seems to be of high importance to firms, since a higher composite tax rate exerts a positive effect on location choice. According to the underlying assumptions, this also means that a higher tax is associated with a higher payoff to the firm (see Equation (5.5)). One possible explanation for this could be that firms engage in later profit shifting activities and therefore do not a priori care about a high profit tax rate. In order to explore this line of argumentation, I also investigate the location decision on the owner country.

With respect to other factors that I controlled for in the regression analyses, the results confirm that the market size positively impacts on the decision where to locate real R&D activity. The effect is statistically significant at 1% throughout all specifications. Furthermore, it is also remarkable that the coefficient estimates of both country-firm-specific variables show a very robust effect across all specifications of Table 5.5. First, distance to MNE exerts a negative effect on location choice that is statistically significant at 1%. This finding indicates that research activity is preferably located closer to the headquarter company. A second interesting finding is that the presence of the MNE in a certain country seems to attract research activity. The coefficient estimate on MNE presence is significantly positive at 1% suggesting that the stronger the presence of an MNE in a country, the more likely it is that the MNE will locate further R&D activity in that country.

Table 5.6 presents results on the owner country decision. Again, the dependent variable in all regressions is a binary choice variable, now indicating which alternative was chosen as an owner country for IP. In Specification (1), I regress location choice on the statutory tax rate of the owner country and do not find a significant

Table 5.5: Regression Results for Inventor Country Decision

Variables	(1)	(2)	(3)	(4)	(5)	(6)
τ_i	-0.002					
	(0.005)					
T_c		0.032***				
		(0.012)				
m_i			0.282***			
			(0.096)			
T_i				-0.030**		-0.008
				(0.013)		(0.011)
T_o					0.148***	0.145***
					(0.035)	(0.035)
market size	3.457***	4.092***	4.521***	4.814***	4.920***	4.990***
	(0.427)	(0.393)	(0.410)	(0.389)	(0.425)	(0.405)
wage level	-0.131***	-0.092*	-0.036	0.002	-0.009	-0.001
	(0.015)	(0.049)	(0.048)	(0.045)	(0.049)	(0.047)
tech. innovat.	1.536	-19.398***	-52.950***	-31.381***	-31.677***	-31.578***
	(4.131)	(6.408)	(11.049)	(9.087)	(9.031)	(8.891)
distance to MNE	-0.438***	-0.417***	-0.425***	-0.425***	-0.429***	-0.429***
	(0.019)	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)
MNE presence	0.086***	0.062***	0.072***	0.072***	0.074***	0.074***
	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)
rule of law	-0.258	0.403	0.285	0.120	-0.143	-0.171
	(0.273)	(0.298)	(0.317)	(0.350)	(0.427)	(0.436)
Observations	15,874,749	6,371,481	5,528,464	5,528,464	5,496,416	5,496,416
Cases	463,040	446,995	391,781	391,781	389,489	389,489

Notes: The dependent variable in all specifications is a binary choice variable taking on the value 1 if the respective country was chosen as inventor location among all alternative countries and zero otherwise. For variable definitions see Table 5.4. All estimations are based on conditional logit. Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Standard errors in parentheses are robust towards heteroscadasticity and clustering at the level of the MNE.

effect. Similarly, I regress location choice on the composite tax rate variable in Specification (2). Contrary to the inventor country decision, the coefficient estimate on the composite tax rate variable is not significantly positive in the owner country decision. The simplest explanation for this finding would be that there is no statistically significant impact of the composite tax rate variable on the owner country decision. However, the positive effect in the inventor country decision draws upon the conjecture that firms benefit from the deduction of R&D costs against a high tax rate. This argument should also hold in the owner country decision, because the owner of the patent is also the one who finances the investments. Since the two decisions are somewhat related in this regard, I also expect to observe a similar result with respect to the composite tax rate variable. Another explanation is that two effects might cancel each other out in this location decision. Prior studies already investigated the location choice of the patent owner and document negative tax effects on location choice (Griffith et al., 2014; Boehm et al., 2012; Karkinsky and

Riedel, 2012; Ernst and Spengel, 2011). For example, Griffith et al. (2014) analyze the location choice for patent ownership in a mixed logit framework and find a statistically negative impact of the statutory tax rate. Similarly, Boehm et al. (2012) find that the tax rate negatively impacts on location choice. Both studies interpret their results as reflecting profit relocations to low-tax countries. This effect might also be present in my sample, as well as a positive effect resulting from the use of deductions. Hence, it is also likely that a negative effect of the tax rate compensates for a positive effect.

