INVESTMENT, GROWTH, AND TAX MORALE: ON THE ROLE OF GOVERNMENT POLICY

University of Wuppertal

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Wuppertal, July 2016

INVESTMENT, GROWTH, AND TAX MORALE: ON THE ROLE OF GOVERNMENT POLICY

A dissertation

submitted to
the Schumpeter School of Business and Economics
of the University of Wuppertal

in partial fulfillment of the requirements for the degree
doctor rerum oeconomicarum
(Doktor der Wirtschaftswissenschaft)

by
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Submitted: July 20, 2016
Doctoral defense: January 30, 2017

Die Dissertation kann wie folgt zitiert werden:

urn:nbn:de:hbz:468-20170222-155312-7
[http://nbn-resolving.de/urn/resolver.pl?urn=urn%3Anbn%3Ade%3Ahbz%3A468-20170222-155312-7]

Acknowledgements

Writing this dissertation is an experience comparable to running a marathon. You first decide to participate in the race possibly because you already ran shorter distances like a half marathon and thinking that you can even go further. Training hours were manageable and you quickly made some progress in technique and speed. Then, attempting to run a longer distance proves to be harder than you thought. Despite some setbacks, you keep on training to reach you goal of 42 kilometers. As soon as you are able to run 30 to 35 kilometers in a decent time, you feel ready to run the whole race and decide to register for it. Finally, it is the day of you marathon and you find yourself somewhere in the starting block with the crowd. Kind of excited, nervous, and maybe also worrying about outcome. Hearing the starting signal pushes you at first and you run faster than usually because you see the others outpace you. As you realize that this is not the speed at which you can run the whole race, you slow down a bit and distribute your energy efficiently. And as you reach 35 kilometers, the rest still seems so far because your thighs and knees hurt. Also, your lungs and your heart work at higher level than during trainings. Yet, you just keep on running as you know what awaits you behind finishing line and just run like an engine with only one goal.

Every runner benefits from the numerous supporting people surrounding them during training and the race, therefore I would like to express my appreciation for those who supported me throughout the last years. Most importantly, I am much obliged for the privilege to work in a fruitful environment together with supervisor at the Chair of Public Economics and Taxation at the University of Wuppertal, Prof. Dr. Kerstin Schneider. I highly benefitted from her profound knowledge in the field of public economics and her experience in econometric methods. Also, she enabled me to participate in numerous international conferences and workshops, where I could exchange my ideas with other researchers. I am also grateful to my co-advisor, Prof. Dr. André Betzer, for his valuable support throughout the research processes. Furthermore, I would like to thank my co-authors Prof. Dr. Sebastian Eichfelder and Paolo Bizzozero for the intensive but productive cooperation. Moreover, I would like to thank Prof. Dr. Paul Welfens, Prof. Dr. Werner Bönte, and PD Dr. Claudia Neugebauer for valuable comments on various problems I encountered during my research, but also for the stimulating exchange of ideas. Not to forget, I thank the staff at the Forschungsdatenzentrum of the Federal Statistical Offices of the Bund and Länder in Berlin and the Konjunkturforschungsstelle at the ETH Zürich for the data access and the technical support. In addition, I give thanks to everyone who supported me morally during this marathon with his or her encouragement, friendship, and patience. Among them my current and former colleagues Dr. Christian Dienes, Vladimir Udalov, Niyaz Valitov, Sonja Jovicic, and Simon Oster. Finally, I want to thank my beloved ones, especially my partner in life and crime Charlotte Perrin, my parents, my brothers and sisters as well as friends for their unconditional support and for all the joy with which they fill my life. In case, you are missing your name in this section, you know who you are.

Wuppertal, July 2016 Hung-Viet-Quoc Lai

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1 Introduction

1.1 Motivation

> *"The skill of making and maintaining Commonwealths consisteth in certain rules, as doth arithmetic and geometry; not, as tennis play, on practice only [...]."*
>
> Thomas Hobbes (1651, pp. 128-129) in Leviathan

In Leviathan, Thomas Hobbes describes a government ruling a country led only by its own self-interest and whose legitimacy results from a social contract. Citizens give up rights and freedom to benefit from state protection (Hobbes, 1651, pp. 103-106). This metaphor reflects an outdated understanding of an absolutist form of government. Nowadays, citizens may not approve such legitimacy of the government albeit being enforced in form of dictatorship. Instead, the legitimacy of the government stems from its role as a coordinator in efficiently redistributing wealth in order to stabilize in periods of recessions and to assure long-term growth (e.g., Phelps, 2014; Abulof, 2015).

From an economic perspective, legitimacy of government intervention is rooted in the failure of markets as well as individuals to efficiently optimize (Bator, 1958; Stiglitz, 1989, 1998). Examples of market failures are the presence of externalities (Coase, 1937, 1960; Buchanan and Stubblebine, 1962), asymmetric information between actors in the market (Akerlof, 1970) or imperfect competition (Tirole, 1988, pp. 277-299). One example of government policy to cope with market failures is the use of fiscal policy in the form of direct subsidies or tax incentives directly aiming at the individual level. Especially in times of economic downturns, the government supports the private sector by means of policy (Romer, 1993). But how firms adapt to changes of economic conditions induced by fluctuations and policy is still up to debate.

While the question of *why* public policy intervenes is more easily answered than the question of *how* public policy affects the economy. At the aggregate level, government policy may benefit the economy, which might be in contrast to its effect on entities at the individual level. The effect of public policy on individuals is ambiguous (Ziemann, Cournède, Garda, and Hoeller, 2015). Ziemann et al. point out that any change in economic conditions by public policy affects firm output and hence employment which in turn affects individual earnings. With growth in earnings, consumption might rise, while more volatility in earnings and consumption might dampen consumption growth. Henceforth, the welfare effect of public policy interventions may be the result of two opposing forces in volatility. But when does public policy do more harm than good? In two of the three studies, this thesis contributes to finding answers to this question.

Government intervention is costly; hence spending has to be financed by tax revenue. Therefore, taxpayers might like spending but dislike the fiscal requirements by the government. Although taxpayers feel that they are entitled to benefits from the provision of public goods, taxes by legal definition do not entitle individuals to equivalent benefits that match the payment[1] (e.g., German Federal Ministry of Finance, 2014). Also, taxpayers will try to maximize utility and, eventually, evade the taxes to be paid. Thus, this counteracts the government's capacity to act effectively. A better understanding of the relationship between the government and

[1] "Taxes shall mean payments of money, other than payments made in consideration of the performance of a particular activity" (Sect. 3, article 1, sentence 1, The Fiscal Code of Germany, 2014, translated and published by the German Federal Ministry of Finance).

taxpayers in the context of public policy may help in improving mutually beneficial economic outcomes for both parties.

The field of public economics investigates behavioral interactions between public institutions and private entities, ultimately with the goal to understand how public policy should be designed to maximize welfare (Slemrod, 2010). The study of public economics is predominantly motivated by practical relevance of future policy design and past policy evaluation (Feldstein, 2002).

1.2 The purpose of the study

As the title of this dissertation suggests, I focus on the effect of government policies for the private sector. This dissertation studies the competing forces of the government in shaping fiscal and public policy. It also acknowledges its role in raising revenue to support long-term growth. I address three specific topics that currently challenge economic researchers while the focus of attention is twofold. First, this thesis focuses on *evidence-based analysis of public policy*. Second, it investigates the *formation of attitudes of individuals towards taxes*. Both focuses aim at ultimately enhancing economic outcomes.

The goal of public policy is to sustain an environment that supports long-term growth in a country. With scarcity of resources and political uncertainty, there is higher demand for effective governmental decision-making (Smith, Nutley, and Davies, 2012, p. 361). In contrast to ideology or faith-based legitimacy of governmental intervention, *evidence-based policy* is based on policy-relevant research. Moreover, with increasingly available access to administrative data on the micro-level and the availability of quasi-experimental or even field experiments, the evidence provided becomes more precise and reliable for effective policy-making (Head, 2010).

The first two studies of the thesis analyze firm behavior. From evidence-based policy perspective, firms are particularly interesting because they constitute important contributors to welfare in a state (Tachibanaki, 2007). For instance, firms invest, produce and create new products. Firms' investments, however, depend not only on the prospective return but also have to handle uncertainties in the market (Baum, Caglayan, and Talavera, 2008). Firms face market failures, which justifies governmental intervention. However, the impact of governmental policy is ambiguous (Ziemann et al., 2015). In order to better understand the effects of policy interventions on the economy, research has to inform evidence-based policy. Hence, the first research question to be answered in this thesis is:

> *How does public policy affect the real economic activity of private sector? And how do subsidies impact the longevity of such economic activity?*

To this end, this thesis investigates the effects of public policy in two settings. Both studies apply econometric methods to explain the impact of public policy on the behavior of firms.

Nevertheless, public policy is only capable of acting when tax revenue is generated. The level of taxation in a country is determined by the level of public services provided and by the demand for income redistribution (European Commission, 2015, pp. 23-25). Understanding the behavior of taxpayers is of high interest to public policy because tax policy affects taxpayers' decision in production as well as consumption to a great extent. For this reason, it is necessary to discern the far-reaching consequences of tax compliance and tax evasion for the economy (see Alm, 2012 for a literature review). In this context, studying the individual taxpayers' attitudes towards compliance or evasion is especially beneficial to the understanding of tax behavior.

Given the complexity of tax systems, people tend to take antagonistic positions towards tax authorities (Kirchler, 2007, pp. 31-39). Consequently, taxpayers' evaluation of the government's quality affects the tax morale, i.e. the intrinsic motivation to pay taxes (Feld and Frey, 2002, 2007; Cummings, Martinez-Vazquez, McKee, and Torgler, 2009).

Hence, another research question to be answered in this thesis is:

> *How does taxpayers' perception of government quality affect individual tax morale? And what shapes the way taxpayers perceive the government?*

While the topics of this dissertation might appear to be quite heterogeneous, the common and unifying feature of the three studies is the role of government policy in shaping behavior and attitudes of private entities.

1.3 The structure of the thesis

The thesis is organized as follows. It is divided in four main parts which can each stand for themselves: Chapter 2 reviews the literature and builds the theoretical foundation for the subsequent chapters. Chapter 3 is joint work with Sebastian Eichfelder and Kerstin Schneider. Chapter 4 is joint work with Paolo Bizzozero. Chapter 5 is a single-authored paper. And, Chapter 6 concludes and provides an outlook.

In Chapter 2, *Public policy, economic activity, and tax evasion*, I review the theoretical background for the studies of the following chapters and important empirical findings. Although each study reviews contains a literature review, Chapter 2 gives an overview on the theoretical considerations on which the empirical studies in the subsequent chapters build upon. As the spectrum of this thesis is wide, this chapter focuses on the role of the government in each study.

In Chapter 3, *Long-term effects of fiscal policy and economic convergence: Evidence from German bonus depreciation*[2], we empirically investigate the effect of a bonus depreciation program on long-term firm growth of firms in Eastern Germany after German Unification. The German reunification required the government to facilitate the economic convergence of Eastern Germany to its Western counterpart, i.e. to increase growth in the Eastern part. One main component of the policy instruments was tax incentives. One of the largest interventions was the Development Area Law (DAL) that was used to subsidize business investment in the Eastern part of Germany. The DAL was enacted in 1991 and expired by the end of 1998. It granted generous bonus depreciation for tax purposes of up to 50% of the invested amount during the first year.

Using German administrative plant-level data from 1995 to 2008, we find that bonus depreciation induced investments lead to overinvestment behavior and hence lower growth for plants in Eastern Germany than for Western plants. This study makes use of exogenous variation in tax regulation to investigate the effect of taxes on firm growth through the channel of increased tax-incentivized business investment. Findings demonstrate a positive relationship building investments during the time of the tax incentive in Eastern Germany and growth in the long-run. This however does not hold for equipment investments. Thus, tax incentives to achieve economic convergence of Eastern and Western Germany have induced inefficient investment behavior but accommodated the necessary infrastructure in the new German market.

[2] The paper benefitted from participants' suggestions and comments of the Finanzwissenschaftlicher Workshop 2014 in Hagen, the 70th Annual Congress 2014 of the International Institute of Public Finance in Lugano, the Verein für Socialpolitik Jahrestagung 2014 in Hamburg and the 1st IIPF Doctoral School 2014 in Oxford.

In Chapter 4, *R&D investment behavior during a crisis: What is the role of subsidies?*[3], we empirically investigate the effect of public subsidies on R&D activity of Swiss firms in the light of the financial crisis 2008. We analyze whether R&D investment behavior during the crisis affects the effectiveness of public R&D funds. This study goes beyond previous research on the effectiveness of subsidies by considering changes in firm behavior due to the crisis. Hence, we are able to analyze impact of the crisis and changes in firm behavior on the effectiveness of public subsidies on R&D activity. The results indicate that crowding out might be driven by uncertainties of the economic crisis. Also, we find that firms keeping R&D investment constant during the crisis may alleviate the crowding out. These findings illustrate the importance of considering economic fluctuations and its effect on firm behavior for the evaluation of public policy.

In Chapter 5, *Social capital, religiosity, and tax morale*[4], I empirically study the effect of social capital on tax morale. This study relates to previous attempts to explain tax compliance by shedding light on tax morale as the intrinsic motivation to pay taxes. The novelty of this study is the implementation of an instrumental variable approach. Using European individual-level data on socio-political and value-oriented survey, I estimate individuals' attitudinal response towards taxes using an instrumental variable strategy, instrumenting for social capital with secularization and religiosity.

The results indicate a large effect of social capital on tax morale, consistent with the existing literature, but less reliable effects for less secularized countries. The findings

[3] The paper benefitted from participants' suggestions and comments of the Brown Bag Seminar at the University of Wuppertal in Winter 2015/16 and the DRUID Academy Conference 2016 in Bordeaux.
[4] The paper benefitted from participants' suggestions and comments of the Brown Bag Seminar at the University of Wuppertal in Winter 2015/16 and the 6th Halle Colloquy on Local Public Economics at the IWH in 2015.

point to the relevance of enhancing trust between citizens and the government to secure tax revenues. For policymakers on the level of local public finances, this result emphasizes the importance of considering tax morale in tax compliance strategies and the promotion of institutional trust among citizens instead of increasing audit rates and penalties.

2 Public policy, economic activity, and tax evasion

This literature review[5] discusses theoretical and empirical findings that motivate the studies of this dissertation, which focuses on the interaction of government policy with firm and individual behavior.

2.1 Tax incentives and subsidies for private investments

The neoclassical investment model by Hall and Jorgenson (1967) provides the theoretical framework for the analysis of the impact of tax policy on business investment in this thesis. Jorgenson (1963, 1967) formulate an investment model based on the neoclassical theory of optimal capital accumulation[6]. Under the assumption of perfect capital markets, a firms' goal is to maximize present value of the firm given the production technology by choosing the optimal level of investment. In the simplest case, firms produce one single output Q with one single input L and one single capital unit I. The corresponding prices are p, w, and q. Hence, the profit net of labor costs and investment expenditure of the firm in period t is

$$R(t) = p(t)Q(t) - w(t)L(t) - q(t)I(t). \tag{2.1}$$

Assuming capital to be of infinite life and to depreciate along an exponential path by a constant and continuous discount rate r, the present value of the firm is

$$W = \int_0^\infty e^{-rt} R(t)dt \cdot \tag{2.2}$$

[5] Focusing on concepts and results of previous studies that build the base and intuitively introduce into the widespread topics of the thesis, this literature review does not claim general completeness. Furthermore, Section 2.1 relies to a great extent on previous work by Eichfelder and Schneider (2014).
[6] The notation and presentation of the model in Equations (2.1) to (2.25) draw on Jorgenson (1967) and Hall and Jorgenson (1967).

A firm maximizing its profit faces two constraints. First, the rate of change in the stock of capital in period *t* equals the investment in that period reduced by the depreciated capital stock. Thus, the first constraint reads[7]

$$\dot{K}(t) = I(t) - \delta K(t), \tag{2.3}$$

with $\dot{K}(t)$ as the change in the stock of capital at time *t* and δ being the rate of depreciation of the capital stock. This constraint holds in each period and hence one can for simplicity omit the time subscripts.

Second, the technology is described by a production function

$$F(Q, L, K) = 0. \tag{2.4}$$

The production function is strictly convex and twice differentiable with positive marginal rates of substitution between inputs and positive marginal products of capital and labor.

A firm maximizes its present value (2.2) with respect to the constraints (2.3) and (2.4). Thus, the Lagrangian function is

$$\begin{aligned} \ell &= \int_0^\infty \left[e^{-rt} R(t) + \lambda_o(t) F(Q, L, K) + \lambda_1(t)(\dot{K} - I + \delta K) \right] dt \\ &= \int_0^\infty f(t)\,dt. \end{aligned} \tag{2.5}$$

In order to solve this Lagrangian function, Jorgenson (1967) relies on the Euler-Lagrange equation[8] with respect to output, labor input, investment, and capital

[7] The dot notation denotes the time derivative $\dot{K}(t) = dK(t)/dt$.

[8] Although the following derivation of the necessary conditions can also be obtained by partial integration, applying the Euler-Lagrange equation formulation is more convenient. In more detail, the necessary condition of function of type $I(x) = \int_a^b F(x(t), x'(t), t)\,dt$ with $F(\alpha, \beta, \gamma)$, being a twice-

services as well as the Lagrangian multipliers. Hence, the Euler necessary conditions are given in Equations (2.6), (2.9), and (2.10),

$$\frac{\partial f}{\partial Q} = e^{-rt} p + \lambda_0(t) \frac{\partial F}{\partial Q} = 0 \, ,$$
$$\frac{\partial f}{\partial L} = -e^{-rt} w + \lambda_0(t) \frac{\partial F}{\partial L} = 0 \, , \qquad (2.6)$$
$$\frac{\partial f}{\partial I} = -e^{-rt} q - \lambda_1(t) = 0 \, .$$

The Euler condition with respect to capital services results directly from the Euler-Lagrange equation and reads

$$\frac{\partial f}{\partial K} - \frac{d}{dt} \frac{\partial f}{\partial \dot{K}} = 0 \, , \qquad (2.7)$$

where its components are the derivatives with respect to *K* and $\dot{K}$, i.e.

$$\frac{\partial f}{\partial K} = \lambda_o(t) \frac{\partial F}{\partial K} + \lambda_1(t) \delta \, ,$$
$$\frac{\partial f}{\partial \dot{K}} = \lambda_1(t) \, . \qquad (2.8)$$

Combining these two derivatives in the Euler-Lagrange Equation (2.7), one obtains the Euler necessary condition for capital services, i.e.

$$\frac{\partial f}{\partial K} - \frac{d}{dt} \frac{\partial f}{\partial \dot{K}} = \lambda_0(t) \frac{\partial F}{\partial K} + \delta \lambda_{1,}(t) - \frac{d}{dt} \lambda_1(t) = 0 \, . \qquad (2.9)$$

Lastly, the Euler necessary conditions with respect to the Lagrangian multipliers are

$$\frac{\partial f}{\partial \lambda_0} = F(Q, L, K) = 0 \, ,$$
$$\frac{\partial f}{\partial \lambda_1} = \dot{K} - I + \delta K = 0 \, . \qquad (2.10)$$

---

differentiable function with respect to (α, β, γ) and $x : [a, b] \subset \Re \to X$, using the Euler-Lagrange equation to find the extremum equals $\frac{\partial F}{\partial x} - \frac{d}{dt} \frac{\partial F}{\partial x'} = 0$ (for proof, see, e.g., Hazewinkel, 1995).

By combining the first order conditions with respect to labor and output, we find the marginal productivity of labor to be

$$\frac{\partial Q}{\partial L} = \frac{w}{p}. \tag{2.11}$$

Similarly, we derive the condition for the marginal productivity of capital. Solving (2.6) for $\lambda_1(t)$ gives

$$\lambda_1(t) = -e^{-rt} q, \tag{2.12}$$

and rewriting the first order condition for capital (2.9) yields

$$\lambda_0(t)\frac{\partial F}{\partial K} - \delta e^{-rt} q - re^{-rt} q + e^{-rt} \dot{q} = 0. \tag{2.13}$$

This condition combined with the first order condition for output gives the marginal productivity of capital

$$\frac{\partial Q}{\partial K} = \frac{q(r+\delta) - \dot{q}}{p} = \frac{c}{p}, \tag{2.14}$$

where the implicit rental value of capital services supplied by the firm to itself is

$$c = q(r+\delta) - \dot{q}. \tag{2.15}$$

The expression in (2.14) reflects that, ceteris paribus, one additional unit of capital *K* results in additional output *Q*, which equals the ratio of implicit rental value of capital services and the price of the output. The implicit rental value of capital services *c* in (2.15) depends positively on the output *q*, the discount rate *r* and the rate of depreciation δ but decreases in the rate of change of the output price.

The interpretation of the user cost of capital in (2.15) becomes more evident by relating the price of capital goods to the price of capital services. In more detail, the flow of capital services over a time interval dt beginning at time t from a unit of investment goods acquired at time s is

$$e^{-\delta(t-s)}dt\,. \tag{2.16}$$

With $c(t)$ being the price of capital services at time t, its discounted price is $e^{-rt}c(t)$, the value of the stream of capital services on the interval dt is

$$e^{-rt}c(t)e^{-\delta(t-s)}dt\,. \tag{2.17}$$

Respectively, with q_s as the price of capital goods at time s, its discounted price is $e^{-rs}q(s)$, we derive the value of a unit of investment goods acquired at time s as

$$e^{-rs}q(s)\,. \tag{2.18}$$

However, the value of investment goods acquired at time s equals to the discounted value of all future capital services derived from these investment goods

$$\begin{aligned} e^{-rs}q(s) &= \int_s^\infty e^{-rt}c(t)e^{-\delta(t-s)}\,dt \\ &= e^{\delta s}\int_s^\infty e^{-(r+\delta)t}c(t)\,dt. \end{aligned} \tag{2.19}$$

Hence, solving for the price of capital goods, we obtain

$$\begin{aligned} q(s) &= e^{(r+\delta)s}\int_s^\infty e^{-(r+\delta)t}c(t)\,dt \\ &= \int_s^\infty e^{-(r+\delta)(t-s)}c(t)\,dt. \end{aligned} \tag{2.20}$$

In order to express the price of capital services, which is implicit in (2.17), we differentiate the price of capital goods with respect to time. This yields

$$\dot{q}(s) = \left[r(s)+\delta\right]q(s) - c(s)\,, \tag{2.21}$$

and hence, the implicit rental value of capital services or user cost of capital is, as in Equation (2.15),

$$c = q(r + \delta) - \dot{q}\,. \tag{2.22}$$

Assuming static expectations about the price of investment goods, the user cost of capital becomes

$$c = q(r + \delta)\,. \tag{2.23}$$

Deriving the user cost of capital, which reflects the effective price of capital goods, allows the consideration of tax effects and tax incentives in investment decisions. Hall and Jorgenson (1967) introduce taxes in the neoclassical investment model by allowing for a constant marginal income tax rate and investment tax credits. The firm pays the proportional tax at rate τ on its income reduced by depreciation allowances. The tax-related deduction of the depreciation value of investment goods over time follows the depreciation function $D(t)$. Since the future value of the investment goods decreases due to depreciation, current investments reduce future tax payments. The rate of the investment tax credit k reduces the price of capital goods. Hence, the equality between the price of investment good and the discounted value of capital services in the presence of taxation becomes

$$q(t) = \int_{s}^{\infty} e^{-r(s-t)}\left[(1-\tau)c(t)e^{-\delta(s-t)} + \tau \cdot q(t)D(s)\right]ds + k \cdot q(t)\,. \tag{2.24}$$

Let z denote depreciation savings per euro invested. Then, the present value of depreciation savings is $z = \int_0^{\infty} e^{-rs}D(s)$. The first term in the bracket captures the after-tax user cost of capital while the second term represents the depreciation savings. Moreover, the last summand of the right-hand side represents the effect of investment tax credit on the discounted value of capital services.