Furthermore, I examine the effect of the exit tax rate on the owner country decision, controlling for the statutory tax rate in Specification (3) and for the composite tax rate variable in Specification (4). As outlined in Section 5.2 firms might fear a high exit tax rate in the country where they locate property, because an exit tax harms the tax-free movement to a foreign country. Therefore, firms could abstain from locating property in a high-tax country that restricts any exit possibilities. Indeed, I find a statistically significant and negative effect of the exit tax rate on location choice in Specification (4). I go on to argue that the exit tax should appear even more as a barrier in high-tax countries. Following this argumentation, I interact the exit tax rate both with the statutory tax rate (Specification (5)) and with the composite tax rate variable (Specification (6)). Interestingly, this line of argumentation cannot be confirmed by the empirical findings. In Specification (5) the exit tax rate and also the statutory income tax rate exert a negative effect on the owner country decision. The coefficient estimate of the interaction term though, which would be expected to be negative as well, does not show a negative impact on location choice. Thus, in a high-tax country the exit tax exerts a less negative effect on location choice than in a low-tax country. The results are similar if instead of the statutory tax rate the composite tax rate variable is interacted with the exit tax. In Specification (6) the interaction term is also positive, while the effect of the exit tax and the composite tax rate variable are both negative, indicating that the exit tax is less harmful towards investment if the firm faces a higher tax burden as compared to facing a low tax burden in a country.

With regard to all other control variables included in the regressions, the results show that the inventor and owner country decision are similar in many respects. The coefficient estimates of market size are positively significant throughout all specifications. The wage level is negatively significant only in Specifications (4) and (6) indicating that the effect is not robust across all specifications. In contrast to the inventor country decision, technological innovativeness does not exert a significant effect on the owner country decision. Again, I find robust effects of both country-firm-specific variables. Thus, a location is more likely to be chosen as an owner country if it is closer to the headquarter of the MNE and if the MNE is already

Table 5.6: Regression Results for Owner Country Decision

Variables	(1)	(2)	(3)	(4)	(5)	(6)
τ_o	0.001		-0.044		-0.110***	
	(0.007)		(0.028)		(0.038)	
T_c		0.010		0.005		-0.427***
		(0.014)		(0.032)		(0.057)
e_o			0.016	-0.025***	-0.111***	-0.552***
			(0.022)	(0.009)	(0.030)	(0.044)
$\tau_o \times e_o$					0.002***	
					(0.001)	
$T_c \times e_o$						0.010***
						(0.001)
market size	3.704***	5.150***	4.616***	5.805***	5.140***	4.749***
	(0.509)	(0.479)	(0.573)	(0.654)	(0.480)	(0.804)
wage level	0.004	0.004	-0.057	-0.218***	-0.112	-0.695***
	(0.045)	(0.063)	(0.088)	(0.084)	(0.077)	(0.127)
tech.innovat.	2.706	-2.421	7.438	3.933	3.741	-3.861
	(4.896)	(5.041)	(4.657)	(4.539)	(4.103)	(7.035)
distance to MNE	-0.559***	-0.526***	-0.526***	-0.475***	-0.526***	-0.454***
	(0.028)	(0.026)	(0.047)	(0.042)	(0.047)	(0.041)
MNE presence	0.105***	0.094***	0.165***	0.177***	0.165***	0.174***
	(0.011)	(0.010)	(0.013)	(0.016)	(0.013)	(0.015)
rule of law	-0.199	0.426	-0.069	0.862*	0.311	1.333***
	(0.338)	(0.446)	(0.310)	(0.490)	(0.275)	(0.475)
Observations	15,924,206	13,220,713	6,036,071	5,054,165	6,036,071	5,054,165
Cases	464,185	385,533	255,995	214,992	255,995	214,992

Notes: The dependent variable in all specifications is a binary choice variable taking on the value 1 if the respective country was chosen as patent ownership location among all alternative countries and zero otherwise. For variable definitions see Table 5.4. All estimations are based on conditional logit. Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Standard errors in parentheses are robust towards heteroscadasticity and clustering at the level of the MNE.

present in that country.

Summing up the results from Table 5.6, the statutory tax rate and the composite tax rate variable are not found to exert a significant and robust effect on location choice. One reason that could be responsible for this finding is that two opposite effects actually are present and cancel each other out. That is, firms might anticipate the profit potential of the research project and locate high profitable patents in low-tax countries to benefit from a low profit tax burden when the project yields high returns. On the other hand, if a low profit potential is anticipated firms may want to locate the patent in a high-tax country. In this case, they do not fear to be hit by a high profit tax rate, because they only earn a small return anyway. Additionally, they can make use of deductions against a high tax rate. This idea has already been introduced in Chapter 4, where indirect evidence is provided to substantiate this idea, and will be further picked up in Section 5.6.

With regard to the exit tax rate, I find statistically significant evidence that an increase in the exit tax rate is associated with a decrease in the probability that this country is chosen as a location for patent ownership. Thus, I conclude that indeed firms anticipate their profit shifting opportunities and related anti-avoidance regulations in the decision from where to finance an R&D investment, because this will be the location where the patent will be ultimately subject to tax. Last, the results suggest that in high-tax countries - with respect to both, the statutory tax rate and the composite tax rate variable - the exit tax impacts less negatively on location choice than in low-tax countries. Although one would not expect to see this result, an explanation could be that firms who decide to locate a patent in a high-tax country do so for the reason of deducting the costs against a high tax rate. As already discussed above, they do not expect to render high returns on such an investment and therefore, view a high exit tax rate as less disadvantageous than in the case of a patent that is expected to yield a high return and that is located in a low-tax country. Consequently, these findings suggest that it could be worthwhile to closer investigate the argument that patents, which are expected to yield high returns, differently respond to taxes than patents, which are expected to yield low returns or even incur a loss.

5.6 Robustness Checks

In a robustness check I closer examine whether patents with a higher profit potential differently react to taxes than patents with less profit potential. Following previous studies I measure profit potential by the quality of a patent (Ernst et al., 2014; Boehm et al., 2012; Griffith et al., 2014). In the literature, different measures of quality have been applied. Ernst et al. (2014) and Boehm et al. (2012) rely on an index that has been introduced by Lanjouw and Schankerman (2004) and Hall (2007). This index is based on three underlying indicators, which are patent family, forward citations and technological classes and is calculated using factor analysis (see also Chapter 4 Section 4.2.2). In contrast, Griffith et al. (2014) use a dummy variable that equals one if the patent is part of a triadic patent family and zero otherwise. A triadic patent family is given if for a patent a related patent application is filed at each of the EPO, the US Patent and Trademark office and the Japan Patent Office. The authors argue that triadic patents are of higher quality because firms only will accept the costs of filing for patent protection at the major patent offices worldwide if they expect the patent to yield high economic rents.

For the purpose of my analysis, I rely on the three indicators for patent quality already applied in Chapter 4, which are patent family, forward citations and technological classes. The data for these indicators is provided by the Orbis Patent database (Bureau van Dijk). The *family size* of a patent covers all countries where patent protection is sought. These will be the countries where the patentee wants to use the patent in the production process and where the products are ultimately sold to the consumer. Since the cost for patent application increases in the number of countries where protection is sought, a firm will only apply in several countries if it expects the profits to outweigh the cost. Consequently, the size of a patent's family can be interpreted as an indicator of the patent's quality and its future earnings potential. In the data, I only observe patent applications from national patent offices. Therefore, I do not double count any filings at the EPO, where a bundle of national patent applications is administered within one application. I identify the patent family via the priority number that every secondary filing carries and that equals the first application number. Furthermore, *forward citations* provide information about how often a patent has been cited by following patent applications. The citations are an instrument to determine the scope of the patent right relative to prior art in the field. However, not necessarily all innovations which draw on an existing patent in fact acknowledge the reference. Therefore, all necessary citations are added to the application by the patent examiner during the filing process. Moreover, an external patent examiner has the benefit of following a consistent and objective patent citation practice. The number of forward citations provides some information on the importance of the invention for future research in the field and hence, will be another indicator of quality of a patent. Forward citations are a separate data item in the Orbis database. I summed up all forward citations to receive the total number for the analysis. Last, I rely on the number of *technological classes* that have been shown by previous research to be an indicator of technological quality (Lerner, 1994). This is a measure of the scope of application of the respective technology. The technological classes are listed in the patent document and are eight digit codes of the International Patent Classification (IPC) system. Similarly to forward citations, this number is calculated as the sum of technological classes, which are listed in a separate data item in Orbis.