By differentiating the price of investment goods with respect to time and solving for the rental value of capital services with taxes under static expectations

$$\begin{aligned} c^{\tau} = & \quad q(r+\delta)\frac{1-\tau\cdot z-k-\tau\cdot z\cdot k}{1-\tau} \\ = & \quad q(r+\delta)\frac{1-\tau\cdot z-v}{1-\tau}, \end{aligned} \tag{2.25}$$

with $k + \tau \cdot z \cdot k$ as the effective rate of investment tax credit v. The fraction in (2.25) represents the tax effect on the cost of capital for investments. In detail, the after-tax cost of one euro of capital is one currency unit minus the depreciation saving and minus effective direct investment tax credits on one currency unit, $(1 - \tau \cdot z - v)$. Dividing this term by $(1 - \tau)$ accounts for the effect of the marginal tax rate τ on after-tax user costs of capital.

This theoretical finding implies that taxes decrease the incentive to invest by increasing the user costs of capital. Hence, tax incentive programs reducing the effective business tax rate should have a positive impact on private capital formation (Auerbach and Summers, 1979; Judd, 1985; Edge and Rudd, 2011).

Other theoretical approaches that investigate business investment are the q-based (Hayashi, 1982) and the Euler-based approach (Shapiro, 1986; Bond and Meghir, 1994). The q-based approach relates investment to firm market value adjusted for taxes and thus considers only publicly traded firms with available financial market information (Devereux, Keen, and Schiantarelli, 1994; Simmler, 2012). Euler-based approaches rely on dynamic optimization by incorporating adjustment costs, which are ignored in the static neoclassical model. Furthermore, dynamic approaches model forecast process and hence allow identification of temporal aspects of financial constraints (Simmler, 2012). Although the neoclassical investment model has, compared to the q-based and Euler-based models, a more ad-hoc characteristic and is static, it is in terms of data requirement and assumptions imposed the most flexible for testing theoretical implications in empirical approaches.

Henceforth, I rely on the neoclassical investment model of Hall and Jorgenson (1967) to analyze the effects of public policy on the economy. The evaluation of current policy measures is of great value for the design of future policy. If governments intervene in markets to promote sustainable economic growth, they rely on policy instruments such as tax incentives or subsidies for firms. Examples are the U.S. depreciation savings program granted in reaction to the 9/11 terrorist attacks (Cohen, Hansen, and Hassett, 2002) and the economic crisis in 2008/2009 (Dennis-Escoffier, 2011) or U.S. investment tax credit (Hulse and Livingstone, 2010).

Empirical findings however show mixed results on this relationship. While there is some stream of research suggesting a positive effect of the 2002 U.S. bonus depreciation on business investment, the evidence is not fully conclusive. Applying a difference-in-differences approach, Cohen and Cummins (2006) find mixed effects of the 2002 U.S. bonus depreciation on investment. Similarly, Hulse and Livingstone (2010) using firm level data by Compustat to analyze the effect of 2002 U.S. bonus depreciation policies on capital expenditure, find mixed effects. These results point to a potential mismatch of goal and effectiveness of public policy. Using the same data set, Dauchy and Martinez (2008) estimate a small effect implying an increase in the investment elasticity of 0.03. Another study by Edgerton (2010) reveals that responsiveness of tax incentives is higher with more cash flows. Potential explanations point to the importance of financing constraints because bonus depreciation may alleviate financing constraints.

The literature offers at least three potential explanations for mixed empirical evidence. First, the 2002 U.S. bonus deprecation was restricted to equipment investment. The present value of depreciation savings is higher for capital goods with long deprecation duration (Cohen et al., 2002) and thus effects from the 2002 U.S. bonus depreciation possibly are too small to be empirically relevant (Desai and Goolsbee, 2004). Second, investors possibly did not anticipate the program which lasted for a relatively short period (Hulse and Livingstone, 2010). With regard to investment adjustment costs, the time to adjust might have been too short to benefit from changes in the investment program. Third, restrictions in data could drive the lack of significant evidence such as Dauchy and Martinez (2008) or Hulse and Livingstone (2010) who are not able to differentiate between long-lived capital goods (with a high present value of depreciation savings) and short-lived assets.

House and Shapiro (2008) emphasize that depreciation savings are especially relevant for long-term business investment. This is due to the fact that investors may shift investment from one period to another in order to receive the benefit. Using asset-level data, House and Shapiro show that investment in assets with the greatest benefit from bonus depreciation, i.e., assets with the longest depreciation period, increase in response to the incentives. Similarly, Eichfelder and Schneider (2014) show in a difference-in-differences approach for German bonus depreciation evidence for a significant positive effect. Also, using a difference-in-differences approach in combination with a weighting scheme as proposed by DiNardo, Fortin, and Lemieux (1996), Yagan (2015) finds that the 2003 dividend tax cut in the U.S. neither affects investment nor employee compensation.

Considering equipment investments, Long and Summers (1991) highlight the relevance of capital formation for economic growth. Hence, the impact of fiscal policy in the form of tax incentive programs on business investment is an important topic of economic research (Hassett and Hubbard, 2002).

Above all, the literature on tax policy on growth effects is scarce and focuses on aggregate macroeconomic analyses, e.g. Kneller, Bleany, and Gemmell (1999). In their study, Kneller et al. (1999) find that distortionary taxes and unproductive fiscal policy reduce growth. Arnold et al. (2011) find that the tax design has crucial implications for economic growth. In particular, income tax reductions of those on low income positively relate to increased growth and recovery in times of recession. In like manner, Aghion, Hémous, and Kharroubi (2014) find that countercyclical fiscal policy increases growth in more financially constrained industries.

The importance of tax policy for business investment and the mixed findings presented in this section point to the need for more research on the effects of fiscal policy on the real economy. In Chapter 3, we take the German post-reunification setting to analyze the effect of bonus depreciation on the productiveness of investments.

2.2 R&D activity, economic growth, and public subsidies

With the shift from a traditional economy based on manufacturing and construction industries to knowledge and service-based economies, investments in intangible goods such as knowledge and patents are at least equally important to foster growth as investments in tangible investments such as equipment and structures. Thereupon, studying investments in knowledge is crucial in analyzing the development of an economy because they constitute of a potential gateway to productivity gains as a first step into innovative processes (Francois and Lloyd-Ellis, 2009).

Based on the findings of the neoclassical growth model by Solow (1956) and Swan (1956), where the stock of technological capacity and knowledge are exogenously given, Romer (1986) and Aghion and Howitt (1992) extend the assumptions of the neoclassical growth model by endogenizing innovation.

Building on the ideas of the Ramsey-Cass-Koopmans model (Ramsey, 1928; Cass, 1965; Koopmans, 1965; Aghion and Howitt, 2009, pp. 52-54), Romer (1986)[9] incorporates the idea of increasing returns to scale of knowledge compared to neoclassical models with constant returns to scale. The model's main idea is that technological knowledge as capital good grows automatically as a byproduct with physical capital.

Firms contribute to the accumulation of technological knowledge by accumulating capital. Instead of fixed coefficients in the production function, each firm $j \in \{1,2,...,N\}$ has the Cobb-Douglas-type production technology

$$y_j = \bar{A} k_j^{\alpha} L_j^{1-\alpha}, \tag{2.26}$$

with k_j and L_j being the firm's usage of capital and labor respectively. Whereas $\bar{A}$ represents the aggregate productivity of the firms and depends on the total amount of capital accumulated by all firms, i.e.

$$\bar{A} = A_0 \cdot \left(\sum_{j=1}^{N} k_j \right)^{\eta}, \tag{2.27}$$

where η represents the extent of knowledge externalities generated by the firms. To simplify, one assumes $L_j = 1$ for all firms *j*. The aggregate capital stock of all firms is expressed as

[9] The representation of the model by Romer (1986) relies on the discussion in Aghion and Howitt (2009, pp. 50-54).

$$K = \sum_{j=1}^{N} k_j \,. \tag{2.28}$$

Furthermore, aggregate output is

$$Y = \sum_{j=1}^{N} y_j \,. \tag{2.29}$$

Due to the fact that all firms produce with the same technology and the same factor prices, they acquire factors in the same proportions, i.e. $k_j = K / N$ for all j firms.

This implies that aggregate productivity in equilibrium equals

$$\bar{A} = A_0 \cdot K^{\eta} \tag{2.30}$$

where $0 < \eta < 1$. Therefore, the output of an individual firm is

$$y_j = A_0 \cdot K^{\eta} (K / N)^{\alpha} \,. \tag{2.31}$$

Hence, aggregate output equals

$$Y = NA_0 \cdot K^{\eta} (K / N)^{\alpha} \,. \tag{2.32}$$

which is equivalent to

$$Y = A \cdot K^{\alpha+\eta} , \tag{2.33}$$

with

$$A = A_0 \cdot N^{1-\alpha} \,. \tag{2.34}$$

The production function (2.32) emphasizes the increasing returns to scale in all input variables. Hence, it underlines the importance of technological progress for economic growth.

In the process of capital accumulation in an economy, we assume a constant savings rate s so that the rate of change in capital becomes

$$\begin{aligned}\dot{K} &= sY - \delta K \\ &= sAK^{\alpha+\eta} - \delta K.\end{aligned} \tag{2.35}$$

Thus, the growth rate of the capital stock equals

$$g_K = \dot{K}/K = sAK^{\alpha+\eta-1} - \delta. \tag{2.36}$$

For simplicity, all individuals are engaged in production instead of selling their labor services and renting capital to firms. A representative individual, who is simultaneously worker-owner of her firm, faces an intertemporal utility maximization problem under the assumption that individuals do not internalize externalities related to the growth of knowledge. In the absence of depreciation and population growth, the owner of the representative one-worker firm optimizes[10]

$$\max \int_0^\infty u(c_t)e^{-\rho t}\,dt \text{ subject to } \dot{k} = \overline{A}k^\alpha - c, \tag{2.37}$$

with k as the capital stock of the individual firm, $y = \overline{A}k^\alpha$ is the firm's output, $c = c_t$ is the owner-worker's consumption level and $\overline{A}$ is aggregate productivity.

Assuming a constant intertemporal elasticity of substitution of the form

$$u(c_t) = \frac{c^{1-\varepsilon} - 1}{1-\varepsilon}, \tag{2.38}$$

where $\varepsilon > 0$ defines the individual's smooth consumption over time independent of the level of consumption. Using the Hamiltonian to solve this maximization problem[11]

[10] This optimization problem is described in detail in Aghion and Howitt (2009, pp. 36-37).
[11] The Hamiltonian optimization approach is described in detail in Aghion and Howitt (2009, pp. 43-45).

$$H = e^{-\rho t}\left[\frac{c_t^{1-\varepsilon}-1}{1-\varepsilon}\right]+\lambda(\overline{A}k_t^{\alpha}-c_t-\dot{k}), \tag{2.39}$$

we obtain the first order conditions

$$H_c = e^{-\rho t}c_t^{-\varepsilon}-\lambda = 0, \tag{2.40}$$

$$H_k = -\dot{\lambda} \Leftrightarrow \dot{\lambda} = -\lambda(\alpha\overline{A}k^{\alpha-1}). \tag{2.41}$$

Taking the log of (2.40) and differentiating with respect to time yields

$$-\rho-\varepsilon\frac{\dot{c}}{c}-\frac{\dot{\lambda}}{\lambda}=0. \tag{2.42}$$

Solving this equation using the marginal product of capital represented in (2.41), we obtain the Euler condition

$$\begin{aligned} -\varepsilon\frac{\dot{c}}{c} &= \rho+\frac{\dot{\lambda}}{\lambda}, \\ -\varepsilon\frac{\dot{c}}{c} &= \rho-\alpha\overline{A}k^{\alpha-1}. \end{aligned} \tag{2.43}$$

With rational expectations, individuals will correctly anticipate that all firms will employ the same amount of capital in equilibrium (if firms are identical as is assumed in (2.30)) such that $K = Nk$ and hence, the Euler condition can be written as

$$-\varepsilon\frac{\dot{c}}{c} = \rho-\alpha A_o N^{\eta}k^{\alpha+\eta-1}. \tag{2.44}$$

This equation relates the growth in consumption to the marginal product of capital, the discount rate and the individual's time preference. The Romer (1986) model implies that individuals do not internalize spillover effects from investing in aggregate capital and therefore without policy intervention would underinvest.

Similarly, Aghion and Howitt (1992) and Aghion and Howitt (2009) present a growth model with endogenous technological change[12]. Reflecting Schumpeterian notions of creative destruction, the authors introduce an intermediate goods sector and put emphasis on technological change stemming from human capital. Instead of just one intermediate product, there is a continuum of intermediate goods, indexed on the interval [0,1]. Hence, the Cobb-Douglas-type production technology is

$$Y_t = L_t^{1-\alpha} \int_0^1 A_{i,t}^{1-\alpha} x_{i,t}^{\alpha} di \,. \tag{2.45}$$

In order to produce one final good Y_t, a firm needs M intermediate goods, $x_{i,t}$, where i indexes the intermediate good. The quality or productivity of the intermediate goods is measured by $A_{i,t}$ and a firm can introduce new intermediate products. Based on the final good production function (2.45), the production function of each intermediate good is

$$Y_{i,t} = (A_{i,t} L)^{1-\alpha} x_{i,t}^{\alpha} \,. \tag{2.46}$$

Each intermediate product has its own monopoly and its price (measured in consumption goods) is equal to its marginal product in the final sector,

$$p_{i,t} = \frac{\partial Y_{i,t}}{\partial x_{i,t}} = \alpha (A_{i,t} L)^{1-\alpha} x_{i,t}^{\alpha-1} . \tag{2.47}$$

Hence, a monopolist in sector i maximizes profits by setting quantity $x_{i,t}$

$$\Pi_{i,t} = p_{i,t} x_{i,t} - x_{i,t} = \alpha (A_{i,t} L)^{1-\alpha} x_{i,t}^{\alpha} - x_{i,t} . \tag{2.48}$$

The first-order condition is $\alpha^2 (A_{i,t} L)^{1-\alpha} x_{i,t}^{\alpha-1} - 1 = 0$ and solving for $x_{i,t}$ yields

[12] The model presented in Equations (2.45) to (2.63) relies on Aghion and Howitt (2009, pp. 85-90 and pp. 92-96).

$$x_{i,t}^{\alpha-1} = \frac{1}{\alpha^2 (A_{i,t}L)^{1-\alpha}},$$

$$x_{i,t}^{\alpha-1} = \alpha^{-2}(A_{i,t}L)^{-(1-\alpha)}, \tag{2.49}$$

$$x_{i,t}^{*} = \alpha^{\frac{2}{1-\alpha}} A_{i,t}L .$$

Inserting the equilibrium quantity into the profit function yields the equilibrium profit

$$\Pi_{i,t}^{*} = \pi A_{i,t}L . \tag{2.50}$$

where $\pi = (1-\alpha)\alpha^{\frac{1+\alpha}{1-\alpha}}$. Aggregating the productivity $A_{i,t}$ of all firms i, the aggregate productivity is $A_t = \int_0^1 A_{i,t}\, di$ and can be interpreted as the unweighted numerical average of all individual productivity measures.

Finally, inserting equilibrium quantity and aggregate productivity into the production function and considering an inelastic fixed stock of labor force L yields

$$Y_t = \alpha^{\frac{2\alpha}{1-\alpha}} A_t L . \tag{2.51}$$

The firms can conduct R&D by choosing optimal levels of R&D expenditure to generate new innovations in intermediate goods to reach higher levels of productivity. But the payoff of R&D spending depends on the probability of innovation success which the Cobb-Douglas form innovation production function takes into account

$$\phi(n_{i,t}) = \lambda n_{i,t}^{\sigma}, \tag{2.52}$$

where λ is a parameter reflecting the research sector's productivity, $n_{i,t}$ is the research expenditure in sector i relative to the target productivity in sector i, i.e. $n_{i,t} = R_{i,t} / A^{*}_{i,t}$. The productivity parameter in case of success is $A^{*}_{i,t}$ and σ is the research elasticity of innovation. The marginal product of (productivity-adjusted) research in generating innovations is positive but decreasing

$$\phi'(n_{i,t}) = \sigma\lambda n_{i,t}^{\sigma-1} > 0 \text{ and } \phi''(n_{i,t}) = \sigma(\sigma-1)\lambda n_{i,t}^{\sigma-2} < 0 . \tag{2.53}$$

By choosing its research expenditure $R_{i,t}$, the firm maximizes its net benefit

$$\phi\left(\frac{R_{i,t}}{A_{i,t}^{*}}\right)\Pi_{i,t}^{*} - R_{i,t}, \tag{2.54}$$

where the profit in case of success is $\Pi_{i,t}^{*}$. The first-order condition is

$$\phi'\left(\frac{R_{i,t}}{A_{t}^{*}}\right)\frac{\Pi_{t}^{*}}{A_{t}^{*}} - 1 = 0 . \tag{2.55}$$

Rewriting (2.55) by using (2.50), we obtain

$$\phi'\left(n_{i,t}\right)\pi L = 1, \tag{2.56}$$

which can be interpreted as a research arbitrage equation. Hence, the productivity-adjusted research equals

$$n = (\sigma\lambda\pi L)^{\frac{1}{1-\sigma}}, \tag{2.57}$$

and the frequency of innovation is given by

$$\mu = \phi(n) = \lambda^{\frac{1}{1-\sigma}}(\sigma\pi L)^{\frac{\sigma}{1-\sigma}} . \tag{2.58}$$

Both parameters are constant and hence the same in all sectors independent of the starting level of productivity $A_{i,t-1}$.

Consequently, productivity of each sector i equals

$$A_{i,t} = \begin{cases} \gamma A_{i,t-1} & \text{with probability} \quad \mu \\ A_{i,t-1} & \text{with probability} \quad 1-\mu \end{cases} . \tag{2.59}$$

Taking this result to the aggregate economy-level, productivity A_t equals the weighted average productivity $A_{1,t}$ of sectors that innovated (μ) at t and average productivity $A_{2,t}$ of sectors that did not (1 - μ) at t

$$A_t = \mu A_{1,t} + (1-\mu)A_{2,t}\,. \tag{2.60}$$

Average productivity $A_{2,t}$ of sectors that did not innovate at t is unchanged and thus by random draw of sectors, it equals last period's economy-wide average $A_{i,t-1}$. Similarly, the average productivity $A_{1,t}$ of innovating firms thus equals last period's productivity times γ, the factor of higher productivity from innovating. Therefore, it holds

$$A_t = \mu\gamma\, A_{t-1} + (1-\mu)A_{t-1}\,. \tag{2.61}$$

Finally, as GDP per capita is proportional to the aggregate productivity measure, the economy's growth rate is also proportional to the growth in aggregate productivity

$$g_t = \frac{A_t - A_{t-1}}{A_{t-1}}\,. \tag{2.62}$$

Using Equation (2.61) and inserting it in (2.62), we obtain a constant growth rate

$$g = \mu \cdot (\gamma - 1) \tag{2.63}$$

as a function of the frequency of innovation and the higher average productivity of the innovating sector.

The two models presented show analytically the role of knowledge for economic growth. As much as capital investments in tangible assets matter for economic growth, investments in intangible assets such as knowledge are at least equally important. One way for firms to invest in knowledge is either to conduct research and development (R&D). The firms themselves can conduct R&D or they can outsource to universities or research organizations. Nowadays, developed economies are based on knowledge and technological progress is an important driver of economic growth (Schumpeter, 1942).

However as Hall and Lerner (2010) point out, R&D investments differ in three aspects from investments of other types. First, uncertainty of the outcome is more pronounced for R&D investments and information asymmetries between R&D conductors and investors make the evaluation of such investments more difficult (Zúñiga-Vicente et al., 2014). Also, limited appropriability of R&D returns induces firms to be reluctant in revealing information regarding innovation projects and hence aggravates problems of information asymmetries (Arrow, 1962). Second, R&D projects require capital to finance high set-up costs; hence investments in R&D result in sunk costs that result in higher loss of foregoing benefits from initial investments. Consequently, firms with R&D investments are less likely to abandon innovation projects (Paunov, 2012). Third, R&D projects require a high labor cost for high-skilled scientists and engineers. The workers' knowledge represents an intangible asset. As workers have specific knowledge on the business and its processes, firms attempt to maintain these knowledge workers in order to benefit from this intangible asset. Hence, the costs of R&D workers face high adjustment costs at the firm level (Hall, Griliches, and Hausman, 1986; Hall and Lerner, 2010).

Hence, one main concern of R&D is that firms have the incentive to underinvest in R&D as they fear other firms benefit from their knowledge albeit not paying for it due to incomplete appropriability of R&D returns (Arrow, 1962). The public good characteristic of R&D investments (non-rivalry and non-excludability), therefore, calls for public policy intervention. Similar to tax incentives for capital investments, public policy may support private R&D investments by direct subsidies or tax credits. Thus, public R&D subsidies reduce the user costs of capital and theoretically have a positive effect on private R&D investments (Auerbach, 1984).

Several empirical studies analyze the effectiveness of public subsidies for R&D (for literature reviews, see David, Hall, and Toole, 2000; Zúñiga-Vicente et al., 2014; Becker, 2015). The effects of public R&D subsidies point in two directions. When public R&D subsidies induce firms to increase private R&D expenditure, one refers to an *additionality effect* or a *crowding in* effect. In contrast, public R&D subsidies inducing firms to decrease private R&D expenditure is referred to as *crowding out* effect (David et al., 2000).

Studies analyzing the effectiveness of public R&D subsidies until the end of the 1990s in many cases neglected potential endogeneity problems by relying on simple regression models (David et al., 2000). Accounting for endogeneity of public R&D subsidies requires methodological advances. And hence, applying methods such as difference-in-differences, sample selection models, instrumental variables and matching methods have become crucial to determine the causal effect of public policy on firm R&D (Zúñiga-Vicente et al., 2014).

In a non-parametric matching approach, Almus and Czarnitzki (2003) find that public R&D subsidies stimulate private R&D activity of Eastern German firms. Using data on firms in Belgium, Czarnitzki and Lopes-Bento (2013) reject full crowding out of public R&D subsidies. Further, the authors find that the effect of the subsidies on R&D activity does not vary over time, the number of grants does not lead to crowding out and finally, neither repeatedly receiving subsides nor support from other sources negatively affects R&D activity. Using panel data on Spanish manufacturing firms, Arqué-Castells (2013) finds positive and significant effects of public R&D subsidies by applying dynamic discrete models. Analyzing labor productivity of Finish small and medium-sized enterprises (SMEs), Karhunen and Houvari (2015) find no significant positive effect of public R&D subsidies. However, considering the effect over time, they find negative effects of productivity growth subsequent to the subsidy year.

To sum up, drawbacks and heterogeneity of the studies' results ascribe to lack of information and analysis regarding several methodological issues, geographical scope, measurement, and definition of variables and econometric methods applied (Zúñiga-Vicente et al., 2014).

Previous studies on the effectiveness of public R&D subsidies are mixed and point to the need of taking individual firm behavior and the economic environment into consideration to evaluate government policy. Recent studies such as Hud and Hussinger (2015) or Paunov (2015) fill this gap but more research in this field is required to understand the interdependencies between firm investment behavior, government policy, and business cycles.

2.3 Tax evasion, the tax compliance puzzle, and tax morale

Policy-making in the form of fiscal policy cannot take place without raising tax revenue. Therefore, research on tax evasion and tax compliance contribute to our understanding. In this section, I review theoretical findings on the formation of tax evasion and its implications.