I identify a high-quality patent by means of a dummy variable that takes on the value one if at least two of the indicators exceed the sample mean, and zero otherwise. The so calculated quality variable has mean 0.16 and standard deviation 0.37.[14] 15.7% of all patents are high-quality patents. In the analysis, I interact quality with the main tax variables to see whether tax effects are different for high- and low-quality patents. In general, I expect that firms care more about the profit tax rate than about the deductibility of costs, with respect to high-quality patents. In other words, I expect to see a negative and significant coefficient estimate on the interaction term of the tax parameters with quality. The results are presented in

[14]The mean and the standard deviation are calculated based on the estimation sample used in Specification (1) of Table 5.7.

Table 5.7: Further Regression Results: High- vs. Low-Quality Patents

	Inventor Location Choice				Owner Location Choice		
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\tau_{i,o}$	-0.001				0.003		
	(0.006)				(0.008)		
$\tau_{i,o}$ × quality	-0.004				-0.012*		
	(0.005)				(0.006)		
T_c		0.039***				0.016	
		(0.010)				(0.014)	
T_c × quality		0.015				-0.032***	
		(0.011)				(0.012)	
T_i			-0.034**				
			(0.013)				
T_i × quality			0.021**				
			(0.009)				
T_o				0.152***			
				(0.035)			
T_o × quality				-0.020***			
				(0.006)			
e_o							-0.006
							(0.006)
e_o × quality							-0.010***
							(0.004)
market size	3.467***	-0.141	4.815***	4.912***	3.737***	5.162***	4.123***
	(0.431)	(1.024)	(0.389)	(0.424)	(0.516)	(0.479)	(0.736)
wage level	-0.023	0.087	0.005	-0.006	0.000	0.000	-0.000
	(0.034)	(0.059)	(0.045)	(0.049)	(0.000)	(0.000)	(0.000)
tech. inno.	1.643	-9.272	-31.606***	-30.286***	2.954	-1.682	8.144*
	(4.129)	(5.801)	(9.139)	(9.025)	(4.885)	(5.057)	(4.786)
distance	-0.433***	-0.407***	-0.424***	-0.429***	-0.001***	-0.001***	-0.001***
	(0.017)	(0.02)	(0.018)	(0.019)	(0.000)	(0.000)	(0.000)
presence	0.086***	0.053***	0.072***	0.074***	0.105***	0.094***	0.163***
	(0.009)	(0.007)	(0.009)	(0.009)	(0.011)	(0.010)	(0.013)
rule of law	-0.261	0.027	0.154	-0.119	-0.209	0.413	0.007
	(0.273)	(0.347)	(0.352)	(0.430)	(0.339)	(0.448)	(0.290)
Observations	15,874,749	4,739,565	5,528,464	5,496,416	15,924,206	13,220,713	6,036,071
Cases	374,983	121,899	156,152	155,238	376,805	312,982	154,032

Notes: The dependent variable is a binary choice variable taking on the value 1 if the respective country was chosen as inventor location among all alternative countries and zero otherwise in specifications (1) to (4). In specifications (5) to (7) the binary choice variable takes on the value 1 if the respective country was chosen as patent ownership location and zero otherwise. For variable definitions see Table 5.4. All estimations are based on conditional logit. Asterisks ($*$, $**$ and $***$) indicate statistical significance at the 10%, 5% and 1% level. Standard errors in parentheses are robust towards heteroscadasticity and clustering at the level of the MNE.

Table 5.7.