The simple model by Allingham and Sandmo (1972) formally explains tax evasion[13]. Their model builds on a rational individual, maximizing expected utility and whose

[13] The notation of Equations (2.64) to (2.70) is based on Allingham and Sandmo (1972), Yitzhaki (1974), Sandmo (2005) and Phoon (2012).

labor supply and hence income, W, are exogenously given. Taxes are levied at a constant rate, θ, on the amount of declared income, X, which the taxpayer is able to choose. Moreover, the expected utility of a taxpayer $E(U)$ is the result of a tax evasion gamble, i.e. the utility of after-tax income ($W - \theta X$) is weighted by the probability of not getting caught ($1 - p$) and the respective utility of after-tax and penalty-reduced income is weighted by the probability of getting caught (p). Sandmo (2005) emphasizes that the probability entering the model is the taxpayer's subjective probability that does not reflect actual detection frequencies by the tax authority. The utility function U is increasing and concave implying risk-averse taxpayers. The penalty in case of being caught is the reduction in income by the penalty to be paid on the unreported income $\pi(W - X)$[14]. Thus, taxpayers maximize their expected utility by choosing the optimal level of income reported to the tax authority X^*. The taxpayers expected utility equals

$$E(U) = (1-p)U(W-\theta X) + pU(W-\theta X-\pi(W-X)). \qquad (2.64)$$

For simplification, the taxpayer's net income in case of not being detected and therefore not punished equals $Y = W - \theta X$. Similarly, the taxpayer's net income in case of being detected and punished equals $Z = W - \theta X - \pi - (W - X)$. Taking the derivative of $E(U)$ with respect to X gives

$$\frac{\partial E(U)}{\partial X} = -\theta(1-p)U'(Y) - (\theta - \pi)pU'(Z) = 0. \qquad (2.65)$$

The second-order condition equals

$$\frac{\partial^2 E(U)}{\partial X^2} = \theta^2(1-p)U''(Y) + (\theta-\pi)^2 pU''(Z), \qquad (2.66)$$

[14] In a modified version of the Allingham-Sandmo model, Yitzhaki (1974) points out that imposing the penalty on the amount of income evaded has different implications as compared to the case where the penalty is imposed on the evaded tax as in, for instance, American tax law.

with a positive first-order condition, i.e. $\frac{\partial E(U)}{\partial X} > 0$ and a negative second-order condition, i.e. $\frac{\partial^2 E(U)}{\partial X^2} < 0$. Therefore, the expected utility function fulfills the assumption of concavity.

Since the amount of income evaded *X* cannot be a priori assumed to lie between 0 and *W*, one has to check whether the first order conditions evaluated at the corners *X* = 0 and *X* = *W* satisfy the conditions for an interior solution. This means

$$\left.\frac{\partial E(U)}{\partial X}\right|_{X=0} = -\theta(1-p)U'(W) - (\theta-\pi)pU'(W(1-\pi)) > 0, \tag{2.67}$$

and

$$\left.\frac{\partial E(U)}{\partial X}\right|_{X=W} = -\theta(1-p)U'(W(1-\theta)) - (\theta-\pi)pU'(W(1-\theta)) < 0\,. \tag{2.68}$$

Rewriting these conditions yields

$$p\pi > \theta\left[p + (1-p)\frac{U'(W)}{U'(W(1-\pi))}\right], \tag{2.69}$$

and

$$p\pi < \theta\,. \tag{2.70}$$

Formally, these conditions give the upper and lower bound of unreported income *X*. The term in brackets in Equation (2.69) is positive but less than one and hence it ensures that the amount of reported income *X* is always positive (*X* > 0), i.e. the lower bound. The upper bound in Equation (2.70) implies that the taxpayer declares income below his actual income (*X* < *W*) only if the expected tax on the undeclared income is lower than the regular tax.

Allingham and Sandmo (1972) find the relation between reported income to both the penalty rate of tax and the detection probability to be negative implying that higher detection probability and higher penalties discourage fraudulent tax behavior. The theoretical implication of the model is that tax-compliant behavior is the result of taxpayers' fear of being caught when evading and hence compliance depends only on enforcement in the form of penalty fees and unannounced auditing.

To illustrate the model's implications, Sandmo (2005) suggests that a penalty rate twice as large as the regular tax rate implies a probability of detection greater than 0.5.[15] This probability of detection is abnormally higher than empirical estimates (Feld and Frey, 2002). Given the fact that the actual probability of audit and penalties are relatively low, rational individuals would underreport income and overstate deductions due to the low likelihood of being detected and penalized (Alm, McClelland, and Schulze, 1992; Frey and Feld, 2002; Alm, 2012). However, actual levels of compliance are higher than the model predicts and imply that governments' enforcement measures do not account for compliance alone (Graetz and Wilde, 1985). Accordingly, this pure economic approach to tax evasion does not provide an explanation for generally tax-compliant behavior and the inability to explain tax evasion leads to the question why people pay taxes. The literature refers to the overprediction of tax evasion as a *tax compliance puzzle* (Alm, McClelland, and Schulze, 1992).

This central limitation led to several extensions such as incorporating individuals' choices, alternative tax enforcement measures, uncertainty and complexity of tax-related measures, public goods provision, social rewards (e.g. Andreoni, Erard, and Feinstein, 1998; Slemrod and Yitzhaki, 2002; Slemrod, 2007). All extensions however build on the enforcement as a main factor in determining tax compliance.

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[15] Transforming the upper bound (2.70) to deter taxpayers from evasion equals $p > \frac{\theta}{\pi}$. Inserting a penalty rate twice as high as the regular tax rate gives $p > \frac{\theta}{2\theta}$ and hence $p > \frac{1}{2}$.

Another strand of literature focusses on behavioral economics approaches to explain tax compliance using findings from other social sciences (Slemrod, 2010). The focus of such approaches is the use of psychological and sociological findings due to the dissatisfaction with standard economic approaches (Alm, 2012). The behavioral economic literature distinguishes two strands: first, some behavioral models build on the limited cognitive abilities of agents to explain individual behavior, e.g, bounded rationality, framing effects, loss aversion etc. (see Alm, 2010). Second, other studies focus on the social context of individuals to inform about individual behavior in groups or group behavior (Alm, 2012). This branch of behavioral economics attempts to explain tax compliance in social interaction by using concepts such as social norm, altruism or tax morale as main drivers (e.g., Traxler, 2010).

The concept of tax morale is flexible in its definition. At the aggregate level, it refers to intrinsic motivations to comply with tax rules (Schmölders, 1960, pp. 36-37). At the individual level, it reflects each individual's motivational postures and attitude towards paying taxes (Kirchler, 2007, p. 102). Linking tax morale to tax compliance requires a theoretical connection between the two concepts. One link may be the theory of reasoned action and planned behavior (Fishbein and Ajzen, 1975; Ajzen, 1991). In an experimental setting Cummings et al. (2009) show that tax morale is an important factor for the actual compliance behavior. Therefore, investigating tax morale potentially contributes to solving the tax compliance puzzle.

While the literature regards tax morale as a soft-fact based parameter in the determination of tax compliance, theoretical approaches to tax morale strengthened and emphasized its importance for tax compliance research in the last decade (e.g., Dell'Anno, 2009; Schnellenbach, 2006; Hashimzade, Myles, and Rablen, 2016). Instead of using tax morale as an exogenous variable in the analysis of tax compliance, recent studies stress that tax morale is not a black box and should hence be treated as an endogenous variable (Feld and Frey, 2002).

The building blocks of tax morale are multifaceted. Tax morale is the result of fairness perceptions, psychological costs and institutional determinants of the relationship and the fiscal exchange between taxpayers and the government (Torgler, 2001; Feld and Frey, 2007; Dell'Anno, 2009). Building on Gordon's (1989) tax evasion model of social stigma, Dell'Anno (2009) presents a theoretical model of tax evasion which incorporates various determinants of tax morale in the standard expected utility model. According to this model, an individual's tax morale constitutes of moral rules or psychic costs and social stigma or reputational costs. Psychic costs arise when a taxpayer feels guilt or shame when underreporting income or overstating deductions when filling out tax return forms (Andreoni et al., 1998; Dell'Anno, 2009). In contrast, social stigma results from anticipated shame by social disapproving of contemplating underreporting. Taxpayers' utility increases with consumption but decreases in psychic costs and reputational costs (social stigma or social disapproval):

$$U(C_{i,t}) - P_{i,t} - S_{i,t}, \tag{2.71}$$

where i indexes the taxpayer and t indexes the time period. A taxpayer's consumption equals the after-tax gross income and the tax evasion gamble weighted by the detection probability,

$$C_{i,t} = Y(1-\tau_t) + \begin{cases} \tau_t E_{i,t} & \text{if not punished with probability } (1\text{-}p) \\ -\lambda \tau_t E_{i,t} & \text{if punished with probability } p \end{cases} . \tag{2.72}$$

The taxpayer receives gross income Y that is liable to a proportional tax rate τ_t. Moreoever, $E_{i,t}$ is the amount of income evaded which is in the case of detection subject to a penalty surcharge of λ. And p is the probability of detection and punishment.

The second term of the utility function $P_{i,t}$ refers to the psychic costs[16]. Honesty affects psychic costs in a simple linear relationship with evaded income $P_{i,t} = v_i E_{i,t}$. The last term of the utility function $S_{i,t}$ in (2.71) reflects social stigma in the firm of a taxpayer's reputational costs. The determinants of social stigma are fairness and the quality of the relationship between taxpayer and government. Fairness decreases with aggregated perceived tax evasion and hence positively affects social stigma. Further, the quality of the relationship between government and taxpayers depends on the effectiveness of meeting the taxpayers' interests and captures macroeconomic taxpayers' satisfaction with policy-making at the macroeconomic level. Formally, the function of social stigma given by $S_{i,t} = M\left[f(1-TE_{t-1}), r(Q_t), E_{i,t}\right]$ where TE_{t-1} is the perceived share on GDP in aggregate tax evasion of the previous period and Q_t is an index of perceived effectiveness in policy-making. The signs of the first derivatives of social stigma with respect to fairness, relationship, and tax evasion are positive. As a simplification, social stigma is a multiplicative function of fairness, relationship, and evasion. Hence, the expected utility of taxpayer i is given by

$$EU\left\{Y(1-\tau_t)+(1-p-p\lambda)\tau_t E_t\right\}-v_i E_t - f_t r_t E_t \,. \tag{2.73}$$

Maximizing taxpayers' expected utilities with respect to tax evasion, one obtains the first order condition

$$U'\left\{C_t\right\}(1-p-p\lambda)\tau_t - v_i - f_t r_t = 0, \tag{2.74}$$

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[16] Assuming that all individuals are honest at the same level of v_i distributed according to a cumulative function $F(v)$ on the interval (0, $\bar{v}$).

which describes the individual's decision rule of evasion with $d_t \equiv U'\{C_t\}(1-p-p\lambda)\tau_t$ being the expected pecuniary benefit from tax evasion in period t and $m_t = f_t r_t$. Hence, the decision rule of taxpayers depends on the level of honesty. If $v_i < d_t - m_t$, the taxpayer is dishonest and evades; if $v_i > d_t - m_t$, the taxpayer is honest and does not evade; finally if $v_i = d_t - m_t$, the taxpayer is indifferent and hence does not change its behavior.

The model presented by Dell'Anno (2009) incorporates the determinants of tax morale to explain tax evasion, i.e., moral rules or honesty, fairness, and the relationship between taxpayer and government and simultaneously, the standard parameters of the standard model by Allingham and Sandmo (1972), i.e. probability of detection, penalty charges, and the marginal tax rate.

Recent empirical studies have paid particular interest in tax morale, e.g., Torgler and Schneider (2005), Torgler (2005, 2006), Alm and Torgler (2006), Torgler, Demir, Macintyre, and Schaffner (2008), Cummings et al. (2009), Filippin, Forio, and Viviano (2013), and others. These studies put tax morale as the dependent variable in the center of analysis. The findings so far point to a relationship between tax morale and various determinants but rarely reflect on causal relationships and thus neglect potential systematic biases from endogeneity. Consequently, Chapter 5 investigates the causal effect of social capital on tax morale.

2.4 Outlook

Existing studies on the effects of public policy on private economic activity primarily focus on the effectiveness of public support for private entities. So far, not much attention has been paid to the analysis of how firms' behavior changes in the presence of public policy. The neoclassical model of Hall and Jorgenson (1967) offers a gateway to considering direct tax effects in investment decisions. Chapter 3 of this thesis picks up on this finding to explain the productivity of subsidized investments. Similarly, the suboptimal R&D investments require the intervention by public institutions and hence imply importance of analyzing the effectiveness of public subsidies. Chapter 4 of this thesis builds on previous studies but puts emphasis on the change in investment behavior as result of the financial crisis 2008. In contrast to the studies in Chapter 3 and 4, Chapter 5 of this thesis does not focus on public expenditures but focuses on the formation of tax morale and hence tax compliance to inform about revenue-side related tax research. Chapter 6 concludes and provides implications for policy and future research.

3 Long-term Effects of Fiscal Policy and Economic Convergence: Evidence from German Bonus Depreciation

3.1 Introduction

3.1.1 Motivation

After German Reunification, the government introduced policy measures to secure the economic recovery of the Eastern German economy and to foster economic convergence to its Western counterpart. One major policy instrument was the use of tax incentives for Eastern German businesses to foster investments and thus to stimulate growth. The "new" German market in the Eastern part promised new investment opportunities but also uncertainty for firms. Hence, this study aims to evaluate the efficiency of tax incentives for business investment. With the unique historical setting and data, we are able to address the counterfactual question: How did the tax incentives affect the growth of firms in Eastern Germany through the channel of increased business investment?

Among the tax incentives put in place for Eastern German businesses, the most important was the Development Area Law[17] (DAL). The DAL was enacted in 1991 and ran out by the end of 1998. It granted generous bonus depreciation for tax purposes of up to 50% in the first year. The DAL tax incentives were similar to the U.S. bonus depreciation programs in reaction to the terrorist attacks in September 2001 (Cohen et al., 2002) and the economic crisis in 2008/2009 (Dennis-Escoffier,

[17] German: Fördergebietsgesetz.

2011). However, unlike the U.S. counterparts, the DAL was available to all plants located in Eastern Germany and therefore consisted of a large-scale subsidy across federal states. Furthermore, compared to the tax incentives in the U.S., the DAL was available for various kinds of investments such as equipment investments and infrastructure investments, e.g., buildings which may be crucial to secure the long-term development of businesses. Lastly, the DAL was easily obtained by simply checking a field in the tax return form.

In this paper, we focus on Germany, where, because of the reunification, the tax incentive for Eastern Germany aims to enhance investment and employment levels and thereby also economic growth. We use administrative plant-level data of the manufacturing industry which allows us to use a quasi-experimental setting to analyze the effect of tax policy on business development. We use East German plants investing during 1995 to 1998 as treatment group and a subsample of West German plants as control group. The expiration of the DAL allows us to exploit it in a matching estimation strategy. Hence, we are able to contribute to the literature by focusing on the effect of investments caused by the DAL on turnover and employment levels after the subsidy period (after 1999) and thus, shed light on the long-term effects of these tax incentives.

While we find some evidence for efficient building investments resulting from the tax incentives, this is not the case for equipment investments: DAL-incentivized investments in equipment have no effect on turnover and are related to lower employment as compared to investments in the control group. This is in line with the argument of investment shifting to earlier periods to benefit from the tax incentives as well as some incidence of overinvestment.

3.1.2 Institutional setting

Subsequent to the collapse of communism in Eastern Europe and the German Reunification, policy was determined to support fast economic convergence of the two parts of Germany. In July 1990, Chancellor Helmut Kohl promised "flourishing landscapes" in the East. However, the initial hope that convergence would happen without policy intervention proved to be wrong because the industrial base in the East was not competitive. One additional problem was the fast increase in wages in Eastern Germany negotiated by the unions and the employer associations (Sinn and Sinn, 1994). Thus, the weak industrial base was further weakened by forgone labor cost advantages. As a result, policymakers decided to set tax incentives for investment in Eastern Germany in order to motivate firms to invest despite high labor costs – compared to neighboring countries such as Poland and the Czech Republic.

While economists argue that fiscal policy in the form of equipment investment subsidies can reduce existing tax distortions (Judd, 1999) and foster growth (Long and Summers, 1991), German policy, not only subsidized investment in equipment but also investment in structures due to the need for initial and major long-term investment. As previously mentioned, the two major programs of this policy were the Development Area Law (DAL) and the Investment Subsidy Law (ISL). According to German government reports on subsidies, the DAL and ISL are among the most costly subsidies in the 1990s. In 1996, the DAL deprecation for business investment (the ISL subsidy for equipment investment) was the most important (the third most important) tax incentive program with tax revenue loss of 4.7 billion € (volume of 1.3 billion €)[18].

[18] (Deutscher Bundestag, Drucksache 12/1525, Drucksache 13/2230, Drucksache 14/1500, Drucksache 15/1635, Drucksache 16/6275).

Table 3.1: Regional investment subsidies (1995-2013)

	Development Area Law (DAL)	Investment Subsidy Law (ISL)
Period	01.01.1991 to 31.12.1998 with amendments and revisions	01.01.1991 to 31.12.2013 with amendments and revisions
General rates	50% (1991-1996); 40% (1997-1998)	12% (1991 to June 1992); 8% (July 1992 to June 1994); 5% (July 1994 to 1998) [c]; 10% (1999); 12.5% (2000-2009); 10% (2010); 7.5% (2011); 5% (2012); 2.5% (2013) [b]
Increased rates	N.A.	+ 5% (SME; 1995 to 1998); double of general rate for equipment investment (SME; 1999 to 2013); + 2.5% (border areas; 2001 to 2009)
Regional specifications	N.A.	Berlin: reduced periods (Berlin West); Reduced subsidy rates under certain conditions (1996 to 2012)
Assessment base	Movable assets (excluding aircrafts); immovable assets; modernization of buildings	New and movable assets (excluding aircrafts, cars, low-value assets[d]); new and immovable assets (since 1999); restriction to initial investments (since 1999)
Formal requirements	Tax return	Formal application

Notes: [a] The latest amendment of the law (ISL 2010) is supposed to run out in 2014. [b] Subsidy might be restricted for sensible sectors like the steel industry, ship building, automotive industry, agriculture. [c] The investment subsidy rate was up to 8% until the end of 1996 if the investment has been started in before July 1994. [d] As excluded by § 6 (2) S.1 of the German Income Tax Act. Source: Eichfelder and Schneider (2014)

The DAL bonus depreciation could simply be declared in the annual tax return for investments in the five Eastern federal states (Brandenburg, Mecklenburg-West Pomerania, Saxony, Saxony-Anhalt, and Thuringia) and Berlin. Applying for the DAL benefits only required checking this option in the investment tax return forms. The DAL was not restricted to specific branches or business types. It was available for movable assets (with the exception of aircraft) and investments in structures including the modernization of buildings. In addition to regular tax depreciation, it allowed a bonus depreciation of 50% of the invested amount. The bonus depreciation could be allocated over the first five years following the investment if no other special depreciation schemes had been used. Initially, the program was planned to expire by the end of 1996. However, a prolongation until December 1998 was enacted in October 1995. The depreciation rate was reduced to 40% for investments in 1997 and 1998. The ISL[19] was enacted at the same time as DAL and ran out at the end of 2013. It granted businesses in the five Eastern federal states and Berlin direct

[19] German: Investitionszulagengesetz.

and tax-exempt subsidies. Table 3.1 gives an overview of the most relevant regulations of both programs.

The remainder of the paper is organized as follows. In Section 3.2, we briefly describe the related literature and the hypotheses to analyze the effect of the DAL on firms. Section 3.3 presents the data. Section 3.4 discusses the identification strategy. Section 3.5 reports the empirical results. Section 3.6 discusses the findings of this paper and concludes.

3.2 Related literature and hypothesis development

3.2.1 Tax policy, investment, and growth

Both theoretical and empirical findings suggest that bonus depreciation increases investment activities (Hall and Jorgenson, 1967; House and Shapiro, 2008). And clearly, investments affect firm growth. The underlying justification of subsidizing investment is that private investors decide on sub-optimally low investments in Eastern Germany because of the poor initial economic conditions and uncertainty regarding the development in the East after German reunification. If tax incentives, however, lead to distorted and inefficiently high investments, investments pushed by the DAL bonus depreciation are less productive and result in lower growth.

Related studies originate from the seminal work of Hall and Jorgenson (1967). The neoclassical investment model states that tax policy affects the effective price of capital goods measured by the user costs of capital. The user cost of capital is a function of several variables such as the price level, after-tax cost of debt and equity, physical rate of depreciation and the anticipated changes in the price level of capital goods and as well as the tax effect (Hayashi, 1982; Auerbach and Hines, 1988).

Hence, tax incentive programs reducing the effective business tax rate theoretically have a positive impact on private capital formation (Auerbach and Summers, 1979; Judd, 1985; Edge and Rudd, 2011).

The empirical literature on the study of the impact of taxes on investments is mixed. According to House and Shapiro (2008), depreciation allowances should have an especially strong impact on long-term business investment. Their explanatory approach relates to the fact that investors may shift investment from one period to another in order to receive the benefit. Confirming these results, Eichfelder and Schneider (2014) show that the DAL significantly increased investment activity. In contrast, Yagan (2015) analyzing the 2003 dividend tax cut in the U.S. finds neither effect of the tax cut on investment nor on employee compensation. Cohen and Cummins (2006) are not able to provide comprehensive empirical evidence by using a difference-in-differences estimation strategy.

While the literature has extensively studied the effects of tax subsidies on investment (e.g., Hassett and Hubbard, 2002; Cohen and Cummins, 2006; Dauchy and Martinez, 2008; Hulse and Livingstone, 2010; Park, 2010; Edgerton, 2011; Eichfelder and Schneider, 2014), the literature on the effects of tax incentives on firm growth is scarce and mostly deals with the enterprise zone (EZ) programs in the United States. For example, Papke (1994) analyzes the effectiveness of the EZ program in the US state of Indiana on local employment and investment using a panel of jurisdictions. The tax incentive involves tax credits, employment tax credits for firms, and an income tax deduction for zone residents. As a result, Papke (1994) argues that the EZ program induces a change in asset composition from reduced investments in machinery and equipment to more investments in inventories and an even stronger decrease in unemployment claims. Another study by Bondonio and Greenbaum

(2007) also utilizes the EZ programs as an exogenous variation to analyze the effect of tax incentives on economic growth. Overall, their result indicates that EZ positively affect employment, sales, and capital expenditure. Both studies neglect the direct tax effects on the user cost of capital of capital goods, which in turn might have implications for corporate growth. The analysis in Eichfelder and Schneider (2014) finds evidence for strong and significant effects of bonus depreciation on investment. This applies particularly to long-lived capital goods, such as nonresidential real property. Large businesses benefit from a higher relative advantage of bonus depreciation. Moreover, investments before the reduction in the depreciation allowances in 1997 are more affected.

The goal of this paper is to analyze the economic efficiency of tax-incentivized investments, i.e. whether and to what extent these investments have an effect the economic development of firms.

3.2.2 German bonus depreciation and relative tax advantages

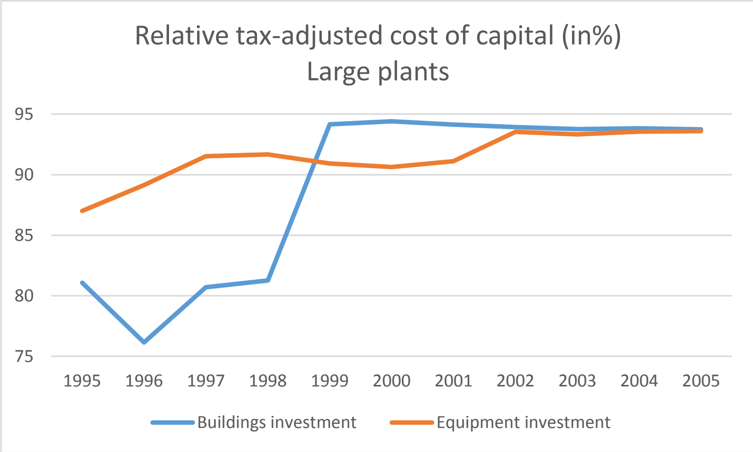
In order to compare relative tax advantages of the DAL between Eastern and Western Germany, we follow Eichfelder and Schneider (2014) by focusing on the relative user cost of capital of both parts of Germany. This measure depends, ceteris paribus, only on the direct tax effects of the bonus depreciation. Since depreciation allowances and subsidies reduce the tax paid, the DAL bonus depreciation reduces the user cost of capital for East German plants and increases the net present value of an investment and hence the relative DAL tax benefit. Put differently, a high value of relative tax-adjusted cost of capital indicates lower tax benefits in the Eastern part compared to the Western part of Germany. And clearly, the tax benefit might distort investment decisions and result in a shifting of investments to earlier periods.

Eichfelder and Schneider (2014) calculate the relative tax-adjusted user cost of capital between Eastern and Western plants from 1995 to 2005 for different asset classes (for the computational details, see Appendix A in Eichfelder and Schneider, 2014).[20] For the purpose of this study, we focus on average relative tax-adjusted cost of capital for large plants (with more than 250 employees) and small and medium-sized plants (SMEs, with less than 250 employees).

Figure 3.1 depicts the time series of relative tax-adjusted cost of capital of Eastern plants compared to Western plants. In both panels, it becomes apparent that for both, large plants and SMEs in Eastern Germany, during the time of DAL bonus depreciation (1995 to 1998), the tax adjusted cost of capital for building investments was lower than in Western German. As for equipment investments, the changes in relative differences in user cost of capital over the sampling period are less pronounced which might be explained by the fact that the ISL, which mainly targets at equipment investments, is in place throughout the entire period.

Given the significant subsidy, we expect businesses to undertake more investments during the period of the DAL. This increase in investments may also reflect firms' incentive to shift investments to earlier periods in order to benefit from the subsidies (Eichfelder and Schneider, 2014). However, tax induced investment behavior might not necessarily enhance business development, but might reflect an inefficient investment behavior during the subsidy period. If this was true, business growth induced by investments during the DAL-period should be lower for East German plants as compared to West German plants.

[20] In the following periods (2006 to 2008), there are no relevant changes. Therefore, we abstain from reporting these results.



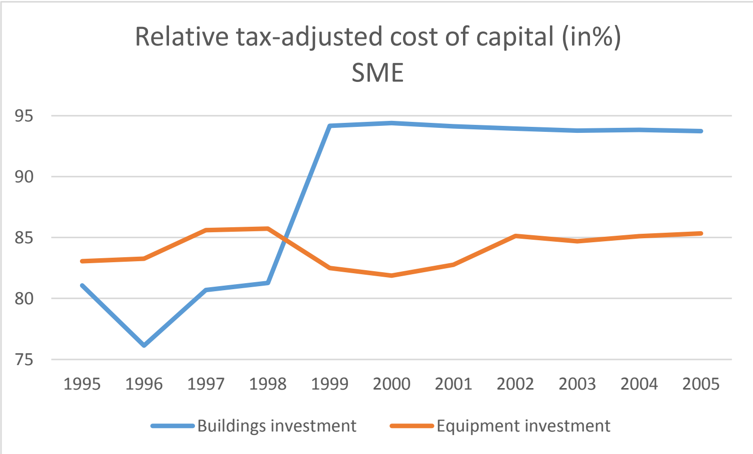


Figure 3.1: Average relative tax-adjusted costs of capital (in %, comparison Eastern vs. Western plants) of building and equipment investments for large plants and SMEs.
Source: based on Table 2 in Eichfelder and Schneider (2014)

Moreover, the tax-adjusted costs of capital for equipment investments decrease even further for SMEs after 1998 even though the effect is not very strong. Thus, we expect to see no difference in the productivity of equipment investments made with or without the DAL. Summarizing, this implies that unproductive equipment investments are less likely to result from the DAL.

3.2.3 Hypothesis development

If tax incentives are able to raise the level of sub-optimally low investments, such that the productivity of investments in the East is the same as the productivity of investments in the West, we expect no difference between growth effects of investments by unsubsidized and DAL-subsidized plants.

> ***Hypothesis 1:*** *DAL bonus depreciation affect the allocative long-term efficiency of investment and encourage efficient investment behavior. As a result, firm growth resulting from DAL-induced investments is no different from the non-subsidized investments.*

As reported in the literature (Cohen et al., 2002; Cohen and Cummins, 2006; House and Shapiro, 2008; Eichfelder and Schneider, 2014), bonus depreciation is more relevant for capital goods with long regular depreciation periods. This implies a larger impact of building investments on growth compared to equipment investments. Moreover, building investments are investments in fixed capacities and equipment investments are more flexible and mobile technological capacities. Hence, the impact of equipment investments on growth is more immediate but possibly less persistent, while building investments primarily affect the structural long-term development. This and given the fact that initial equipment investments were still subsidized after the expiration of DAL, we expect a stronger and more persistent relationship between subsidized investments in long-lived capital goods and growth as compared to growth effects of short-lived capital goods in DAL-subsidized plants Germany.

> ***Hypothesis 2:*** *The DAL bonus depreciation effect on growth is stronger for investments in buildings than in equipment.*

3.3 Data

The analysis is based on the German AFID[21]-panel for the manufacturing and mining sector, which comprises a number of mandatory business surveys conducted by the German Federal Statistical Office[22] (Malchin and Voshage, 2009). We rely on a panel from 1995 to 2008 using the Investment Survey of Establishments[23], the Monthly Report of Plants[24], and the Cost Structure Survey of Firms[25]. The Cost Structure Survey is based on a stratified random sample of German firms in the manufacturing and mining sector with more than 20 employees. The Investment Survey and the Monthly Report collect information on all business plants and firms with at least 20 employees in that industry. While the Cost Structure Survey reports data on the firm level, the Investment Survey and the Monthly Report provide information on the plant level. We also collected data on the district level (GDP per capita, population, and unemployment rate) from Regiostat and the German Federal Employment Agency to obtain a detailed picture on regional economic conditions. Hence, we have a unique firm panel covering the time period from 1995 to 2008. The variables used in our analysis are defined in Table 3.2.

[21] German: Amtliche Firmendaten in Deutschland.
[22] The data is available for scientific research and can only be accessed by remote data processing. It is provided by the German Federal Statistical Office.
[23] German: Investitionserhebung bei Betrieben des Verarbeitenden Gewerbes sowie der Gewinnung von Steinen und Erden.
[24] German: Monatsbericht bei Betrieben des Verarbeitenden Gewerbes sowie der Gewinnung von Steinen und Erden.
[25] German: Kostenstrukturerhebung bei Unternehmen des Verarbeitenden Gewerbes sowie der Gewinnung von Steinen und Erden.

Table 3.2: Variable definitions

Variable	Definition
Dependent variables	
Turnover level	ln(turnover)
Employment level	ln(number of employees)
Explanatory variables	
East	= 1 if plant located in Eastern Germany
Before'99	= 1 if plant existed between 1995 and 1998
Sum of investments in buildings between 2000-03	ln(sum of investments in buildings between 2000-03)
Sum of investments in equipment between 2000-03	ln(the sum of investments in equipment between 2000-03)
Sum of investments in buildings between 1995-98	ln(sum of investments in buildings between 1995-98)
Sum of investments in equipment between 1995-98	ln(sum of investments in equipment between 1995-98)
Lagged investments in buildings	First lag (*t*-1) of ln(investments in buildings)
Lagged investments in equipment	First lag (*t*-1) of ln(investments in equipment)
Relative predicted difference in building investments	ln(investments in buildings) minus predicted ln(investments in buildings)
Relative predicted difference in equipment investments	ln(investments in equipment) minus predicted ln(investments in equipment)
Plant-level control variables	
Capital stock	First lag (*t*-1) of ln(capital)
Share of exports	Share of exports on turnover, in %
Share of manufacturing	Share of manufacturing, in %
District-level regional control variables	
GDP per capita	In 1,000 euros
Unemployment rate	In %
Population size	In 1,000

A major advantage of our data is the detailed information on equipment investment and building investment on the plant level. Unlike earlier studies, we are therefore able to estimate the impact of investment subsidies on long-term capital goods (with a stronger expected effect of the DAL) and short-term capital goods of plants in Eastern Germany compared to the Western part. Therefore, the data provides us with a powerful identification strategy. Compared to accounting databases (Compustat, AMADEUS), our data does not rely on publications of firms, but on a census of all business plants of the manufacturing and mining industry with more than 20 employees. Thus, self-selection of disclosed information is not an issue. In addition, the panel does not only include large corporations, but also small and medium-sized businesses. The participation in all business surveys is mandatory. Therefore, missing information is limited to a small number of cases.

We restrict the final sample in a number of ways. We consider a total of 691,822 observations of business plants from 1995 to 2008, which participated at the Investment Survey and the Monthly Report and provide full information on the plant code and the firm code. For the sake of different funding criteria for the Berlin area, we drop 13,394 observations located in the state of Berlin. We focus on the manufacturing sector and do not account for 21,019 observations of firms in the mining sector.

Hence, the sample consists of 657,409 observations[26] for 66,024 plants in the manufacturing sector. Due to mergers and acquisitions and other forms of restructurings, one plant may be part of more than one firm over the whole period. We use the full sample containing plant-level data for Western and Eastern Germany for our analysis. Table 3.3 summarizes the plant data by region. Panel A describes the data for all observations in real terms,[27] while the panels B and C refer to Western Germany (550,726 observations) and Eastern Germany (106,629 observations) for 1995 to 2008, respectively.

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[26] This is obtained by reducing the total number of observations 691,822 by observations in Berlin, 13,394 and the firms in the mining sector, 21,019.

[27] For price adjustment we use the producer price index for the manufacturing sector, which has been published by the German Council of Economic Experts (2011), p. 409.

Table 3.3: Descriptive statistics by region (full sample)

Panel A: GERMANY	n	Mean	Std. Dev.
Dependent Variables			
Turnover (1,000,000 Euro)	654,936	28.46	290.31
Number of employees	654,937	130.00	572.43
Log turnover	631,145	15.68	1.51
Log staff	654,937	4.01	1.18
Real Investments (1,000 Euro)			
Gross investment (1,000 Euro)	595,516	1130.05	11094.20
Building investment (1,000 Euro)	595,516	132.42	1489.78
Equipment investment (1,000 Euro)	595,516	989.77	10183.07
Relative predicted difference in building investments	574,188	0.13	4.35
Relative predicted difference in equipment investments	574,188	0.24	4.04
Control variables			
Capital stock (1,000 Euro)	654,937	4932.61	25521.76
Share of exports (%)	631,145	16.22	22.94
Share of manufacturing (%)	631,145	94.28	14.45
GDP per capita (1,000 Euro)	657,355	25.30	9.87
Population (1,000)	657,355	278.34	254.18
Unemployment rate (%)	657,355	10.38	4.57
Panel B: WEST	**n**	**Mean**	**Std. Dev.**
Dependent Variables			
Turnover (1,000,000 Euro)	548,596	31.31	315.37
Number of employees	548,597	139.81	621.29
Log turnover	526,675	15.78	1.50
Log staff	548,597	4.06	1.19
Real Investments (1,000 Euro)			
Gross investment (1,000 Euro)	498,756	1144.69	11347.77
Building investment (1,000 Euro)	498,756	127.01	1395.24
Equipment investment (1,000 Euro)	498,756	1009.55	10424.61
Relative predicted difference in building investments	478,733	0.04	4.24
Relative predicted difference in equipment investments	478,733	0.28	4.03
Control variables			
Capital stock (1,000 Euro)	548,597	5033.59	26431.20
Share of exports (%)	526,675	17.53	23.43
Share of manufacturing (%)	526,675	94.10	14.66
GDP per capita (1,000 Euro)	550,726	26.80	9.94
Population (1,000)	550,726	302.60	267.98
Unemployment rate (%)	550,726	8.89	2.97
Panel C: EAST	**n**	**Mean**	**Std. Dev.**
Dependent Variables			
Turnover (1,000,000 Euro)	106,340	13.78	75.56
Number of employees	106,340	79.39	154.08
Log turnover	104,470	15.19	1.45
Log staff	106,340	3.78	1.08
Real Investments (1,000 Euro)			
Gross investment (1,000 Euro)	96,760	1054.58	9682.05
Building investment (1,000 Euro)	96,760	160.32	1903.77
Equipment investment (1,000 Euro)	96,760	887.82	8833.23
Relative predicted difference in building investments	95,455	0.59	4.88
Relative predicted difference in equipment investments	95,455	0.06	4.12
Control variables			
Capital stock (1,000 Euro)	106,340	4411.65	20181.50
Share of exports (%)	104,470	9.58	18.95
Share of manufacturing (%)	104,470	95.23	13.34
GDP per capita (1,000 Euro)	106,629	17.58	4.49
Population (1,000)	106,629	153.07	92.99
Unemployment rate (%)	106,629	18.08	3.50

Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

3.4 Identification strategy

On average, price-adjusted turnover in Western Germany (31.31 million €) is higher than in Eastern Germany (13.78 million €) in the full sample as displayed in Table 3.3. That holds also for the number of employees with 139.8 staff members on average in the West compared to only 79.4 in the East. By simply comparing the means of the outcomes of the treatment and control groups, one ignores the important differences of plants in each group.

Our identification strategy comprises of two steps. First, we analyze the effectiveness of DAL tax incentives on firm growth in a matching approach without considering investments as a driving force of economic growth. As the comparability of Eastern and Western plants is restricted due to large structural differences, this step attempts to measure the extent of the diverging development in both parts of Germany despite the reunification. Second, we analyze the impact of the tax-incentivized investments on firm growth in the long-term in a match-paired regression analysis. Using the matching result from the previous step, we include investments in the equation as they provide a driving force of economic growth. Furthermore, it allows us to explain the effectiveness of DAL through the channel of investments and thereby also the structural differences of both parts.

3.4.1 Matching approach

The main issue in quantifying the effect of DAL on firm growth is that the true level of turnover (or any other outcome variable) in the Eastern German plants in absence of DAL is a non-observable counterfactual. At each point in time t, each plant i is observed in one state, i.e. it is either located in Eastern Germany or in Western Germany. Thus, a plant located in Eastern Germany is eligible to benefits from the bonus depreciation granted by the DAL by investing during the period of 1995 to 1998 (treatment group). On the contrary, Western German plants cannot benefit from this subsidy (control group).

In order to quantify the effect of the bonus depreciation, one compares a plant's observed actual state with its unobserved counterfactual state, i.e. how the plants in the control group would have invested if they were subsidized (see, e.g., Morgan and Winship, 2007).

Rosenbaum and Rubin (1983) suggest the propensity score matching to reduce the bias in the estimation of treatment effects using observational data. The parameter of interest is the Average Treatment Effect on the Treated (ATT), which measures the average treatment effect of benefitting from the DAL on average level of turnover (or any other outcome variable Y_i) and can be formulated as

$$\text{ATT} = E\left[Y_i \mid DAL_i = 1\right] = E\left[Y_{1i} \mid DAL_i = 1\right] - \underbrace{E\left[Y_{0i} \mid DAL_i = 1\right]}_{\text{unobserved counterfactual}}. \tag{3.1}$$

In words, the expression is the difference between level of outcome of plant *i* which invested in the East during 1995 to 1998 and benefitted from the DAL, Y_{1i}, and the outcome level of the same plant *i* if it hypothetically did not invest in the East during 1995 to 1998, Y_{0i}. Since the latter is unobservable, an adequate counterfactual has to be determined in order to derive the ATT.

By simply comparing the turnover levels of Eastern German plants and Western German plants however yield the ATT with an additional effect from possible structural differences of Eastern German plants (Angrist and Pischke, 2009, pp. 12-15). Put differently, Eastern German plants might be a selective group of plants. Comparing the observed differences in turnover leads to the naïve estimator, i.e.

$$\underbrace{E\left[Y_i \mid DAL_i = 1\right] - E\left[Y_i \mid DAL_i = 0\right]}_{\text{observed difference in turnover}} = \underbrace{E\left[Y_{1i} - Y_{0i} \mid DAL_i = 1\right]}_{\text{ATT}} + \underbrace{E\left[Y_{0i} \mid DAL_i = 1\right] - E\left[Y_{0i} \mid DAL_i = 0\right]}_{\text{selection-bias}}. \quad (3.2)$$

The observed difference in the outcome variable, i.e. turnover of DAL-benefitting plants compared to those who do not benefit from DAL, equals the ATT (first summand of the right-hand side) and the selection bias term (second and third summands). This bias results from the correlation between the error term and the treatment status and reflects the difference in potential outcomes between the treated and untreated due to selective choice of investing in Eastern Germany during the time of the DAL instead of exogenous treatment.

This naïve estimator would be equal to the ATT only if the individual outcomes of plants from treatment and control groups would not differ in the absence of treatment. This would only be possible if Eastern plants yield the same level of outcome as Western plants so that it would hold

$$E\left[Y_{0i} \mid DAL_i = 1\right] - E\left[Y_{0i} \mid DAL_i = 0\right] = 0. \quad (3.3)$$

Equation (3.3) can only hold if the error term of the regression of the outcome on the treatment is the same across different treatment statuses, i.e. only if the expected outcome of observations in the control group given the treatment status does not vary. This allows the identification of the ATT simply by taking the difference in outcome between observed entities.

Since we deal with observational data, we have to build the empirical strategy on some identifying assumptions to reduce the bias resulting from selective investment. It is likely that the plant's choice of investing in Eastern Germany during the time of the DAL is the result of selective investment behavior according to particular characteristics of the plant. Therefore, investments by East German plants cannot be regarded as a random choice of treatment and this may have direct effects on turnover levels of the plant. Hence, plants that benefit from the DAL cannot be regarded as a random sample. As a consequence, determinants for investing in Eastern Germany, and hence to benefit from DAL, can simultaneously influence the outcome variable, i.e. turnover or number of employees.

To cope with the bias stemming from the endogenous investment decision and to allow potential endogeneity problems, the econometric literature suggests different approaches (Angrist and Pischke, 2009). We use propensity score matching methods to minimize the bias from the selective choice of investing in Eastern Germany during the time of the DAL.

The matching approach hinges on the challenge to determine a control group similar to the treatment. Only if the matching is successful, the comparison of the outcome variable of both groups is meaningful. In order for the propensity score matching approach to be valid, the *Conditional Independence Assumption* (CIA), also referred to as unconfoundedness, has to hold. It requires that the decision to invest in Eastern Germany during the time of the bonus depreciation is assumed to be based only on observable variables so that differences in outcomes between the treatment and the control group are only attributable to the treatment (Imbens, 2004; Angrist and Pischke, 2009). With the CIA, one assumes that conditional on observed covariates X_i, potential outcomes $\{Y_{1i}, Y_{0i}\}$ are independent of the treatment status DAL_i, i.e. $\{Y_{1i}, Y_{0i}\} \perp DAL_i \mid X_i$. Hence, given the observed covariates X_i, assignment to treatment is as good as randomly assigned.

Another assumption ensuring the consistent identification of treatment effects by matching estimators is *overlap* or *common support*. This assumption requires the probability of treatment assignment to be bounded away from zero and one

$$0 < \Pr(DAL_i = 1 \mid X_i) < 1 . \tag{3.4}$$

Common support is given for any sample in which plants can actually decide to invest and hence to benefit from the DAL (treatment). If the two assumptions of unconfoundedness and overlap hold, Rosenbaum and Rubin (1983) define the treatment to be strongly ignorable and in our context we can identify the ATT of the DAL bonus depreciation.

The implementation of the matching estimator consists of two stages. The first stage, we compute a balancing score, which represents functions of relevant observed covariates in the form of a propensity score by running a probit estimation reflecting the probability of receiving treatment determined by the covariates that determine the choice of investing in Eastern Germany during the time of the DAL (treatment) (Rosenbaum and Rubin, 1983). We use different specifications[28] of matching algorithms and different covariate sets.

Using the estimated propensity scores of treatment status from the first stage, we look at its effect on the outcome in the second stage. By matching each treatment observation *i* with one or several control observations *j*, based on similar propensity scores and including a dummy for each block[29], we assure the comparability of treatment and control group (Heckman, Ichimura, and Todd, 1998; Smith and Todd, 2005). Using these matched pairs, we estimate the

[28] In more detail, we apply different bandwidths for the Kernel matching estimator (0,06, 0.03 and 0.01) and nearest neighbor matching with one and five neighbors (for results, see Appendix A.1).

[29] This controls for similarities within that group such that the absolute difference in propensity scores between *i* and j is minimized (min $|p_i - p_j|$).

$$\text{ATT} = \frac{1}{N^T} \sum_{i \in I_T} \left[Y_{1i} - \sum_{j \in I_C} w(i,j) Y_{0i} \right]. \tag{3.5}$$

with I_T being the set of treated firms, N^T the number of treated firms and I_C being the set of control firms (Smith and Todd, 2005). The choice between different matching algorithms affects the number of control plants as well as the weight $w(i,j) \in [0,1]$ of each control observation.

We apply the Kernel matching estimator as proposed by Heckman et al. (1998) and Smith and Todd (2005). Kernel matching forms a weighting function by considering all observations of the untreated group. The weights reflect the distance between a treated observation *i* and a control observation *j*. Using a kernel function $G(x)$ with bandwidth parameter *h*, the weight assigned to control observation *j* is

$$w(i,j) = \frac{G(\frac{p_i - p_j}{h})}{\sum_{j \in \{DAL_i = 0\}} G(\frac{p_i - p_j}{h})}. \tag{3.6}$$

In our case, we use the Epanechnikov kernel implying that among the untreated group, observations are chosen in a moving window within a fixed caliper (bandwidth) *h* from $|p_i - p_j| < h$ (Heckman et al., 1998; Smith and Todd, 2005). Thus, we calculate the counterfactual as the weighted average of all control units while the weight is higher for observations with similar propensity score. This estimator provides the best properties in terms of a tradeoff between bias and efficiency (Caliendo and Kopeinig, 2008).

3.4.2 Matched sample

We need to include all variables X_i that influence both the outcome variable as well as the treatment variable (DAL-induced investments) in order to support the CIA (e.g., Sianesi, 2004; Smith and Todd, 2005; Caliendo and Kopeinig, 2008).

The decision to invest during the time of DAL is non-random and can be formulated as a capital accumulation optimization problem (e.g., Jorgenson, 1963). Firms maximize the present value of a profit stream subject to a production function relating the flow of output to flows of labor and capital services (Hall and Jorgenson, 1967). Plants maximize profits by choosing optimal amounts of input and labor under budget time constraints. The degree of the use of the DAL bonus depreciation, in turn, is a function of investment requirements and planned investments. We therefore include a large set of plant characteristics to capture the plants' constraints and preferences with respect to investment behavior and particularities of the businesses. The set of covariates can be differentiated into four groups: structural plant characteristics, input structure, capital activity, market participation and regional economic characteristics (see Table 3.4 for more details).

Since we expect differences in size and investment behavior depending on structural plant characteristics, we control for type of plant, industry sector, product category, and legal form. For instance, single businesses and partnerships are less likely to benefit from the DAL due to lower investment levels, which, in turn, result in lower growth compared to incorporated multinational firms. Also, we include industry dummies to consider industry-wide differences in investments due to different requirements.