Specifications (1) to (4) are referring to the inventor location choice. The findings presented in Table 5.5 reveal that the deductibility of costs against a high tax rate is a very important argument to firms in the inventor country decision, as a higher composite tax rate increases the likelihood that a firm chooses a location for real R&D activity. This result still holds when interacting the composite tax rate variable with quality, see Specification (2) of Table 5.7. The effect is even applicable to high-quality patents, as the coefficient estimate of the interaction term turns out to be non-significant. Looking at the tax burden measure in the inventor country T_i for contract R&D agreements, its effect on location choice is significantly negative regarding low-quality patents, but almost fully compensated by the significantly positive interaction effect for high-quality patents (see Specification (3)). That means, that for high-quality patents the tax burden they face in the inventor country if they engage in a contract R&D agreement plays almost no role. On the other hand, the tax burden in the owner country exerts a less positive effect on location choice for high-quality patents (see Specification (4)). The result is reasonable, because high-quality patents are expected to render high returns and thus, the argument of deductibility of costs is of less importance as compared to the concern about a high profit tax rate. Nevertheless, in the inventor location choice the argument of deductibility still prevails over the argument of a low profit tax rate, even for high-quality patents. The results confirm my hypothesis in that the deductibility is of less relevance for high-quality patents as compared to low-quality patents.

The results regarding the owner location choice are presented in Specifications (5) to (7) of Table 5.7. Specification (5) regresses the statutory tax rate of the owner country on owner location choice. As in Table 5.6 the statutory tax rate does not significantly impact on location choice. However, for high-quality patents I observe a negative effect on location choice indicating that the probability to locate a high-quality patent in a country decreases if the statutory tax rate in that country increases. The effect is statistically significant at 10%. The same effect is found for the composite tax rate variable and the exit tax rate. In both cases, the negative effect is statistically significant at 1%. Together, these results suggest that in the owner location choice firms care more about the profit tax rate that is imposed on the returns from R&D. Especially high-quality patents are less likely to be located in a country that has a high tax rate, a high composite tax burden and a high exit tax rate. The effect of the exit tax rate in Specification (7) also documents that firms anticipate adverse tax regulations on a later transfer of assets cross-border.

Overall, the results from Table 5.7 confirm the hypothesis that firms are more concerned about a high profit tax rate than about the deductibility of costs in the decision on an owner location than in the decision on an inventor location. This finding is especially important for high-quality patents. The findings of Specifications (1) to (4) in Table 5.7 also reveal that in the inventor location choice firms choose to locate real R&D activity in a location with a higher profit tax rate to make use of deductions of costs incurred against the high tax rate, even in the case of a high-quality patent. As this is counter-intuitive, firms apparently follow other structures to circumvent high profit taxation if patents yield high returns. For example, they could engage in the later transfer of patents to a low-tax location after they have benefited from deducting costs against a high tax rate. A hint in favor of this conjecture are the significantly negative coefficient estimates on the exit tax rate and on the interaction term of the exit tax rate with the quality dummy in the owner location choice (see Specifications (4) to (6) in Table 5.6 and Specification (7) in Table 5.7).

5.7 Conclusion

Recent developments intend to prevent multinational enterprises from implementing tax practices that merely aim to reduce the overall tax burden of the firm and thus, lead to severe losses in countries' tax revenues. The OECD's report on base erosion and profit shifting (OECD, 2013b) also discusses structures that involve R&D firms collaborating within cost sharing or cost contribution arrangements with a view to generate intellectual property, deduct the costs in a high-tax jurisdiction and locate the intellectual property in another jurisdiction where its profits are subject to a low tax rate. To tackle such practices by introducing new and effective anti-tax avoidance measures, it is important to know how firms may react to such measures. Therefore, this study investigates the sensitivity of innovative activity to taxes. Specifically, I examine whether the tax burden a firm will face by locating its R&D activity in a certain country has an impact on the choice of location for real R&D activity. In this analysis, I will further investigate the effects of anti-tax avoidance measures on the location of innovative activity as well as on the location of patent ownership. This is a crucial question, because if firms anticipate adverse effects from anti-tax avoidance measures and refrain from locating real R&D activity in the respective country, the anti-tax avoidance measure did not achieve the desired result of securing a country's tax base. Rather, it had led to a disinvestment in the respective country with negative welfare effects on employment and the lack of spillovers from innovation.