Table 3.4: Description of variables of the conditioning set

Structural plant characteristics	
Plant type	Dummies indicating whether the plant is a single business, a plant belonging to a nationally operating firm with multiple plants, a plant being part of a multinational enterprise or a plant owned by a foreign firm.
Industry sector	Dummies indicating the economic branch classified by WZ2003.
Product category	Dummies indicating production of intermediate goods, investment goods, commodities, consumer goods or energy.
Legal form	Dummies indicating legal form, which is single business, partnerships or corporations.
Input	
Material input use	Log material use
Energy use	Log energy use
R&D expenditure	Log expenditure for R&D
R&D wage payments	Log wage payments for R&D staff
Capital activity	
Interest payments	Log interest payments
Capital stock	Estimated capital stock (see Eichfelder and Schneider, 2014 for detailed procedure)
Market participation	
Share of exports	Share of exports on turnover in %
Share of manufacturing	Share of manufacturing on turnover in %
Regional macroeconomic variables	
Unemployment rate	District-level unemployment rate in %
GDP per capita	District-level GDP per capita
Population	District-level population

For instance, to capture the plants' input choices, we include the input of materials, energy use, R&D expenditure and R&D wage payments as well as the square of those variables to capture non-linear effects. Non-linear effects might be relevant; as for instance firms that invest more in R&D are more likely to have follow-up investments due to the sunk-cost characteristic of R&D expenditures (Sutton, 1991).

We also include interest payments and interest payment squared in the conditioning set to proxy for financing structure and capital structure. The capital stock of a plant could also influence DAL-induced investments and firm growth. Therefore, we control for the estimated capital stock at the beginning of a period and its square to capture differences in asset endowments. Moreover, we include the share of exports on turnover, the share of manufacturing on turnover to account for the international orientation of the business, and the focus of the plant on the manufacturing industry.

Table 3.5: Descriptive statistics by region (match-paired sample)

Panel A: GERMANY	n	Mean	Std. Dev.
Dependent Variables			
Turnover (1,000,000 Euro)	178,302	19.89	145.33
Number of employees	178,302	104.67	346.53
Log turnover	178,302	15.49	1.43
Log staff	178,302	3.96	1.08
Real Investments			
Gross investment (1,000 Euro)	178,302	969.59	8278.47
Building investment (1,000 Euro)	178,302	132.05	1211.85
Equipment investment (1,000 Euro)	178,302	831.63	7580.85
Control variables			
Capital stock (1,000 Euro)	178,302	4700.79	17488.15
Share of exports (%)	178,302	12.32	20.72
Share of manufacturing (%)	178,302	95.10	13.21
GDP per capita (1,000 Euro)	178,302	19.96	5.78
Population (1,000)	178,302	198.47	141.76
Unemployment rate (%)	178,302	15.09	3.86
Panel B: WEST	**n**	**Mean**	**Std. Dev.**
Dependent Variables			
Turnover (1,000,000 Euro)	89,151	24.84	191.32
Number of employees	89,151	124.60	462.39
Log turnover	89,151	15.63	1.49
Log staff	89,151	4.02	1.16
Real Investments			
Gross investment (1,000 Euro)	89,151	950.53	8106.85
Building investment (1,000 Euro)	89,151	113.86	1117.00
Equipment investment (1,000 Euro)	89,151	831.01	7443.07
Control variables			
Capital stock (1,000 Euro)	89,151	4953.59	19487.77
Share of exports (%)	89,151	14.45	21.76
Share of manufacturing (%)	89,151	94.91	13.32
GDP per capita (1,000 Euro)	89,151	22.06	6.09
Population (1,000)	89,151	239.64	166.49
Unemployment rate (%)	89,151	12.58	2.71
Panel C: EAST	**n**	**Mean**	**Std. Dev.**
Dependent Variables			
Turnover (1,000,000 Euro)	89,151	14.95	74.76
Number of employees	89,151	84.74	159.88
Log turnover	89,151	15.36	1.34
Log staff	89,151	3.90	0.99
Real Investments			
Gross investment (1,000 Euro)	89,151	988.65	8446.60
Building investment (1,000 Euro)	89,151	150.23	1299.56
Equipment investment (1,000 Euro)	89,151	832.25	7716.20
Control variables			
Capital stock (1,000 Euro)	89,151	4447.99	15224.10
Share of exports (%)	89,151	10.18	19.40
Share of manufacturing (%)	89,151	95.28	13.11
GDP per capita (1,000 Euro)	89,151	17.86	4.56
Population (1,000)	89,151	157.29	95.29
Unemployment rate (%)	89,151	17.60	3.13

Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

Finally, in order to approximate regional structural differences, we further control for macroeconomic differences in different regions by including the regional unemployment rate, regional GDP per capita and population on the district level.

3.4.3 Long-term effects of bonus depreciation

We are not only interested in the short-term effects of the bonus depreciation on firms by means of increased investments activities, but also in the long-term causal effects of the DAL and thus the convergence process between the economy in Eastern and Western Germany. In order to study the long-run effects, we make use of the matching approach and hence exclude unmatched plants. This leaves us with a total of 178,302 observations in the match-paired sample. Table 3.5 summarizes the plant data by affiliation status with West German parent firms. Panel A describes the data for all observations (in real terms), while the panels B and C document descriptive statistics for Western plants (89,151 observations) and Eastern plants (89,151 observations) for 1995 to 2008.

We consider the panel data between 2000 and 2008 and include the sum of past investments between 1995 and 1998 (time period of the DAL) as time-invariant explanatory variables. Thus, we estimate the model

$$y_{i,t} = \gamma_0 \cdot east + \beta_1 \cdot I_{i,t-1} + \beta_2 \cdot I_{i,t-1} \cdot east + \beta_3 \cdot X_{i,t} \\ + \gamma_1 \cdot \sum I_{i,95-98} + \gamma_2 \cdot \sum I_{i,95-98} \cdot east + \alpha_i + \delta_t + u_{i,t}. \quad (3.7)$$

The dependent variable is either log turnover or log number of employees between 2000 and 2008. We include a dummy variable equal to one if the plant is located in Eastern Germany. Furthermore, we include lagged investments as well as an interaction of lagged investment and east. Including the sum of investments between

1995 and 1998 and its interaction with the east-dummy allows us to assess the long-term effects of investments on our dependent variable. A fixed effects approach would sweep out firm specific effects but also time-invariant regressors. Hence, we apply the random effects model, keeping the known drawbacks of the approach in mind.

We think that growth of plants within one firm and year are likely to be highly correlated because any increase in turnover of the plant in one year is likely to correlate with the growth of another plant of the same firm in the same year. By treating the observations as non-i.i.d., we avoid overstating of the precision of the standard estimator's variance (Cameron and Miller, 2015). Thus, we allow for correlation in our dependent variable across plants within a firm-plant-year cell by clustering the standard errors by firm-plant-year.

Furthermore, we include a variable, $\Delta_{i,t}$, in the regression capturing the extent to which plants in Eastern Germany invest differently compared to plants in Western Germany. This variable is calculated in three steps. We first regress each type of investment by Western plants on all available control variables. Then, we predict $\hat{I}_{i,t}$ for both types of investments in Eastern and Western Germany using the estimated coefficients. We compare the predicted investments with the actual investments to obtain a counterfactual measure of how Eastern plants would have invested if they faced the same conditions as the Western counterparts. This is calculated as the difference of the actual amount of investment and the predicted investments. We denote this measure as the *relative predicted difference in investments* which is given by

$$\Delta_{i,t} = I_{i,t} - \hat{I}_{i,t}. \quad (3.8)$$

Extending Eqn. (3.7) by including (3.8) for both types of investments becomes

$$\begin{aligned} y_{i,t} = \gamma_0 \cdot east + \beta_1 \cdot I_{i,t-1} + \beta_2 \cdot I_{i,t-1} \cdot east + \beta_3 \cdot X_{i,t} \\ +\gamma_1 \cdot \sum I_{i,95-98} + \gamma_2 \cdot \sum I_{i,95-98} \cdot east. \\ +\Delta_{i,t} + \alpha_i + \delta_t + u_{i,t}. \end{aligned} \quad (3.9)$$

3.5 Results

3.5.1 Average effect of bonus depreciation on DAL-investing plants

We display the average treatment effects of the bonus depreciation for treated plants in Table 3.6. The ATT for turnover is statistically significant and about 0.197. With log-transformed outcome variables, the coefficients can be interpreted as semi-elasticities using an approximation proposed by Kennedy (1981). The relative changes in the outcome variable depending on subsidy granting is given by $\exp\left(\hat{ATT_i} - \frac{1}{2} \cdot \mathrm{Var}\left(\hat{ATT_i}\right)\right) - 1$ where $\hat{ATT_i}$ is the estimated regression coefficient and $\mathrm{Var}\left(\hat{ATT_i}\right)$ is the variance. For the turnover level, the estimated ATT indicates that plants benefitting from the DAL bonus depreciation show a higher level of turnover by 21.7%[30]. Using turnover growth as the dependent variable, we obtain a statistically significant negative coefficient of -0.05 indicating that the turnover growth is slower for DAL-incentivized investments by Eastern plants by 5%[31]. Thus, DAL investments might have a negative effect on turnover growth and possibly point to a hampered convergence process.

[30] The relative change in turnover by DAL is obtained by using the transformation according to Kennedy (1981), i.e. exp(0.1966 - 0.5 · 0.0308^2) - 1 = 0.2167.
[31] This relative change is also obtained using the transformation according to Kennedy (1981).

Table 3.6: Average treatment effect on the treated

	Turnover	Turnover growth	N° employees	N° employees growth
	(1)	(2)	(3)	(4)
ATT	0.1966***	-0.0503***	0.2326***	-0.0240***
	(0.0308)	(0.0088)	(0.024)	(0.0051)
t-stat	6.39	-5.72	9.36	-4.70
N treatment	6,698	6,698	6,698	6,698
N control	28,980	28,980	28,980	28,980
N off-support	23,995	23,995	23,995	23,995
Median bias (%)	2.9	2.9	2.9	2.9

Standard errors in parentheses. *p < 0.1; **p < 0.05; ***p < 0.01.
Notes: Kernel matching estimation with bandwidth 0.06. The outcome variables are log turnover, log number of employees, and their growth rates respectively. Treatment dummy is DAL bonus depreciation. The propensity score is estimated via probit (in Table A.1).
Source: AFiD enterprise panel (1995-2008), own calculations.

After matching, we are able to attribute the effect found to the bonus depreciation and to reject our Hypothesis 1 that the DAL is associated to equally productive as non-subsidized investments. More precisely, we find that DAL bonus depreciation leads to higher turnover levels for Eastern plants while growth of DAL-investments is yet lower than that of unsubsidized investments by Western plants. Similarly, this also holds for number of employees. Here, the ATT reveals that the DAL bonus depreciation increases number of employees by 26.1%[32] while its growth slows down by 2.4%.

3.5.2 Matching quality

The first part of the propensity score matching comprises of the estimation of plant-individual propensity scores reflecting the predicted probabilities of DAL-incentivized investment on the basis on observable covariates (the estimated coefficients of this step are displayed in Table A.1 of the appendix). Most importantly, the results indicate that plants being part of an enterprise group are less

[32] This relative change and the following are also obtained using the transformation according to Kennedy (1981).

likely to be located in the East and to benefit from DAL. Then, producers of investment goods and producers of consumer goods have a higher likelihood of benefitting from the DAL. Also, a plant being incorporated positively affects the likelihood of DAL.

With the estimated propensity scores and the chosen matching method, we are able determine the selective choice of investing in Eastern Germany during the time of the DAL. Assessing the covariate balance between both groups is crucial in matching methods. By looking at the overall statistics on covariate balance, we are able to have a glance on the appropriateness of the chosen method.

Table 3.7: Overall statistics on covariate balance

Sample	Pseudo R^2	LR chi^2	p>chi^2	Mean bias	Median bias
Unmatched	0.624	26179.42	0.000	22.9	5.7
Matched	0.034	625.18	0.000	4.6	2.9

Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

Table 3.7 indicates a satisfying matching quality. The pseudo-R^2 values indicate that the explanatory power of the covariates is lower in the matched sample (0.03) than in the unmatched sample (0.62) but also show that in the matched sample, systematic differences between treatment and control group are eliminated by the matching algorithm (Caliendo and Kopeinig, 2008). Testing for the hypothesis that all coefficients are zero with a likelihood test, can be rejected in the unmatched sample. In contrast, we cannot reject the hypothesis in the case of the matched sample. This just confirms that by matching the probability to benefit from DAL (being in the East) is unrelated to observable firm characteristics. Finally, the mean bias before matching equals 22.9% reduces after matching to 4.6%.

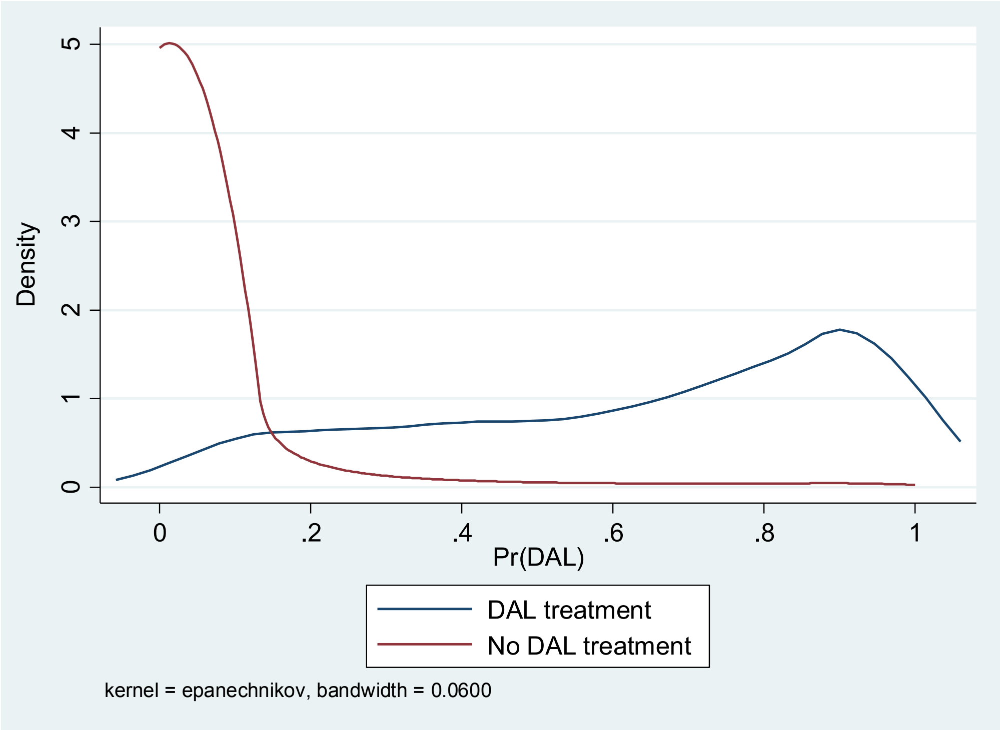

Figure 3.2: Assessment of the common support assumption
Notes: Kernel density plots of the propensity to benefit from DAL bonus depreciation with bandwidth 0.06.
Source: Data from the AFiD enterprise panel (2015), own graph.

We assess the common support condition graphically by depicting the kernel plot for the propensity scores for plants with and without treatment (Figure 3.2). The graph shows an intersection of the supports of the propensity score of treated and control cases so that both treatment and control groups have an overlap in the propensity which technically allows us the comparison of both groups conditional on the choice of covariates. There is a higher mass of distribution at the lower levels of the propensity score for plants without DAL treatment. The reason may be that plants who do not benefit from DAL are the numerous plants located in the Western part of Germany which are unable to benefit from DAL. Also, a higher mass of distribution of the propensity score for DAL-treated plants gives rise to the fact that almost all Eastern plants made use of the bonus depreciation.

The similarity of the treatment and the control group is crucial for the estimation of treatment effects. Therefore, matching should not only balance in propensity score but also in the observable plant characteristic. For almost all covariates, the means of treatment and control group, we are able to reject the hypothesis of mean difference which can be interpreted as an indicator for appropriate matching quality (see Table 3.8).

Table 3.8: Sample descriptive statistics after kernel matching with bandwidth 0.06

	DAL Treatment (n = 6,698)	no-DAL Control (n = 28,980)	Std. bias (%)	t-stat	p-value of t-tests on mean differences
Plant part of an enterprise group	0.022	0.028	-2.9	-2.52	0.012
Plant part of a foreign enterprise	0.418	0.441	-4.8	-2.75	0.006
Investment goods producer	0.357	0.361	-1	-0.58	0.563
Durable goods producer	0.051	0.043	4	2.42	0.016
Food, drink, and consumer goods producer	0.132	0.121	3.4	1.94	0.052
Energy producer	0.001	0.001	-1.3	-0.96	0.338
Incorporated	0.809	0.813	-1	-0.62	0.533
Other legal form	0.003	0.001	2.9	2.09	0.037
Resource input use	16.500	16.327	8.3	4.59	0.000
Resource input use² ($\times 10^{18}$)	3.000	2.300	1.6	2.06	0.04
Energy use	13.291	13.127	7.6	4.37	0.000
Energy use² ($\times 10^{15}$)	1.500	1.00	0.6	1.61	0.108
Interest payments	12.564	12.448	4.7	2.82	0.005
Interest payments² ($\times 10^{16}$)	1.400	1.200	2.5	1.38	0.169
R&D expenditure	13.134	13.055	3.1	1.84	0.065
R&D expenditure² ($\times 10^{16}$)	178.770	176.640	2.9	1.72	0.086
R&D wage payments	2.275	2.178	4.8	2.92	0.004
R&D wage payments² ($\times 10^{6}$)	7.1	6.0	2.5	1.33	0.185
Capital stock	15.368	15.078	21.1	12.53	0.000
Capital stock²	238.050	229.080	20.7	12.39	0.000
Share of exports	0.240	0.234	2	1.19	0.236
Share of exports²	0.124	0.122	0.9	0.58	0.564
Share of manufacturing	0.959	0.959	-0.1	-0.1	0.917
Share of manufacturing²	0.931	0.932	-0.4	-0.31	0.755
Unemployment rate	17.956	18.107	-4.3	-2.28	0.023
GDP per capita	9.806	9.846	-14.1	-9.87	0.000
Population	11.868	11.856	1.9	1.23	0.219

Notes: Descriptive statistics of the full sample versus the matched sample after kernel matching using bandwidth 0.06.
Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

According to Rosenbaum and Rubin (1985) the standardized bias gives a more robust measure of covariate balance. A standardized bias below 5% is in most of the cases given which indicates good matching quality (Caliendo and Kopeinig, 2008).

In some cases such as capital stock the standardized bias remains large which can be explained by the fact that Eastern and Western Germany are after reunification in terms of infrastructure still in a process of convergence. Overall, matching works sufficiently well in obtaining a control group similar to the treatment group. The observable determinants of DAL treatment work well conditional on ruling out the influence of unobservables such that the remaining assignment to control and treatment group is as good as random, given the propensity score. Hence, we are able to compute the differences in our outcome variables.

3.5.3 Long-term effects of DAL-incentivized investments

Based on the results presented in Section 3.5.1, we suspect that the large differences in turnover and employment cannot be directly attributed to the DAL and that the longevity of investments plays a crucial role for the development of businesses. Therefore, we focus on investments as the channel driving turnover and employment. By estimating the random effects specification using the matched sample, we focus on long-run implications of investments while taking into consideration the differences across both parts of Germany. The results are summarized in Table 3.9.

The coefficient of the east-dummy is negative and significant in all specifications. Thus, the level of turnover in the post-DAL period is lower in East German plants compared to West German plants. The elasticity of lagged building investments (I_{t-1}^{Build}) implies increases in turnover of 0.01%, when lagged investments increase by 10%. However, these elasticities are only significant to the 5% level in columns (1) and (2), and become insignificant in column (3) when adding the relative predicted difference in investment. Analogously for lagged equipment investments (I_{t-1}^{Equip}), the elasticities imply changes in turnover between 0.05 and 0.1% as investments increase by 10% in the previous period. The interaction of investments in buildings and the east-dummy ($I_{t-1}^{Build} \cdot$ east) is negative but insignificant. On the contrary, the interaction effect for equipment investment is positive but insignificant. Both results indicate that buildings and equipment investments after 1998 have the same effects on turnover for Eastern and Western plants.

By looking at coefficients of the sum of investments before 1999 ($\Sigma\, I_{95\text{-}98}$), we find the expected positive and significant relationship between past investments and turnover. The elasticities imply increases in turnover of about 0.1% following increases in building investments before 1999 ($\Sigma\, I_{95\text{-}98}^{Build}$) of 10%. In case of equipment investments ($\Sigma\, I_{95\text{-}98}^{Equip}$), increases in investments during the period 1995 to 1998 of 10% imply increases in turnover of 0.08%.

When interacting the sum of buildings investments before 1999 with the east-dummy ($\Sigma\, I_{95\text{-}98}^{Build} \cdot$east), the coefficient indicates smaller but also positive effects of investments before 1999 on turnover in Eastern Germany. That is Eastern plants increasing building investments during the DAL period by 10% are associated with turnover increases of about 0.08% which is significant at the 5% level. For the interaction term, the coefficients show that increases in equipment investments during DAL in the East ($\Sigma\, I_{95\text{-}98}^{Equip} \cdot$ east) is negative but insignificant.

Table 3.9: Long-term effects of DAL-induced investments on post-DAL log turnover and log number of employees in a random effects model (2000-08) – matched-paired sample

	Turnover		
VARIABLES	(1)	(2)	(3)
Eastern plants	-0.599***	-0.493***	-0.498***
	(0.0401)	(0.0443)	(0.0440)
I_{t-1}^{Build}	0.000944**	0.000903**	0.000669
	(0.000426)	(0.000425)	(0.000416)
$I_{t-1}^{Build} \cdot$ east	-0.000467	-8.90e-05	-0.06e-05
	(0.000997)	(0.000982)	(0.000977)
I_{t-1}^{Equip}	0.00469***	0.00468***	0.00406***
	(0.000910)	(0.000908)	(0.000892)
$I_{t-1}^{Equip} \cdot$ east	0.00234	0.00237	0.00264
	(0.00195)	(0.00195)	(0.00192)
$\Sigma I_{95\text{-}98}^{Build}$	0.0136***	0.0138***	0.0132***
	(0.00149)	(0.00149)	(0.00148)
$\Sigma I_{95\text{-}98}^{Build} \cdot$ east	0.00791**	0.00799**	0.00797**
	(0.00354)	(0.00355)	(0.00352)
$\Sigma I_{95\text{-}98}^{Equip}$	0.00864***	0.00828***	0.00793***
	(0.00180)	(0.00181)	(0.00180)
$\Sigma I_{95\text{-}98}^{Equip} \cdot$ east	-0.00438	-0.00345	-0.00309
	(0.00383)	(0.00384)	(0.00381)
Δ^{Build}			0.00152***
			(0.000388)
Δ^{Equip}			0.00739***
			(0.000900)
Constant	8.411***	0.0138***	7.034***
	(0.163)	(0.00149)	(0.336)
Observations	30,744	30,744	30,744
Capital stock	YES	YES	YES
Plant-level controls	YES	YES	YES
Macroeconomic controls	NO	YES	YES
Year effects	YES	YES	YES
Industry effects	YES	YES	YES
Within R2	0.155	0.159	0.161
Between R2	0.746	0.746	0.749
Overall R2	0.733	0.732	0.734
Number of Establishments	8,627	8,627	8,627

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

As expected, the results imply that investing in buildings and equipment during the time of DAL increases turnover in the post-DAL period in both parts of Germany. However, the respective interaction terms imply that there are differences in the development of business depending on the types of investment. Hence, we find no effect of subsidized equipment investment on turnover. Nevertheless, building investments that benefitted from the DAL are associated with higher turnover. This suggests that investments in infrastructures, i.e. buildings, might have been necessary to build the minimum infrastructure and thus to ensure long-term development of businesses in Eastern Germany. In comparison, the effect of DAL-benefitting equipment investments with shorter longevity suggests less a supporting effect in the development of businesses than the building investments. Thus, the results might be interpreted as evidence for Hypothesis 2.

When including the relative predicted difference in investments (column 3 of Table 3.9) in the estimation equation, the coefficients reveal for both types of investments a positive and significant relationship. In economic magnitude, the coefficients for building investments reveal that increasing investments of 10% in addition to what Western plants would have invested increases turnover by 0.01%. In case of equipment investments, this is even larger at almost 0.1%.

Since the relative predicted difference in investments reflects the investment amount that Eastern plants hypothetically invest in addition to what Western plants invest, this result reflects how Eastern plants' overinvesting behavior affects their development. The DAL seems to induce higher investment compared to Western plants that do not contribute to the development of business and hence reflects overinvestment behavior of subsidized plants. Consequently, firm growth resulting from DAL-incentivized overinvestments is different than growth from non-subsidized investments and hence, we are able to reject Hypothesis 1. And again, the differences in the coefficients across types of investments suggest that the effect of overinvestment by DAL-incentivized equipment investments on turnover is lower than that of building investments. In comparison, building investments affecting the long-term development and being indispensable to revive the Eastern economy may have suffered less from overinvestment. Thus, we find further evidence for Hypothesis 2.

Table 3.10: Long-term effects of DAL-induced investments on post-DAL log number of employees in a random effects model (2000-08) – matched-paired sample

	(1)	(2)	(3)
VARIABLES		N° of employees	
Eastern plants	-0.295***	-0.232***	-0.234***
	(0.0221)	(0.0242)	(0.0240)
I_{t-1}^{Build}	0.000212	0.000170	0.000108
	(0.000197)	(0.000197)	(0.000189)
$I_{t-1}^{\text{Build}} \cdot$ east	0.000845	0.00111*	0.00112**
	(0.000579)	(0.000572)	(0.000570)
I_{t-1}^{Equip}	0.00258***	0.00258***	0.00233***
	(0.000451)	(0.000448)	(0.000442)
$I_{t-1}^{\text{Equip}} \cdot$ east	0.00114	0.00113	0.00124
	(0.00103)	(0.00102)	(0.00102)
$\Sigma I_{95\text{-}98}^{\text{Build}}$	0.00653***	0.00661***	0.00643***
	(0.000914)	(0.000916)	(0.000911)
$\Sigma I_{95\text{-}98}^{\text{Build}} \cdot$ east	0.00808***	0.00805***	0.00803***
	(0.00197)	(0.00197)	(0.00196)
$\Sigma I_{95\text{-}98}^{\text{Equip}}$	0.0117***	0.0113***	0.0111***
	(0.00104)	(0.00105)	(0.00105)
$\Sigma I_{95\text{-}98}^{\text{Equip}} \cdot$ east	-0.00646***	-0.00569***	-0.00554***
	(0.00212)	(0.00213)	(0.00212)
Δ^{Build}_i			0.000285
			(0.000204)
Δ^{Equip}_i			0.00339***
			(0.000415)
Constant	-3.717***	-3.656***	-3.670***
	(0.135)	(0.222)	(0.221)
Observations	30,744	30,744	30,744
Capital stock	NO	YES	YES
Plant-level controls	NO	YES	YES
Macroeconomic controls	NO	NO	YES
Year effects	YES	YES	YES
Industry effects	NO	YES	YES
Industry year effcts	NO	NO	NO
Within R2	0.480	0.485	0.486
Between R2	0.884	0.884	0.885
Overall R2	0.866	0.866	0.867
Number of Establishments	8,627	8,627	8,627

Notes: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

Since employee growth in a plant also reflects economic growth, we use log employment as the dependent variable in (3.7) and (3.9) with the log number of employees (see Table 3.10). The coefficients for the dummy indicating the location of the plant in Eastern Germany are always negative and significant. By looking at the coefficients for the lagged investments in buildings for both parts of Germany, we find no effect on number of employees. Also, when interacting, lagged building investments with the east-dummy, we obtain virtually no significant coefficient estimates. This however does not hold in the case of lagged equipment investments. As in the previous specification with turnover as outcome variable, lagged equipment investments are positively associated with number of employees. Regarding the interaction term of lagged equipment investments and the east-dummy, we find no effect on the number of employees.

The effects stemming from the sum of investments between 1995 and 1998 are more pronounced in case of number of employees as compared to turnover. The coefficients for sum of building investments between 1995 and 1998 positively affects the number of employees and suggest an increase of about 0.06% following increases in building investments of 10%. In Eastern Germany, building investments during that same period even reveal a higher elasticity, i.e. 0.08% increase in number of employees following a 10% increase in investments. When looking at the coefficients for the sum of investments in equipment between 1995 and 1998, the coefficients reveal a larger effect of 0.1% following a 10% increase in equipment investments during the DAL-period. When interacting the sum of equipment investments between 1995 and 1998, the coefficients reveal negative effects on number of employees. The elasticity of these investments imply a decrease in number of employees of 0.06% following increases in equipment investments during the DAL in Eastern Germany. Just like the results for turnover, this finding confirms that Eastern plants overinvested in equipment as result of the DAL, which cannot be confirmed for building investments.

Finally, the relative predicted difference in investments reveal no effect in case of building investments but also positive effects in case of equipment investments as in the case of turnover. The coefficient implies that increasing equipment investments of 10% in addition to what Western plants would have invested increases number of employees by 0.03%. Thus, we find qualitatively the same results as for turnover. However, but the effects are even more pronounced which gives us additional confidence in rejecting Hypothesis 1 and supporting Hypothesis 2.

This empirical analysis has several limitations. First, the quality of matching techniques requires detailed plant-level data. In our analysis, we are able to reduce the median bias between treatment and control group to 2.9%. However, matching estimators are not robust to a "hidden bias" (Rosenbaum, 2002, pp. 105-110; Morgan and Winship, 2007, p. 122; Caliendo and Kopeinig, 2008). This is a general problem that can be solved best by sensitivity analyses. Using various matching estimators, we are able to sufficiently reduce bias and to obtain robust results (see Table A. 2). Second, applying a match-paired sample regression analysis assumes that the estimated propensity score of receiving treatment is the true one. In our approach, we are unable to consider that the selective choice of investing in Eastern Germany during the time of the DAL is estimated and hence, standard errors might be biased to the extent that matching is biased. But applying various matching approaches, we choose the one with the smallest median bias for the match-paired analysis to ensure that subsequent biases are also limited.

3.6 Discussion and concluding remarks

In this paper, we study the effects of the DAL bonus depreciation on turnover and employment of German businesses. In particular, we focus on the long-term effects of DAL-incentivized investments that have implications on the convergence process. The potential of the available plant-level data allows us to analyze the effects of German tax policy on the real economy. Despite the mentioned drawbacks, the main result points that the level of investments during the DAL was higher in the Eastern part of Germany as a result of a "gold rush fever" of Western entrepreneurs after the German Reunification. As Eastern Germany opened its borders, a new market was accessible to investors and entrepreneurs. It seems that the subsidy program strengthened the Eastern German market by increased investment but could not solve problems associated with riskiness of unestablished markets in terms of incertitude and information asymmetries. Consequently, the subsidized investments in long-lived capital goods seem to at least partially pay out in the long run. Also, since Eastern Germany after Reunification had neither the economic nor the infrastructural conditions to accommodate new investors, the subsidy seemed to be a suitable gateway to ensure the minimum structural capacity in form of buildings. However, DAL-incentivized investments in equipment reveal large inefficiencies in the sense of overinvestment behavior. The subsidized equipment investments did not enhance the development of firm turnover in the same way as the non-subsidized investment. This has implications for the evaluation of policies based on tax incentives. While this paper can certainly not give a final answer to the question of the long-run efficiency of tax incentives or the welfare effect of the policy, our results can add to this important debate.

Appendix A

Table A. 1: Estimation of DAL bonus depreciation dummy

	Coefficient	Std.Err.
Plant part of an enterprise group	-0.5450***	0.0627
Plant part of a foreign enterprise	0.0252	0.0312
Investment goods producer	0.1835***	0.0397
Durable goods producer	-0.0991	0.0649
Food, drink, and consumer goods producer	0.1460***	0.0513
Energy producer	0.4408	0.5135
Incorporated	0.2430***	0.0271
Other legal form	0.2290	0.1886
Resource input use	-0.1001***	0.0136
Resource input use²	0.0000	0.0000
Energy use	0.0593***	0.0124
Energy use²	0.0000***	0.0000
Interest payments	-0.0028	0.0068
Interest payments²	0.0000***	0.0000
R&D expenditure	0.1772***	0.0389
R&D expenditure²	-0.0089***	0.0016
R&D wage payments	0.0887***	0.0153
R&D wage payments²	0.0000**	0.0000
Capital stock	-0.3899***	0.1397
Capital stock²	0.0172***	0.0045
Share of exports	-1.3472***	0.1335
Share of exports²	0.9907***	0.1598
Share of manufacturing	0.2662	0.5148
Share of manufacturing²	0.2408	0.3497
Unemployment rate	0.2305***	0.0027
GDP per capita	-1.8990***	0.0488
Population	-0.0937***	0.0193
Constant	17.3930***	1.2349
Year dummies	Yes	
Branch dummies	Yes	
Observations	60,031	
LR Chi2	26222.92	
p	0.0000	
Log-likelihood	-7916.2353	
Pseudo R2	0.6235	

Significance levels *p < 0.1; **p < 0.05; ***p < 0.01
Notes: Probit estimation of DAL bonus depreciation.
Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

A.1 Robustness

We further check the robustness of the results in additional analyses. Since the chosen matching algorithm might drive the results, we also apply kernel matching with different bandwidths and nearest neighbor matching (Table A. 2). Throughout all matching algorithms, we are able to confirm robustness in the estimated ATTs. Sign and significance are stable for all specifications. The economic magnitude of the ATTs only varies slightly with different matching specifications.

Table A. 2: Robustness check - various matching algorithms

	Kernel matching		Nearest neighbor matching, caliper 0.001	
	0.03	0.01	one neighbor	five neighbors
	(1)	(2)	(3)	(4)
Turnover				
ATT	0.2126***	0.2191***	0.1909***	0.2077***
	(0.0311)	(0.0313)	(0.0451)	(0.0375)
t-stat	6.84	7.00	4.23	5.54
Turnover growth				
ATT	-0.0512***	-0.0516***	-0.0370***	-0.0532***
	(0.0089)	(0.0090)	(0.0159)	(0.0115)
t-stat	-5.74	-5.75	-2.32	-4.61
N° employees				
ATT	0.2425***	0.2463***	0.2395***	0.2341***
	(0.025)	(0.0253)	(0.0355)	(0.0299)
t-stat	9.65	9.73	6.74	7.82
N° employees growth				
ATT	-0.0251***	-0.0257***	-0.02383***	-0.0284***
	(0.0052)	(0.0052)	(0.0098)	(0.0075)
t-stat	-4.85	-4.92	-2.43	-3.79
N treatment	6,698	6,698	6,625	6,625
N control	28,980	28,980	28,060	28,060
N off-support	23,995	23,995	24,988	24,988
Median bias (%)	3.0	3.0	2.9	2.9

Standard errors in parentheses. *p < 0.1; **p < 0.05; ***p < 0.01.
Notes: The outcome variables are log turnover, log number of employees, and their growth rates respectively. Treatment dummy is DAL bonus depreciation. The propensity score is estimated via probit (in Table A. 1). Different specifications estimated are kernel matching with various bandwidths and nearest neighbor matching with one neighbor and five neighbors.
Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

We also estimate a specification based on Eqn. (3.7) and (3.9) in which we collapse the data to a cross-section of establishments in order to estimate the long-run effects of average investments between 1999 and 2007, the sum of investments during the DAL on average turnover and employment between 2000 and 2008 and the relative predicted difference in investments:

$$\begin{aligned} \overline{y}_{i,00-08} = \alpha + \beta_1 \cdot east + \beta_2 \cdot \bar{I}_{i,99-07} + \beta_3 \cdot \bar{I}_{i,99-07} \cdot east \\ + \beta_4 \cdot \sum I_{i,95-98} + \beta_5 \cdot \sum I_{i,95-98} \cdot east + \Delta_i + \gamma \cdot \overline{X}_i + u_i . \end{aligned} \quad (3.10)$$

Table A. 3: Long-term effects of DAL-induced investments on post-DAL log turnover in the cross-section (2000-08) – match-paired sample

	Turnover		
VARIABLES	(1)	(2)	(3)
Eastern plants	-0.785***	-0.804***	-0.814***
	(0.0689)	(0.0736)	(0.0736)
$\bar{I}_{99\text{-}07}^{Build}$	-0.00211	-0.00188	-0.00737***
	(0.00186)	(0.00186)	(0.00254)
$\bar{I}_{99\text{-}07}^{Build} \cdot$ east	0.0125***	0.0123***	0.0121***
	(0.00400)	(0.00402)	(0.00401)
$\bar{I}_{99\text{-}07}^{Equip}$	0.0215***	0.0213***	0.00433
	(0.00316)	(0.00314)	(0.00409)
$\bar{I}_{99\text{-}07}^{Equip} \cdot$ east	0.0185***	0.0192***	0.0195***
	(0.00605)	(0.00608)	(0.00607)
$\Sigma I_{95\text{-}98}^{Build}$	0.00339**	0.00340**	0.00300**
	(0.00138)	(0.00138)	(0.00138)
$\Sigma I_{95\text{-}98}^{Build} \cdot$ east	0.00329	0.00313	0.00337
	(0.00349)	(0.00349)	(0.00347)
$\Sigma I_{95\text{-}98}^{Equip}$	-0.00152	-0.00120	-0.00130
	(0.00158)	(0.00159)	(0.00158)
$\Sigma I_{95\text{-}98}^{Equip} \cdot$ east	0.00173	0.000963	0.00114
	(0.00358)	(0.00360)	(0.00358)
Δ^{Build}_{i}			0.00681***
			(0.00236)
Δ^{Equip}_{i}			0.0249***
			(0.00378)
Constant	5.815***	5.332***	5.308***
	(0.131)	(0.340)	(0.339)
Observations	8,627	8,627	8,627
R-squared	0.764	0.765	0.767
Capital stock	YES	YES	YES
Plant-level controls	YES	YES	YES
Macroeconomic controls	NO	YES	YES
Industry dummies	YES	YES	YES

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Source: Data from the AFiD enterprise panel (1995-2008), own calculations.

Table A. 3 summarizes the cross-section regression results for the estimates. As expected, the results are qualitatively the same as in the random effects specifications but are larger in magnitudes. The coefficients of the sum of investments however are in almost all specifications insignificant except for past building in both Eastern and Western plants. Especially the coefficients for the relative predicted difference reveal that long-term effects of the DAL-incentivized investments have long lasting effects on firm growth.

4 R&D investment behavior during a crisis: What is the role of subsidies?

4.1 Introduction

With increasing importance of technological development, innovations have become crucial in fostering economic growth (Schumpeter, 1942; Grossman and Helpman, 1991; Howitt and Aghion, 1998). Many countries have adopted public innovation grants to support private R&D investments. Switzerland, through the Commission for Technology and Innovation (CTI), put into place a nationwide grant for R&D investments. This allows firms to apply for R&D project related funding. While the effect of public policy on firm's investment in R&D is still not fully understood, the effect of R&D policy in times of economic crisis is even less well understood. During the last decade, the financial crisis that started in 2008 certainly affected the global economy and governments reacted by expansionary fiscal policy that aimed at smoothing the downturn. However, there remains uncertainty during economic fluctuations and it is important to understand how economic fluctuations influence the effectiveness of public subsidies and firm behavior.

So far attention has been paid to the analysis of effectiveness of public subsidies on private investment but only few studies investigate the impact of crises on the effectiveness of public subsidies on R&D activity (e.g., Hud and Hussinger, 2015; Paunov, 2012). Understanding the impact of economic downturns is crucial to assess the interplay both between fiscal policy and economic growth as well as the interdependencies between technological change and economic growth. Few studies have investigated the behavior of firms regarding R&D investments (e.g. Arvanitis and Woerter, 2014) or disentangled the effects of public funds during the crisis on firm R&D investment behavior (e.g., Paunov, 2012).

This paper relates to different fields of empirical literature. First, we contribute to the field of innovation economics by analyzing the effect of public subsidies on R&D expenditure. Second, this paper relates to the literature analyzing the real effects of tax policy. Finally, this study contributes to the financial economics literature analyzing the interplay between governmental policy and firm investment behavior. We contribute to these three strands of literature by estimating the impact of public subsidies on R&D activity. Also, we analyze the impact of the crisis on subsidy effectiveness. Further, we document how different R&D firm behavior during the crisis alters the effectiveness of public subsidies.

We use Swiss firm-level data from 2005 to 2013 comprising of four waves. The empirical strategy comprises of three steps. First, we analyze whether R&D public subsidies have an impact on R&D activity. This analysis consists of the estimation of a counterfactual setting in which subsidized firms (treatment group) and unsubsidized firms (control group) are compared. Second, we analyze the impact of the crisis on R&D effectiveness with a difference-in-differences matching approach. Third, using a specific question in the 2013 survey in which firms indicated their reaction to the 2008 crisis, we analyze the impact of persistent R&D investment behavior on the effectiveness of subsidies.

The paper is structured as follows. Section 4.2 reviews the literature and the institutional background. Section 4.3 describes the data. Section 4 discusses the empirical strategy. Section 4.5 presents the empirical results. Finally, Section 4.6 discusses the main findings and concludes.

4.2 Literature review and institutional background

4.2.1 Public R&D support and crowding out

Although, technological development is an important driver of economic growth and vice versa (Schumpeter, 1942; Schmookler, 1976; Grossman and Helpman, 1991; Aghion and Howitt, 1992; Howitt and Aghion, 1998), firms have an incentive to underinvest in R&D due to the public good characteristic of new knowledge. A firm's decision to underinvest in R&D goes along with the fear of other firms free-riding by imitating its innovations. This problem of incomplete appropriability of R&D returns finally leads to a socially suboptimal level of R&D investment (Arrow, 1962). Yet, even in the absence of incomplete appropriability of R&D returns a socially optimal level of R&D investments cannot be reached due to information asymmetries between investors and innovating firms and the general risk associated with R&D investments (Griliches, 1986).

These market failures justify the use of public innovation grants to foster private R&D activities. Public funding decreases the costs of private R&D projects by facilitating the realization of the innovation project. The term 'additionality effect' or 'crowding in' refers to the positive effect of public subsidies on private R&D expenditure. However, public R&D support can also lead to 'crowding out' of private R&D investments. This occurs when public R&D funds substitute private ones because application costs for public R&D support are relatively low and in case of positive decisions, firms exploit benefits from the grant (for literature review see David et al., 2000).

Existing literature analyzed the effectiveness of public R&D subsidies. However, empirical findings do not provide conclusive and generally valid results due to the heterogeneity of institutional backgrounds, underlying data, variables used and empirical approaches (recent surveys provided by Zúñiga-Vicente et al., 2014; Becker, 2015).

Studies such as Hussinger (2008) take potential bias by self-selection into public funding into consideration by applying a semi-parametric two-step selection model using German data. Her results reject the hypothesis of full crowding out of private R&D by public subsidies. Aerts and Schmidt (2008) find similar results using data for Flanders and Germany using a nonparametric matching estimator combined with a difference-in-difference estimator. Like Hussinger (2008), they reject the crowding out hypothesis. However, a more recent study by Dai and Cheng (2015) refutes previous results using a generalized propensity score approach and hence, find support for a partial or even a complete crowding out of private R&D investments for Chinese manufacturing firms.

4.2.2 The role of business cycles

The "Schumpeterian" idea of creative destruction views technological development as a crucial factor in shaping the business cycle and vice versa. Notably, innovations aim at capturing the monopoly rents but at the same time destroy monopoly rents that motivated previous innovations (Schumpeter, 1942, pp. 81-86; Aghion and Howitt, 1992; Francois and Lloyd-Ellis, 2009; Filippetti and Archiburgi, 2011).

In response to economic downturns, governments support the economy by loosening their fiscal policy (Romer, 1993; Makkonen, 2013). One fiscal response to recessions is the provision of subsidies such as public innovation grants. Even without public support, firms' R&D investment behavior during recessions is ambiguous: R&D investment behavior is 'pro-cyclical' when investment effort is reduced; on the contrary, R&D investment behavior is 'counter-cyclical' when investment effort is increased or unchanged. This behavior is independent of business cycles and is also referred to as persistency in investing in R&D (Mansfield, 1969).

An explanation for persistent R&D behavior, i.e. R&D behavior that is independent of business cycles, may be sunk costs (Sutton, 1991). Once a firm decides to engage in conducting R&D, it faces several setup costs such as staff and infrastructure. Hence, it will not stop ongoing R&D projects until the innovation results in a final product. Furthermore, persistency in R&D can be due to accumulation of knowledge over time reflected in the human capital and its knowledge, skills and creativity (Nelson and Winter, 1982, pp. 275-301; Peters, 2009). Another explanation for persistency in R&D is 'true state dependence' implying that successful innovations enhance the technological opportunities and thus making subsequent innovation success more likely (Heckman, 1981; Mansfield, 1969; Arqué-Castells, 2013; Peters, 2009).

Also, the opportunity-cost argument implies that firms should undertake R&D investments when costs are low, i.e., during a crisis, in order to benefit from those investments in better times (Aghion and Saint-Paul, 1998; Barlevy, 2007). Supply-side driven factors can explain counter-cyclical R&D investment behavior since labor costs, for example are lower during downturns. In other words, it would be more cost-effective for firms to employ R&D personnel during downturns. For all of the reasons, R&D investment behavior may be largely affected during economic downturns as firms face important decisions.

In contrast, pro-cyclical R&D investment behavior may be explained by demand-side driven factors when sales are positively related to the investment innovation activities (Schmookler, 1976). Moreover, the availability of external financing is a function of agency costs between investors and firms which are pro-cyclical and therefore renders R&D investment pro-cyclical (Bernanke and Gertler, 1989).

Whether R&D investments are pro-cyclical or counter-cyclical has been subject in many studies. Theoretical and empirical studies of the cyclicality of R&D investments report mixed findings (Griliches, 1990; Comin and Gertler, 2006; Francois and Lloyd-Ellis, 2009; Ouyang, 2011a, 2011b; Huergo, Trenado, and Ubierma, 2015).

Recent studies, e.g., Paunov (2012) and Hud and Hussinger (2015) focus on the effect of public subsidies during the crisis and find that they support firms' R&D activities during the crisis. From a macroeconomic perspective, Brautzsch et al. (2015) also find positive effects of fiscal policy on the stabilization of the economy during recessions.

This brief literature review suggests ambiguous effects of economic fluctuations on R&D investment behavior. In the next section, we will discuss the institutional background of the Swiss public innovation funding scheme.

4.2.3 Public funding by the Commission of Technology and Innovation

Switzerland's overall investment in R&D was CHF 4.6 billion in 2010, corresponding to 0.81% of the national GDP. Compared to the other 31 OECD countries, Switzerland ranked 11th regarding the ratio of R&D funding as a share of GDP. The Commission for Technology and Innovation (CTI) and the Swiss National Science Foundation (SNSF) are the two main public agencies that promote innovation. The CTI and the SNSF differ mainly in one aspect: whereas the CTI focuses on the financing R&D projects with an immediate commercial objective, the

SNSF finances applied research. The firms in our data are mainly financed through CTI subsidies (CTI, 2011; Swiss Federal Statistical Office, 2012).