This study presents evidence that firms care more about the deductibility of costs against a high tax rate than about the high tax rate on profits when they decide where they should locate a new R&D project. Thus, the composite tax variable, which measures the tax burden a firm possibly faces when investing in a respective country, exerts a positive effect on location choice. Consequently, I conclude that firms do not anticipate adverse tax effects on profits from R&D when deciding on the location of innovative activity, but rather think in shorter terms and decide to locate R&D activity in a country where costs are most valuable and can be deducted against a high tax rate. On the other hand, however, the tax rate on profits seems to be of higher importance in the decision on patent ownership, although the model fails to identify a robust negative effect of the statutory and composite tax rate on location choice. A possible explanation could be that both effects, the deductibility of costs and the tax burden on profits, cancel each other out since they act in opposite directions. Nevertheless, I do find a statistically significant effect of the exit tax rate on location choice about patent ownership. As the exit tax rate negatively impacts on location choice, I conclude that firms indeed anticipate adverse effects from anti-tax avoidance measures in the patent ownership location choice. This finding is further substantiated by the findings that in a high-tax country the exit tax exerts a less negative effect on location choice than in a low-tax country or, put differently, that if the exit tax is high the statutory tax rate exerts a less negative effect on the patent ownership location choice. On first sight, this finding seems to be counter-intuitive. One would have expected that firms view the exit tax to be even more harmful given that the patent is located in a high-tax country, because the exit tax prevents from moving the patent into a low-tax location. However, the finding also emphasizes that if the firms would not anticipate adverse effects from a tight exit tax regime, it may find itself in a situation where the patent is owned in a high-tax jurisdiction and cannot be relocated to a low-tax jurisdiction due to a high exit tax. In such a case, I would expect to observe a negative sign on the interaction term of exit tax and the statutory tax rate. As the regression results, however, return a positive sign of the interaction term, I conclude that firms do not even find themselves in situations sketched above. Thus, I further conclude that firms do anticipate that a tight exit tax regime would prevent them from relocating patents to low-tax jurisdictions later to avoid being subject to a high profit tax rate and, hence, do not even locate patents in jurisdictions that impose a high exit tax rate. This finding also confirms the notion by Mutti and Grubert (2009) that firms apparently employ other structures, not observable to the econometrician, to avoid profits being subject to a high tax rate.

Chapter 6

Conclusion

The aim of the presented thesis was to provide empirical evidence on the microeconomics of R&D investments with regard to corporate taxes. In particular, the core research question was how firms react to existing tax regulations that are either designed to incentivize R&D activity or to secure the fiscal sovereignty of states over profits stemming from R&D activity. Three studies have been undertaken to gain more insights in the behavior of firms with respect to their R&D investments. First, a survey study was conducted among 47 top financial and tax managers of very large multinational companies to learn about the decision-making process in R&D intensive multinationals. Second, the question whether R&D tax incentives exert an effect on the quality of R&D projects was tested using data on patent applications to the European Patent Office. Third, evidence on the impact of taxes on the location decisions of R&D investments is provided. The results from the presented studies are summarized in the following:

1. The first part of analyses in our questionnaire was devoted to descriptive evidence to draw a picture of the firms in our sample with respect to their views on R&D tax planning. It provides insights as to what considerations are important to them and what motives drives them to act like they do when investing in R&D and IP, respectively. Thus, in a first question we asked them what factors are important in the decision on the amount of R&D spending. Among financial, accounting and tax factors, the answers reveal that financial and accounting factors are important factors influencing the amount of R&D spending, but taxes are less important. We conclude that R&D investments seem to critically depend on the availability of equity capital and on the liquidity of firms.

2. In a second question, we asked what general country characteristics are important to firms in their decision to locate R&D activity in one country or

another. Similarly, we ask which of these characteristics are important in the location decision for IP. Regarding the R&D location decision, the most important factor are the skills and availability of the workforce. Not surprisingly, tax costs are the least important country characteristic. With respect to the IP location decision, the most important factor is the legal stability and the security of IP, while tax costs are rated second least important. Comparing the answers that were given to the R&D location decision question with the answers from the IP location decision question, the answers differ significantly in three of five country characteristics. Tax costs are slightly more important in the location decision of IP than of R&D. We conclude, that the results highlight the separation of the two location decisions in the decision-making process regarding R&D investments.

3. Furthermore, we compare various tax factors with each other and ask firms to indicate their importance in the R&D and the IP location decision. The results show that the most important factor for the location of R&D activity is the regulation that determines the deductions for R&D expenditure and the most important factor for the location of IP is the double tax treaty network. Moreover, the second an third most important tax factor in the IP location decision are the transfer pricing regulations of a country and the imposition of an exit tax upon the cross-border transfer of assets. R&D and IP location decision also significantly differ in two aspects: the applicable profit tax rate and the imposition of an exit tax are important factors in the IP location decision, while they are of less importance in the R&D location decision. In sum, it seems that in the location decision of IP tax planning considerations are of higher importance as compared to the R&D location decision.

4. One advantage of survey research is that motives can be detected that drive firm's behavior. We thus asked about the considerations in the decision to locate patents away from where R&D took place and motives why firms considered to locate patents at a low-tax affiliate. Respondents agree that they considered the fact that contract R&D is a means to geographically separate the IP location from the location where the associated R&D activity took place. Moreover, they agree to the notion that exit taxes are an important obstacle to the cross-border transfer of patents within the group. Nevertheless, when we asked how they actually achieve to locate patents in low-tax countries, they answered that they rather sell patents to affiliates in low-tax countries than conduct R&D activity in a low-tax country to apply for patent protection afterwards. The most important motive to consider relocating patents to low-tax affiliates is that the expected return related to a patent is high. Also, respondents agree that the relocation of patents to low-tax affiliates reduced

the overall tax burden of the MNE and that it can be achieved in a rather simple way, because patents are mobile assets.

5. More generally, we were also interested how R&D is organized within a multinational firm to get an idea what kind of structures are commonly implemented by firms. The most prevalent form of organization was in-house R&D, followed by contract R&D within the group and pool-financing agreements among several affiliates. Last ranks outsourcing of R&D activity to a third party, e.g. universities or research institutes.

6. We also posed one question that relates to traditional R&D tax incentives like tax credits or additional allowances for R&D expenditure. We were interested which attribute of an R&D tax incentive is most effective in raising additional R&D spending. Our findings confirm prior literature in that on average respondents view an immediate impact on liquidity to be the most important attribute of a tax incentive, followed by planning certainty and simplicity in its administration. Tax planning considerations as reflected by restrictions on the location of R&D activity and the location of patents, respectively are ranked least important. This result is in line with our previous findings, that tax planning considerations are less present in business decisions relating to real R&D activity.

7. In a regression analysis, we test a theory, based on the organizational design literature, for the intensity in which the tax department coordinates with managers from other business units to intervene with real investment decisions. The allocation of management and control in the business decision process finds expression in the coordination intensity between agents in the firm. Our theoretical considerations predict that R&D intensity is an important determinant of the tax department's role. We indeed find supporting evidence that in R&D intensive multinational firms the tax department operates more as a controller than as a manager. In particular, tax departments of R&D intensive firms make less tax planning effort, are less ambitious to minimize the tax burden of the firm, are later involved in the decision-making process of a new investment project, but are more likely to have a veto right in the decision on a new investment project as compared to less R&D intensive firms. Conditional on R&D intensity, however, the level of intangible assets in the firm is associated with more tax planning efforts and ambitions. Our results are statistically significant and robust towards several sensitivity checks.

8. The insights obtained from the survey study allow us to anticipate potential consequences of profit shifting restrictions for the tax department's role in

R&D intensive firms. If such restrictions are put in place, tax planning activities will no longer be shifted to the second stage of the R&D investment process, as IP transfers will be too costly to implement. Thus, forgone tax savings in uncoordinated investment decisions will become increasingly irreversible and tax executives may be incited to intervene earlier and with a stronger focus on decision management. This notion is in line with previous theoretical predictions of adverse investment effects of profit shifting restrictions. While more research on the interrelation of tax avoidance and real economic decisions is certainly required, our findings provide additional support for a careful consideration of the potentially ambiguous effects of tight anti-avoidance legislation.