A peculiarity of the Swiss system is its *bottom-up* indirect approach of supporting innovation. Private firms can submit their R&D projects (without requirements regarding the technological activities) to a committee. Upon approval, the CTI will directly fund the public partner (universities, universities of applied sciences or research institutes). Receiving the CTI innovation grant requires the recipient to contribute at least 50% of the expected project costs (CTI, 2013).[33]

Figure 4.1 depicts the R&D project applications over the period 2005-2014. As it can be seen, the number of applications is steady between 400 and 600 until 2008, then there is an increase in the number of applications in the crisis years from 2009 to 2010. The relative percentage of approved projects, however, decreases during the time of the crisis and recovers after 2011.

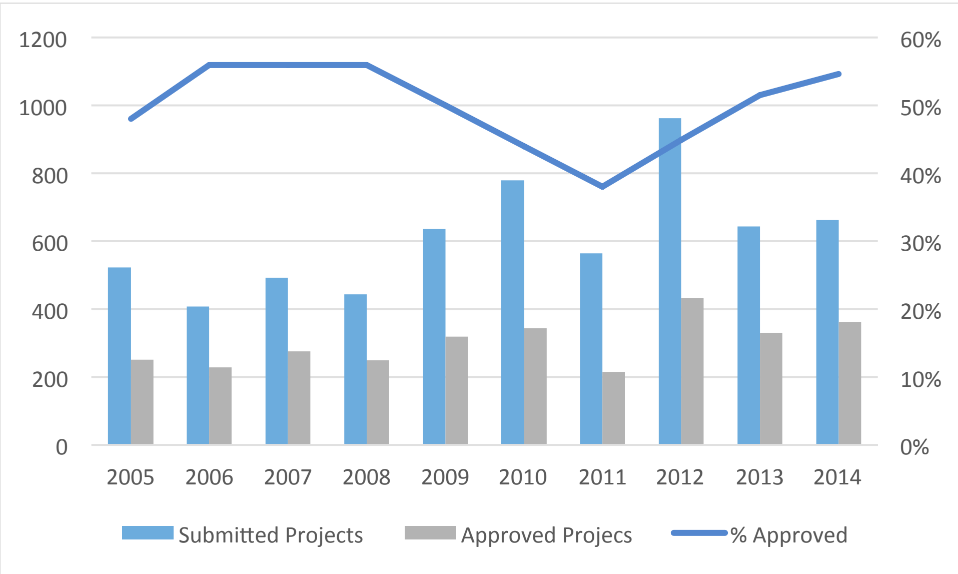

Figure 4.1: Time series of R&D project granting by the CTI
Source: CTI (2013)

[33] This cooperation is intended to promote an active collaboration between the private and public sector. In the period 2005-2010, 51.6 % of the R&D applications have been granted support (CTI, 2013).

4.3 Data

We use firm-level data from four waves (2005, 2008, 2011, and 2013) provided by the Konjunkturforschungsstelle (KOF) enterprise panel. The panel consists of about 6,500 firms in the official business register. Roughly 2,000 firms reply to the questionnaire in each wave. The panel includes firms from various sectors such as the high-tech sector, traditional, modern and construction sector (see Table B. 1 in the appendix for a detailed classification of industries and sectors). As the panel provides longitudinal data on the micro-level including information on economic outcomes as well as firm-level characteristics, it is well-suited for the purpose of this study allowing the analysis of responses in the R&D investment behavior of firms. In addition to the regular questionnaire, the 2013 questionnaire included a special section asking the firms about the consequences of the 2008 financial crisis.

Table 4.1: Firms receiving domestic public innovation grants

Year		2005	in %	2008	in %	2011	in %	2013	in %
Domestic public innovation grants	No	1,352	92.5%	1,108	92.4%	1,094	89.5%	813	85.9%
	Yes	109	7.5%	91	7.6%	128	10.5%	133	14.1%
Total		1,461		1,199		1,222		946	

Source: Data from KOF (2016), own calculations.

We consider the waves 2005, 2008, 2011, and 2013 since information regarding receipt of public innovation grants have been collected only in these waves. Table 4.1 shows the number of Swiss firms in each wave and the percentage of publicly subsidized firms. In the following analysis, the treatment group consists of all subsidized firms, whereas the control group comprises of the firms without subsidies.

4.4 Identification strategy

On average, levels of R&D expenditure (CHF 94 thousands), turnover (CHF 356 millions), and number of employees (739 employees) of subsidized firms are significantly higher than those of unsubsidized firms as displayed in Table 4.2 (summary statistics of covariates used are displayed in Table B. 2 in the appendix). But clearly, the large differences between the two groups do not result from subsidies. The differences, however, point to endogeneity bias as a result of self-selection into subsidies.

Table 4.2: Summary statistics, subsidized versus unsubsidized firms (2005 – 2013)

	Subsidized (N = 461)			Unsubsidized (N = 4,367)			
Variable	N	Mean	Std. Dev.	N	Mean	Std. Dev.	p-value of t-tests on mean differences
R&D expenditure in thousands	447	94.30	362.08	3,923	39.37	872.11	0.0129
Turnover in thds.	433	356,247.21	1,151,456.64	4,060	173,078.21	1,159,220.53	0.0017
Total number of employees (full-time equivalents)	461	739.66	2,889.54	4,367	321.75	1,988.46	0.0025

Source: Data from KOF (2016), own calculations

Consequently, our empirical strategy comprises of three steps. First, we analyze the effectiveness of R&D public subsidies on R&D activity in a matching approach. Second, we analyze the impact of the crisis on R&D effectiveness in a difference-in-differences matching approach. Third, we analyze the impact of persistent R&D investment behavior on the effectiveness of subsidies.

4.4.1 Measuring subsidy effectiveness

To quantify the effect of public subsidies, one compares a firm's observed actual state with its unobserved counterfactual state, i.e., how the firms in the control group would have invested if they were subsidized (see, e.g., Morgan and Winship, 2007).

In measuring the average effect of public subsidies on subsidized firms, we formalize the parameter of interest as the Average Treatment Effect on the Treated (ATT) where S_i is the treatment status[34]:

$$\text{ATT} = E\left[Y_i \mid S_i = 1\right] = E\left[Y_{1i} \mid S_i = 1\right] - \underbrace{E\left[Y_{0i} \mid S_i = 1\right]}_{\text{unobserved counterfactual}} . \tag{4.1}$$

The ATT measures the difference between the level of outcome of firm i which invested in R&D and benefited from public subsidies, Y_{1i}, and the outcome of the same firm if, hypothetically, the same firm did not receive a subsidy, Y_{0i}. As the counterfactual is unobserved, using observational data to compare the R&D investments of subsidized and unsubsidized firms suffers from a self-selection bias (Angrist and Pischke, 2009, pp. 12-15):

$$\begin{aligned} &\underbrace{E\left[Y_i \mid S_i = 1\right] - E\left[Y_i \mid S_i = 0\right]}_{\text{observed difference in outcome}} \\ &\qquad = \underbrace{E\left[Y_{1i} - Y_{0i} \mid S_i = 1\right]}_{ATT} + \underbrace{E\left[Y_{0i} \mid S_i = 1\right] - E\left[Y_{0i} \mid S_i = 0\right]}_{\text{self-selection bias}}. \end{aligned} \tag{4.2}$$

The observed difference in the outcome variable, i.e. the level of subsidized investments compared to those who do not subsidized, equals the ATT (first summand of the right-hand side) and the selection bias term (second and third summands). This bias results from the correlation between the error term and the treatment status and reflects the difference in potential outcomes between treated and untreated due to self-selection into subsidy receipt.

This naïve estimator would be equal to the ATT only if the individual outcomes of plants from treatment and control groups would not differ in the absence of

[34] The following explanations of the applied methods in this section draw on the same background as presented in section 3.4.1. Similarities and repetition are intended as both chapters, despite using similar methodology, stand for themselves and can be read independently.

treatment. In this case, only if subsidized firms would invest exactly the same amount. It would hold that

$$E\left[Y_{0i} \mid S_i = 1\right] - E\left[Y_{0i} \mid S_i = 0\right] = 0 . \tag{4.3}$$

Equation (4.3) can only hold if the error term of the regression of the outcome on the treatment is the same across different treatment statuses, i.e. only if the expected outcome of observations in the control group given the treatment status does not vary. This would allow the identification of the ATT simply by taking the difference in outcome between observed subsidized and unsubsidized firms.

Since we deal with observational data, we have to build the empirical strategy on some identifying assumptions to reduce the bias resulting from self-selection into subsidy receipt. It is likely that a firm's choice of applying for and receiving subsidies is the result of self-selection according to particular characteristics of the firm. Therefore, subsidy receipt cannot be regarded as a random choice of treatment. As a consequence, the determinant of the decision process of applying for and receiving subsidies can simultaneously influence the outcome variable, i.e. the level of R&D investments.

Propensity score matching is a commonly used technique to reduce the potential self-selection bias (Rosenbaum and Rubin, 1983). In order for this approach to be valid, the Conditional Independence Assumption (CIA) or unconfoundedness assumption has to hold. The CIA states that conditional on observed covariates X_i, potential outcomes $\{Y_{1i}, Y_{0i}\}$ are independent of the treatment status S_i, thus $\{Y_{1i}, Y_{0i}\} \perp S_i \mid X_i$. As a result, given the observed covariates X_i, assignment to treatment is almost randomly assigned.

Another assumption ensuring the consistent identification of treatment effects by matching estimators is called *overlap* or *common support* assumption. This assumption requires the probability of treatment assignment to be bounded away from zero and one

$$0 < \Pr(S_i = 1 \mid X_i) < 1 . \qquad (4.4)$$

Common support is given for any sample in which firms potentially can either self-select into the treatment or the control group. With both assumptions of unconfoundedness and overlap holding, we are able to estimate of the ATT of public R&D subsidies (Rosenbaum and Rubin, 1983).

The implementation of the matching estimator consists of two stages. In the first stage, we compute a balancing score, representing functions of relevant observed covariates in the form of a propensity score by running a probit estimation that reflects the probability of receiving treatment determined by the covariates that determine selection into treatment (Rosenbaum and Rubin, 1983).

In a second stage, we look at the treatment effect on the outcome. By matching each treatment observation *i* with one or several control observations *j*, based on similar propensity scores and including a dummy for each block[35], we assure the comparability of treatment and control group (Heckman et al., 1998; Smith and Todd, 2005). Using these matched pairs, we estimate the

$$\text{ATT} = \frac{1}{N^T} \sum_{i \in I_T} \left[Y_{1i} - \sum_{j \in I_C} w(i,j) Y_{0i} \right]. \qquad (4.5)$$

[35] This controls for similarities within that group such that the absolute difference in propensity scores between *i* and *j* is minimized (min $|p_i - p_j|$).

with I_T being the set of treated firms, N^T the number of treated firms and I_C being the set of control firms (Smith and Todd, 2005). The choice between different matching algorithms affects the number of firms in the control group as well as the weighting $w(i,j) \in [0,1]$ of each control observation.

We apply the Kernel matching estimator as proposed by Heckman et al. (1998) and Smith and Todd (2005). Kernel matching forms a weighting function by considering all observations of the untreated group. The weights reflect the distance between a treated observation *i* and a control observation *j*. Using a kernel function $G(x)$ with bandwidth parameter *h*, the weight assigned to control observation *j* is

$$w(i,j) = \frac{G(\frac{p_i - p_j}{h})}{\sum_{j \in \{S_i = 0\}} G(\frac{p_i - p_j}{h})}. \tag{4.6}$$

In our case, we use the Epanechnikov kernel implying that among the untreated group, observations are chosen in a moving window within a fixed caliper (bandwidth) *h* of 0.06 from $|p_i - p_j| < h$ (Heckman et al., 1998; Smith and Todd, 2005). Thus, we calculate the counterfactual as the weighted average of all control units while the weight is higher for observations with similar propensity score. This estimator provides the best properties in terms of a tradeoff between bias and efficiency (Caliendo and Kopeinig, 2008). We further use different specifications[36] for robustness checks (in Table B. 4 of the Appendix).

[36] In more detail, we apply different bandwidth parameters for the Kernel matching estimator (0.03 and 0.01) and nearest neighbor matching with one and five neighbors. Furthermore, we apply a one-to-one matching which reduces the number of observations because each treated firm is matched only to one control firm due to no replacement in matching.

4.4.2 Selection into public innovation grants

We include a large set of firm characteristics to support the CIA in our context. Nevertheless, since there might be some unobservable causing correlation between the subsidy receipt and R&D investments, we also take into account time-invariant observed plant characteristics. The choice of covariates X_i determining the treatment status is determined such that the CIA holds. We need to include all observables determining both the outcome variable as well as the treatment variable (subsidy receipt) (e.g., Heckman et al., 1998; Sianesi, 2004; Smith and Todd, 2005; Caliendo and Kopeinig, 2008). The set of covariates can be differentiated into four groups: structural firm characteristics, economic indicators, innovativeness, and employment structure (see Table 4.3 for more details).

Table 4.3: Description of matching covariates

Structural firm characteristics	Part of an enterprise group	Dummy indicating whether the firm belongs to an enterprise group
	Foreign owned	Dummy indicating whether the firm belongs to a foreign owned corporation
	SME	Dummy indicating whether the firm is a SME (below 250 employees)
	Exports	Dummy indicating whether the firm is engaged in exporting goods and services
	Share of exports in turnover	in %
	R&D co-operations	Dummy indicating whether the firm is cooperating in R&D with other institutions
	Log firm age	
Economic indicators	Log gross investments	Gross investments in real CHF (base year is 2010)
	Log turnover	
	Log number of employees	
	Number of competitors <= 5	Dummies indicating the number of competitors the firm is facing
	Number of competitors 6-10	
	Number of competitors 11-15	
	Number of competitors 16-50	
Innovativeness	Number of patents	Number of patents registered at time t
	Technological potential	Self-reported technological potential on a five-scale with 1 as very low and 5 as very high technological potential
Employment structure	Share of trained employees	in %
	Share of untrained and partly trained employees	
	Share of apprentices	
	Share of employees with college/university degree	

The decision to apply for and receiving public innovation grants is non-random and can be determined by time-invariant and time-variant firm characteristics. A firm being part of an enterprise group may facilitate innovative capacities by benefitting more easily from knowledge spillovers in a larger network of firms and easier access to information within the enterprise group. Therefore, group membership may signal to the subsidy-granting institution a higher likelihood to obtain innovations grants (Hud and Hussinger, 2015).

Since firms with a foreign ownership are also open to foreign markets, these are likely to be more innovative (Arnold and Hussinger, 2005). However, the domestic subsidy granting institution might reconsider the grant when a foreign headquarter is involved because the subsidy granting institution might have a home bias.

Regarding the size of firms, SMEs are likely to suffer more from cyclical fluctuations if they are active in small markets and are not diversified. Larger firms with more diversified markets can more easily cope with business climate fluctuations (Hud and Hussinger, 2015). Hence, the project evaluation criteria might be directly affected by firm size.

Other studies investigating the relationship between innovation and export market argue that export-oriented firms apply more often for R&D subsidies (e.g., Woerter and Roper, 2010). This is included as a binary variable. Also, we include the share of exports on turnover to capture the intensity of exporting behavior.

Firms engaging in R&D cooperation are more likely to receive a subsidy. Hence, the CTI accounts for this in the evaluation process of subsidy grants. Therefore, we include a binary variable for R&D cooperation. As firm age potentially affects the decision of the subsidy granting institution, we include log firm age as covariate. We further include log gross investments as covariate, which indicates the general economic activity of the firm. This is likely to increase the likelihood for project-proposal approval.

Following the large strand of literature that relates competition to innovativeness, e.g., in an inverted-U relationship as suggested by Aghion et al., (2005), we include dummies capturing the number of competitors of the firm.

With regard to the innovativeness of firms and its association with R&D subsidy receipt, we include a dummy for R&D co-operations, number of patents and technological potential. It is unarguably easier for firms with more technological potential to innovate and therefore to obtain innovation grants. With a larger stock of patents, a firm can also signal a history of successful innovation which increases the likelihood of subsidy receipt. Likewise R&D cooperation can serve as a signal for innovative success.

Also, the structure of employment in the firm can affect the innovativeness and thus the probability of subsidy receipt. With a higher share on academic employees, research might be reinforced, while a higher share of trained employees might also indicate a high level of employees with product-specific knowledge (Müller and Peters, 2010). As a result, trained and high-skilled workers are more difficult to be replaced and therefore enhance the sunk-cost characteristic of R&D investments. That is why we include the share of trained, untrained employees and the share of apprentices as well as employees with a tertiary degree to control for effects of employment structure on selection into treatment.

Since we expect differences in subsidy receipt depending on structural industry traits, we further include industry branches based on NOGA 2008, which is equivalent to the European NACE, Rev. 1.1 industry classification.

4.4.3 Measuring the impact of the crisis on subsidy effectiveness

Since the estimated ATT in Equation (4.5) is of cross-sectional nature, it ignores the time dimension of the data. The cross-sectional matching estimator builds on the assumption of the absence of confounding due to unobserved systematic differences at the firm level. By acknowledging that unobserved factors might affect subsidy receipt and R&D expenditures, employing a difference-in-difference (DiD) propensity score matching takes these time-invariant unobserved firm level difference in the outcome into account (Heckman et al., 1998). Hence, the DiD matching estimator is given by

$$\mathrm{ATT}_{\mathrm{DiD}} = \frac{1}{N^T}\sum_{i\in I_T}\left[\Delta Y_{1i} - \sum_{j\in I_C} w(i,j)\Delta Y_{0i}\right], \tag{4.7}$$

where ΔY_{1i} and ΔY_{0i} are the differences in the outcome between baseline (2005-08) and follow-up period (2011-13) for treated and control firms respectively (cp. Blundell and Costa-Dias, 2002; Blundell, Costa-Dias, Meghir, and van Reenen, 2002). In the case of longitudinal or repeated cross-sectional data, this approach provides a more robust estimator of the treatment under less restrictive assumptions.

4.4.4 R&D persistency and the crisis

We analyze the average effect of keeping R&D expenditure despite of the crisis constant in a Kernel DiD-matching approach. We rely on the information provided in the 2013 questionnaire that provides a special section asking about the short and medium-term consequences of the financial crisis 2008. The questionnaire contains one question asking about the firm's decisions on R&D investments. Out of 935 firms in 2013, 646 (69.1%) stated that they did not change investment despite the 2008 crisis. We make use of this information available only for 2013 by carrying it backward to past years for each firm to evaluate post-crisis information evaluation of R&D investment behavior.

Hence, we estimate the following equation that gives the effect of persistent R&D investment behavior

$$\text{ATT}_{\text{DiD}} = \frac{1}{N^T} \sum_{i \in I_T} \left[(Y_{1i}^{\text{no change}} - Y_{1i}^{\text{change}}) - \sum_{j \in I_C} w(i,j)(Y_{0j}^{\text{no change}} - Y_{0j}^{\text{change}}) \right]. \qquad (4.8)$$

4.5 Empirical Results

4.5.1 The effect of public grants on R&D activity

The first part of the propensity score matching comprises of the estimation of firm-individual propensity scores reflecting the predicted probabilities of receiving treatment based on observable covariates. We estimate the propensity of successful grant on the covariates described in Section 4.2 and successively extent the covariate set by adding branch dummies (column 2 of Table 4.4) and year-branch dummies (column 3 of Table 4.4).

Table 4.4: Estimation of the propensity of successful grant application

	(1)	(2)	(3)
Part of an enterprise group yes/no	-0.1041	-0.1787	-0.1899
	(0.1395)	(0.1561)	(0.1675)
Foreign owned yes/no	0.2215	0.2833	0.3721
	(0.3840)	(0.3936)	(0.4245)
SME	-0.2939	-0.2987	-0.2296
	(0.2071)	(0.2287)	(0.2421)
Exports yes/no	0.4141*	0.4648	0.4187
	(0.2482)	(0.3132)	(0.3382)
R&D co-operations yes/no	0.5024	0.5070***	0.4856***
	(0.1314)	(0.1455)	(0.1582)
Log turnover	-0.0449	0.0988	0.1515
	(0.1214)	(0.1490)	(0.1573)
Log number of employees	0.0719	-0.0269	-0.0579
	(0.1561)	(0.1911)	(0.2033)
Log gross investments	0.0585	0.0871**	0.0953**
	(0.0392)	(0.0415)	(0.0442)
Number of competitors <= 5	-0.6476***	-0.8362***	-0.8972***
	(0.2281)	(0.2637)	(0.2820)
Number of competitors 6-10	-0.4445*	-0.6027**	-0.6312**
	(0.2292)	(0.2641)	(0.2820)
Number of competitors 11-15	-0.7142***	-0.8212***	-0.8485***
	(0.2681)	(0.3069)	(0.3309)
Number of competitors 16-50	-0.7381***	-0.7907**	-0.8124**
	(0.2831)	(0.3133)	(0.3324)
Share of exports in turnover	0.0023	-0.0009	-0.0018
	(0.0021)	(0.0026)	(0.0028)
Log firm age	0.2464	0.1775	0.1644
	(0.0941)	(0.1112)	(0.1169)
Number of patents	0.0051	0.0044	0.0029
	(0.0036)	(0.0035)	(0.0036)
Technological potential	-0.0309	-0.0356	-0.0657
	(0.0689)	(0.0761)	(0.0822)
Share of trained employees	-0.0045	-0.0027	-0.0034
	(0.0057)	(0.0063)	(0.0067)
Share of untrained	-0.0024	-0.0031	-0.0037
and partly trained employees	(0.0056)	(0.0063)	(0.0068)
Share of apprentices	-0.0001	-0.0109	-0.0132
	(0.0153)	(0.0172)	(0.0180)
Share of employees	0.0131	0.0200**	0.0243**
with college/university degree	(0.0080)	(0.0090)	(0.0100)
Constant	-1.9618	-2.899*	-3.3006**
	(1.2287)	(1.5913)	(1.6947)
Year dummies	YES	YES	YES
Branch dummies		YES	YES
Year-branch dummies			YES
Observations	639	610	545
LR Chi2	97.99	133.89	135.53
P	(<0.0001)	(<0.0001)	(<0.0001)
Log-likelihood	-258.18	-234.09	-218.26
Pseudo R2	0.1595	0.2224	0.2369

Standard errors in parentheses. *p < 0.1; **p < 0.05; ***p < 0.01
Notes: Probit estimation of subsidy among all firms in the sample.
Baseline is number of competitors > 50.
Source: Data from KOF (2016), own calculations.

Moreover, having a higher share of employees with a tertiary degree positively affects subsidy probability. Whereas the firm age positively affects the probability of receiving subsidies, a more competitive environment decreases it. The coefficients of the dummies capturing the number of competitors show a negative and significant association with subsidy receipt. Furthermore, technological potential and number of patents are not significant and hence suggest no effect on the probability of receiving a subsidy. This may seem counter-intuitive but may be explained by the fact that we consider all firms in the sample, i.e. firms that applied for public grants and received it, firms that applied but did not succeed, and firms that neither applied nor received any public grant. The group of firms that neither applied nor received a grant may represent a considerable share of all firms and thus might drive the probability of subsidy receipt.

Table 4.5: Overall statistics on covariate balance

Covariate sets	(1)		(2)		(3)	
Sample	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
Pseudo R2	0.16	0.01	0.16	0.01	0.16	0.01
LR chi2	97.67	2.66	97.12	1.88	91.38	4.32
p>chi2	0	1.0	0	1.0	0	1.0
Mean bias	28.4	3.6	28.9	3.3	28.2	4.7

Source: Data from KOF (2016), own calculations.