9. Chapter 4 presents a study on the impact of tax incentives on the quality of corporate R&D projects, i.e. their innovativeness and earnings potential. The study contributes to a strand of research that empirically assessed the effect of special tax provisions on the quantity of R&D activities. We distinguish between traditional R&D tax incentives, like tax credits or additional allowances, and the patent income tax rate, which is the corporate income tax rate accounting for patent box regime where applicable. Exploiting a dataset on patent applications to the European Patent Office, we find that a low patent income tax rate raises the average profitability and innovation level of the projects undertaken in a country. The effect is statistically significant and economically relevant and prevails in a number of sensitivity checks. Generous R&D tax credits and tax allowances are in contrast found to exert a negative impact on project quality.

10. The results from the study of R&D quality may have important implications for the design of tax instruments that aim at fostering and raising R&D activity undertaken by firms. In recent years, we observe a trend in Europe towards the introduction of tax regimes that significantly reduce the corporate tax rate on income from innovation, so-called patent boxes. Policy makers justified the introduction of such regimes with the aim to attract and foster innovative R&D activities. Our findings confirm this notion and suggest that low patent income tax rates are indeed instrumental in attracting R&D projects with an above average earnings potential and innovativeness. On the other hand, we do not find an analogous effect for traditional R&D tax incentives, like tax credits or additional allowances. In fact, our results suggest that traditional R&D tax incentives reduce the average project quality. From a welfare perspective, positive welfare consequences of increases in R&D quantity induced by R&D tax credits and allowances may be partly counteracted by negative effects on average project quality (i.e. lower profitability and thus, a lower contribution

to tax revenues, and less spillovers on other firms in the economy). With respect to low patent income tax rates, the welfare assessment is positive from a national perspective as low patent income taxes do not only expand R&D activity (as suggested by previous work) but also trigger the inflow of R&D activity with above average quality. The picture looks less optimistic from an international perspective though. In particular, as countries compete for internationally mobile R&D projects, projects gained by one country are lost by another. As governments do not account for the consequences of their policy choices on other countries, patent income tax rates are set inefficiently low from a global perspective.

11. The study on the impact of taxes on R&D location decisions reveals that tax factors do impact on R&D location decisions, but they exert different effects in different location choices. In particular, I examine the location of real R&D activity (as proxied by the country of the patent inventor) and the location of IP (as proxied by the country of the patent owner). With respect to the location choice of real R&D activity, the results show that firms care more about the deductibility of costs against a high tax rate than about the high tax rate on profits. This conclusion is reflected in the positive impact of taxes on inventor location choice indicating that a country with a higher tax rate is more likely to be chosen as an inventor location than a country with a lower tax rate. I explain this finding, that on first sight seems counter-intuitive, by the fact that deductible costs are most valuable in high-tax countries. As during the phase of invention only costs occur, the firm primarily benefits from deducting these costs against a high tax rate. These results also hold for high-quality patents.

12. Furthermore, I also investigate the effect of taxes on the location choice of the patent owner country. The baseline results do not confirm that the effective tax burden a firm faces in a country exerts a significant effect on the location choice for patent ownership. However, the exit tax rate of a country negatively and statistically significantly impacts on the owner country decision. Together these findings suggest that while the effective tax burden in the owner country does not play a significant role for the firm, the firm anticipates adverse tax effects from cross-border relocations of patents caused by an exit taxation regime and thus, is less prone to locate a patent in a country with a high exit tax rate. Further regression results suggest that for high-quality patents the effects of the corporate tax rate are indeed significant. The findings show that high-quality patents are less likely to be owned in countries that trigger a high tax burden for the firm.

13. Overall, the study of tax effects on R&D location decisions highlights the importance of expense deductibility in the first stage of the R&D process, when the investment is made and costs occur. Moreover, the results emphasize that in the location choice for patent ownership (the second stage of the R&D process), firms anticipate adverse tax effects from a tight exit tax regime and thus, abstain from locating patents in jurisdictions that impose a high exit tax rate. The corporate tax rate, in turn, does not exert a significantly negative effect on patent owner location choice, except for high-quality patents where it negatively impacts on location choice.

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