With the previously estimated propensity scores and the chosen matching method, we are able ensure comparability of treatment and control group. Assessing the covariate balance between both groups and thus the appropriateness of the model is a crucial element of matching methods: we do this by looking at the overall statistics on covariate balance of the three sets of covariates. Table 4.5 indicates satisfying matching quality in all three specifications. The pseudo-R^2 values indicate that the explanatory power of the covariates is lower in the matched sample (0.01) than in the unmatched sample (0.16) and also show that in the matched sample, systematic differences between treatment and control group are eliminated by the matching algorithm for all covariate sets (Imbens, 2004, 2014). Testing the hypothesis that all coefficients are zero with a likelihood ratio test can be rejected in the unmatched sample. In the case of the matched sample, however, we cannot reject the hypothesis. This evidence confirms that in the matched sample the probability to receive subsidies is unrelated to observable firm characteristics and can therefore be considered as randomized. Finally, assessing the mean bias before matching of all specifications shows that in specification 2 before matching is at 28.9% and can be reduced to the lowest mean bias of 3.3% after matching among the three covariate sets. In specification 1 and 3, the mean biases after matching are reduced to 3.6% and 4.7% respectively. In the following, we focus on covariate set 2 that obtains the lowest mean bias.

We assess the common support condition graphically by depicting the kernel plot for the propensity scores for plants with and without treatment estimated (Figure 4.2). The propensity score lies between zero and one for treatment and control group and show both distributions sharing an area of common support so that identification of subsidized and unsubsidized firms featuring similar probabilities is achievable. The higher mass of distribution at the lower levels of the propensity score for firms without subsidy indicates that firms not receiving subsidies are smaller firms which are unlikely to obtain public funds.

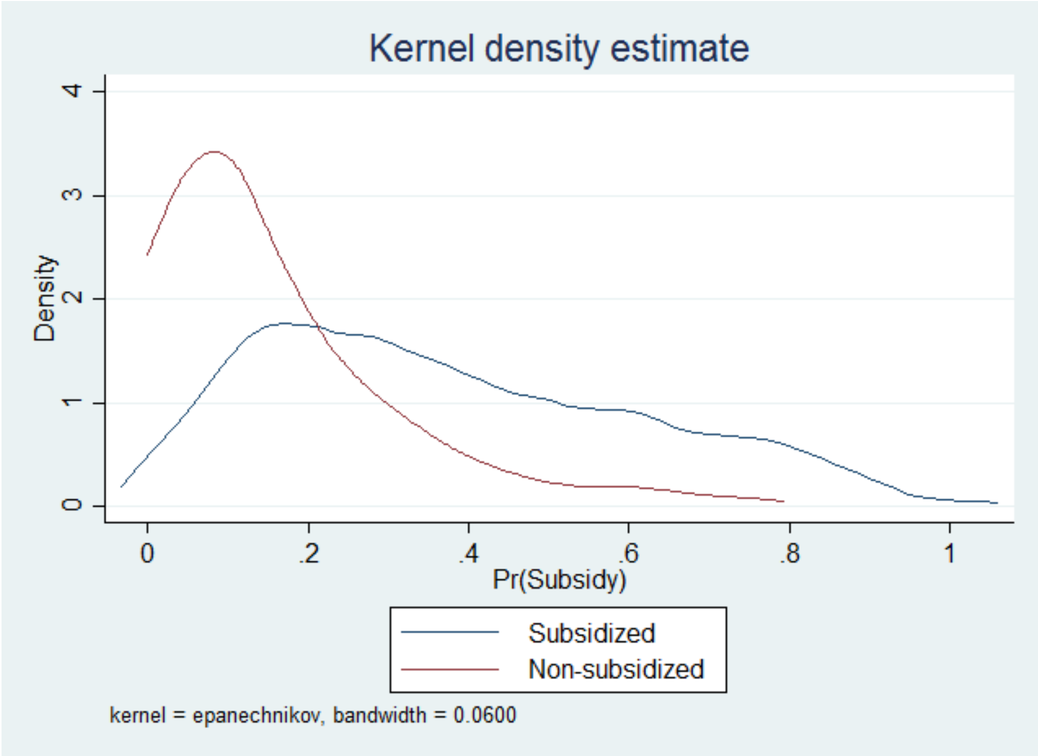

Figure 4.2: Assessment of the common support assumption
Notes: Kernel density plots of the propensity to receive and to not receive public R&D subsidy with covariate set 2 and bandwidth 0.06.
Source: Data from KOF (2016), own graph

After matching, the covariates reveal in a two-tailed *t*-test no difference between subsidized firms and unsubsidized firms, which again confirms the matching quality (see Table 4.6). Overall, matching works sufficiently well in obtaining a control group similar to the treatment group. The observable determinants of receiving the grant work well, conditional on ruling out the influence of unobservables. Given the propensity score, the remaining assignment to control and treatment group is as good as random. Thus, we are able to compute the differences in our outcome variables by taking potential self-selection bias into account.

Table 4.6: Sample descriptive statistics after matching

	Unsubsidized (Control) N = 305 Mean	Subsidized (Treatment) N = 101 Mean	t-Test	p-value of t-tests on mean differences
Covariates				
Part of an enterprise group	0.541	0.558	-0.26	0.797
Foreign owned	0.036	0.037	-0.05	0.962
SME	0.541	0.566	-0.38	0.701
Exports	0.937	0.928	0.27	0.785
R&D co-operations	0.640	0.646	-0.10	0.917
Log turnover	13.333	13.272	0.32	0.752
Log number of employees	5.309	5.215	0.58	0.561
Log gross investments	10.013	9.885	0.46	0.644
Number of competitors <= 5	0.315	0.330	-0.23	0.816
Number of competitors 6-10	0.342	0.332	0.16	0.876
Number of competitors 11-15	0.126	0.118	0.19	0.851
Number of competitors 16-50	0.099	0.089	0.26	0.797
Number of competitors >50	0.117	0.131	-0.31	0.758
Share of exports in turnover	59.144	59.247	-0.02	0.983
Log firm age	4.031	3.969	0.63	0.532
Number of patents	10.117	9.462	0.25	0.802
Technological potential	3.297	3.377	-0.63	0.529
Share of trained employees	41.617	41.606	0.00	0.996
Share of untrained and partly trained employees	22.422	22.812	-0.15	0.882
Share of apprentices	5.214	5.139	0.11	0.909
Share of employees with college/university degree	11.084	10.873	0.11	0.909

Notes: Descriptive statistics of the full sample versus the matched sample after kernel matching using covariate set 2 and bandwidth 0.06.
Source: Data from KOF (2016), own calculations.

As Table 4.7 shows, the average treatment effect of the subsidy on the treated on R&D expenditure is negative but not significant in all specifications[37]. The point estimates vary slightly depending on the chosen covariate set used in the estimation of the propensity score. Applying a kernel matching using bandwidth 0.06 and covariate set 2 (column 2 of Table 4.7), the matching quality is sufficient to ensure comparability between treatment and control groups with a mean bias of 3.3%. Thus, subsidized firms show no significant differences in R&D activity which points to potential crowding out of R&D public subsidies in the cross-section. The implication

[37] The ATT estimate's t-statistic in column 3 of Table 4.7 is the largest (1.59) among the specifications in the table. However, due to the relatively small sample size, the t-statistic does not reveal any significance below the threshhold of 10 %.

is that potential crowding out might be a serious problem, as public R&D subsidies do not enhance investments in R&D.

Table 4.7: Estimates of average treatment effects on the treated

	Kernel matching Bandwidth 0.06		
	(1)	(2)	(3)
ATT	-0.0576	-0.6212	-1.0212
	(0.5860)	(0.5905)	(0.1550)
t-stat	-0.10	-1.05	-1.59
N treatment	116	111	118
N control	484	405	352
N off-support	36	91	73
Mean bias (%)	3.6	3.3	4.7
Structural characteristics	YES	YES	YES
Economic indicators	YES	YES	YES
Innovativeness	YES	YES	YES
Employment structure	YES	YES	YES
Year dummies		YES	YES
Branch dummies		YES	YES
Year branch dummies			YES

Standard errors in parentheses. *p < 0.1; **p < 0.05; ***p < 0.01.
Notes: Estimated average treatment effect of funding by Kernel matching (bandwidth 0.06) in the region of common support for three different sets of covariates. The respective propensity scores are estimated via probit (in column 2 of Table 4.4). The outcome variable is log R&D expenditure. Treatment dummy is grant.
We discard observations with an estimated propensity score outside the interval [0.02, 0.98] as suggested by Crump et al. (2009) to guarantee sufficient overlap.
Source: Data from KOF (2016), own calculations.

4.5.2 Impact subsidy treatment during the crisis

So far, we ignored the time dimension of the available data. The results in Table 4.8 show estimated parameters of the Kernel DiD-matching using covariate specification 2 with the pre-crisis and post-crisis periods as baseline and follow-up period respectively. The comparison groups comprise of subsidy receipt as treatment and non-subsidy receipt as control group. In the first column of Table 4.8, we display the kernel-weighted matched log mean outcome variable for the control group in the baseline case with its standard error, t-statistic, p-value, and the number of observations respective for each case. By comparing the differences of treatment and control in the baseline case (cp. column 3) with those of the follow-up case (cp. column 6), we are able to obtain a DiD estimate of the average treatment effect as given by Equation (4.8) (cp. column 7). The ATT for R&D expenditures is negative but not significant. This insignificant ATT gives rise to concern that subsidy receipt might have crowded out private R&D investment during the crisis. This implies during the recession, public subsidies are not able to enhance private R&D investments.

Table 4.8: Estimates of the impact of the crisis on R&D expenditure

	Before crisis (2005-08)			Crisis (2009-11)			
R&D Exp.	Control	Treated	Difference	Control	Treated	Difference	DiD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	8.5442	9.0108	0.4666	8.4173	7.4574	-0.9599	-1.4265
Std. Error	0.6875	0.6717	0.9611	0.3358	0.3358	0.4749	1.0721
t	12.4283	13.4154	0.4855	25.0637	22.2053	-2.0211	-1.3306
P>|t|			0.6276			0.0438	0.1839
n	102	22		303	88		
N							515

Standard errors in parentheses. *p < 0.1; **p < 0.05; ***p < 0.01.
Notes: DiD kernel matching with bandwidth 0.06. The outcome variable is log R&D expenditure. The propensity score is estimated via probit (in column 2 of Table 4.4). Treatment dummy is grant. The baseline is before-crisis period.
Source: Data from KOF (2016), own calculations.

4.5.3 Impact of R&D investment behavior during the crisis

With the results presented in section 4.5.2, we shed light on the impact of subsidy treatment during the crisis on R&D investing. The results raise the question of how firm behavior affects the impact of public R&D subsidies on firms. To investigate this matter, we also rely on a kernel matching DiD approach using covariate set 2. We introduce change in R&D investment behavior as comparison group to compare the impact of subsidies depending on R&D investment behavior during the crisis.

Table 4.9: Estimates of the impact of R&D investment behavior on subsidy effectiveness

R&D Exp	Change in R&D behavior			No change in R&D behavior			
	Control	Treated	Difference	Control	Treated	Difference	DiD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	8.8095	5.3142	-3.4953***	8.3995	8.2313	-0.1682	3.3271***
Std. Error	0.7576	0.7576	1.0714	0.4243	0.4243	0.6001	1.228
t	11.6283	7.0146	-3.2624	19.7945	19.398	-0.2804	2.7093
P>|t|			0.0012			0.7794	0.0071
n	66	16		181	51		
N							314

Standard errors in parentheses. *p < 0.1; **p < 0.05; ***p < 0.01.
Notes: DiD kernel matching with bandwidth 0.06. The outcome variable is log R&D expenditure. The propensity score is estimated via probit (in Table 4.4). Treatment dummy is grant. The baseline is a dummy indicating change in R&D investment behavior due to the crisis.
Source: Data from: KOF (2016), own calculations.

Table 4.9 provides estimates of the differential effects of R&D behavior on subsidy effectiveness using kernel DiD-matching. We estimate the difference-in-differences estimator by comparing the average outcomes of treatment and control each for firms changing and firms not changing R&D behavior. Similarly to Table 4.8, Table 4.9 displays the estimated coefficient for control (cp. column 1) and treatment group (col. 2) and their differences for each firms changing R&D behavior (col. 3) and also firms not changing (columns 4, 5, and 6 respectively). Finally by comparing the difference in the differences (col. 7), we obtain the effect of subsidies when not changing R&D investment behavior despite of the crisis on R&D expenditure.

We find that firms keeping R&D constant despite of the crisis while obtaining public subsidies increase R&D expenditure. The DiD coefficient is positive and significant at the 1%-level. Relating this result to the previous result of Section 4.5.2, the search for public funds and persistent R&D investment behavior positively affect the economy during the crisis by alleviating the crowding out of private R&D expenditure by public subsidies. To conclude, we find that firms keeping R&D constant during the crisis may contribute to the effectiveness of public subsidies.

4.5.4 Study limitations

This study has several limitations. First, the data available, although rich in terms of information of about 6,500 firms in the Business Register of the Federal Statistical Office of Switzerland, does not constitute a longitudinal dataset with repeated observations on the same cross section (Wooldridge, 2002, p. 6; Angrist and Pischke, 2009, pp. 222-227). The data are repeated cross-sections with only a little number of firms with repeated observations. Applying a matching approach to investigate the effectiveness of subsidies is thus appropriate when ignoring the time-dimension and estimating the average effects in a cross-section. Nevertheless, in order to properly consider the crisis-period and to ensure the comparability of treatment and control group, we apply the difference-in-differences matching method using repeated cross-sections which provides a robust and appropriate choice under less restrictive assumptions (Blundell and Costa-Dias, 2002). Second, the questionnaire is not obligatory for firms such that a non-response bias might be an issue. We are unable to control for this setback as response rates are not reported. Notwithstanding, the matching methods applied conditional on the common support assumption ensure appropriate comparison of treatment and control group despite selectivity in answering the questionnaire. Third, applying matching techniques requires detailed data on firm characteristics to determine selection into treatment on observables. Hence, matching can only be as good as the data. In our analysis, we are able to reduce the mean bias between treatment and control group to 3.3% in the main specification. Still matching estimators are not robust to a “hidden bias” (Rosenbaum, 2002, pp. 105-110; Morgan and Winship, 2007, p. 122; Caliendo and Kopeinig, 2008). Using various matching estimators, we are able to sufficiently reduce bias and to show robustness of the results.

There is room for future research. It may be benefitting to include information on the selection processes of applications such as the scores of project applications in order to better understand the underlying mechanisms to understand the effectiveness of public subsidies on firms. Using this additional information would allow researchers to use methods such as regression discontinuity design or instrumental variables to better inform about the effectiveness of subsidies. Furthermore, it may be interesting to include information on the "intensity" of public support measured by subsidy volume, for example by using data by the subsidy granting institutions. This may provide deeper insights on the effectiveness of public policy on the economy. Also, we are not able to distinguish effects of the R&D subsidies on the extensive margin, i.e. whether there is a rise in the share of R&D performers (Huergo et al., 2015).

4.6 Concluding remarks

To sum up, this study analyzes the effects of public subsidies on R&D activity over the period 2005 to 2013, when the 2008 financial crisis hit the global economy. First, the average effect of R&D subsidies on receiving firms reveals no significant difference between subsidized and unsubsidized Swiss firms in terms of R&D activity. This result underlines the issue of crowding out of private R&D investments by public funding and sheds light on the effectiveness of public subsidies. Crowding out behavior raises the concern that low application costs cause an exploitative behavior of firms regarding public subsidies (David et al., 2000). The setting of the financial crisis of 2008, however, underlines the need of considering business cycles in the evaluation of effectiveness of public funds.

Second, when considering that the crisis hit in the relevant period, crowding out may seem plausible if we consider that firms were adapting to the crisis by altering their investment decisions. Hence, we find that granting of public subsidies during the crisis did not alter R&D expenditure. The reason for this might be that firms during the crisis that were in need of financial help made use of the availability of public funds to overcome financial constraints.

Third, by analyzing the differential effect of persistently keeping R&D investments constant despite of the crisis, we find confirmation for crowding out and that not changing R&D behavior reduces the extent to which crowding out affects R&D expenditure. The reasons for such persistency in R&D investments during economic downturns are sunk costs, opportunity costs or accumulation of knowledge (Sutton, 1991; Nelson and Winter, 1982; Schmookler, 1976).

We are careful in interpreting the results as the empirical strategy applied bears several limitations that may affect inference and policy implications. Nevertheless, our results have important implications for public policy. We show that firm behavior driven by uncertainties of the economic crisis drive the crowding out by firms. Also, we cannot rule out that public innovation grants failed to provide to the stabilization of the economy. However, if public policy is ineffective in securing private R&D spending during recessions, then firms bear the economic costs of the crisis by persistently investing at the price of lower economic outcome. And if persistence in R&D behavior is crucial for coping with recessions, public policy may consider taking this into account for by extending the share of supported firms. However, public subsidies aiming at increasing the extensive margin may attract firms to overinvest in R&D only to benefit from the public funds.

Appendix B

Table B. 1: Industry and sector classification based on NOGA 2008

Manufacturing		
1	Food	Traditional
2	Textile	Traditional
3	Clothing	Traditional
4	Wood	Traditional
5	Paper	Traditional
6	Graf. Industrie	Traditional
7	Chemistry	High-Tech
8	Plastics	High-Tech
9	Nonmetallic minerals	Traditional
10	Metal manufacturing	Traditional
11	Metalware	Traditional
12	Machinery	High-Tech
13	Electrical	High-Tech
14	Elektronics/Instruments	High-Tech
15	Watches	Traditional
16	Vehicles	High-Tech
17	Other industries	Traditional
18	Energy	Traditional
Construction		
19	Construction	
Services		
20	Wholesale	Traditional
21	Retail	Traditional
22	Hospitality	Traditional
23	Traffic	Traditional
24	Banks/Insurance	Modern
25	Real estate/rent	Traditional
26	Computer science services/ R&D	Modern
27	Business services	Modern
28	Personal services	Traditional
29	Telecommunications	Modern
30	Education	Traditional
31	Health service	Traditional
32	Waste treatment	Traditional
33	Entertainment, culture, sports	Traditional

Source: Data from KOF (2016)

Table B. 2: Summary statistics of covariates, subsidized versus unsubsidized firms

Variable	Subsidized			Unsubsidized			p-value of t-tests on mean differences
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	
Gross investments in millions	425	28.30	192.00	3,908	8.04	61.10	0.0306
Log investments	425	9.73	2.67	3,908	8.59	2.70	(<0.0001)
Number of competitors <= 5	443	0.38	0.49	4,234	0.33	0.47	0.0403
Number of competitors 6-10	443	0.32	0.47	4,234	0.31	0.46	0.6695
Number of competitors 11-15	443	0.10	0.30	4,234	0.13	0.34	0.0482
Number of competitors 16-50	443	0.09	0.29	4,234	0.12	0.32	0.0404
Number of competitors > 50	443	0.11	0.31	4,234	0.12	0.32	0.5196
Share of exports in turnover	435	54.13	38.11	4,251	28.83	36.24	(<0.0001)
Log firm age	450	3.92	0.80	4,230	3.79	0.86	0.0011
Part of an enterprise group yes/no	260	0.49	0.50	2,323	0.39	0.49	0.0022
Foreign owned yes/no	460	0.20	0.40	4,344	0.18	0.39	0.3068
SME	461	0.64	0.48	4,367	0.80	0.40	(<0.0001)
Exports yes/no	453	0.86	0.34	4,335	0.61	0.49	(<0.0001)
R&D co-operations yes/no	448	0.66	0.47	4,048	0.23	0.42	(<0.0001)
Share of trained employees	416	41.17	19.70	4,106	46.95	21.90	(<0.0001)
Share of untrained and partly trained employees	416	21.54	19.93	4,106	23.91	23.53	0.0233
Share of apprentices	416	4.46	4.74	4,106	5.47	6.92	0.0001
Share of employees with college/university degree	416	13.34	17.70	4,106	7.01	12.42	(<0.0001)
R&D yes/no	461	0.93	0.25	4,367	0.62	0.49	(<0.0001)
Turnover / total number of employees	433	468,418.12	1,141,576.32	4,060	549,250.57	4,561,181.59	0.37
Hightech	461	0.55	0.50	4,367	0.32	0.47	(<0.0001)
Traditional	461	0.54	0.50	4,367	0.58	0.49	0.1019
Modern	461	0.09	0.28	4,367	0.16	0.36	(<0.0001)
Construction	461	0.02	0.15	4,367	0.05	0.22	0.0001

Source: Data from KOF (2016), own calculations.

B.1 Robustness

We further check the robustness of the results in several additional analyses. Based the previous result on R&D activity, we find potential crowding out in the cross-section. We would expect that this results from the 2008 financial crisis which substantially affected R&D investment behavior and the allocation of funds. Since we are also concerned that this crowding out might be driven by unobserved trends before and after the crisis, we exclude years 2005 and 2013, and repeat the matching. The estimates in Table B. 3 indicate qualitatively the same results and suggest robustness across macroeconomic fluctuations. The effect on R&D expenditure is negative but insignificant. In the crisis years (2008 and 2011), public subsidies do not result in significant changes in private R&D investments; however, excluding non-crisis years might bias the inference.

Table B. 3: Estimates of average treatment effects on the treated during crisis years

	Kernel matching Bandwidth 0.06 Only years 2008, 2011
ATT	-0.9652
	(1.018)
t-stat	-0.95
N treatment	60
N control	108
N off-support	233
Median bias (%)	7.3

Standard errors in parentheses. *p < 0.1; **p < 0.05; ***p < 0.01.
Notes: Sub-sample is restricted to only crisis years. The propensity score is estimated via probit (unreported). The outcome variable is log R&D expenditure. Treatment dummy is subsidy receipt. Source: Data from KOF (2016), own calculations.

Since the results might be driven by the chosen matching algorithm, we also apply a one-to-one matching as well as nearest neighbor matching with different specifications (Table B. 4). In all specifications, the effect of the subsidy grant on R&D expenditure is negative but imprecise and thus point to the same interpretation as before. In the case of one-to-one matching, the bias after matching remains substantially high. This is due to the high loss on observations as a result of imposing the common support assumption. Hence, across different specifications and different matching algorithms, we find null effects of public subsidies on R&D expenditure.

Table B. 4: Estimates of average treatment effects on the treated with different matching algorithms

	Kernel matching		Nearest neighbor matching, caliper 0.001		One-to-one matching
	0.03	0.01	one neighbor	five neighbors	
	(1)	(2)	(3)	(4)	(5)
ATT	-0.5201 (0.6543)	-0.5891 (0.6897)	-1.0910 (0.8707)	-0.9437 (0.8810)	-0.5681 (0.5111)
t-stat	-0.79	-1.09	-1.25	-1.07	-1.11
N treatment	118	118	56	56	118
N control	339	339	106	106	118
N off-support	90	90	385	385	311
Median bias (%)	6.3	7.4	7.3	7.5	37.1

Standard errors in parentheses. *p < 0.1; **p < 0.05; ***p < 0.01.
Notes: The propensity score is estimated via probit (in column 2 of Table 4.4). The outcome variable is log R&D expenditure. Treatment dummy is subsidy receipt.
Source: Data from KOF (2016), own calculations.

5 Social capital, religiosity, and tax morale

5.1 Introduction

In most European countries, public authorities claim taxes on employees' incomes by wage tax deduction, i.e. a source tax. The opportunities for tax evasion are thereby restricted. Yet, it is possible for taxpayers to engage in the shadow economy and hide earnings from public authorities (Kirchler, 2007, p. 72), resulting in losses of tax revenue. However, tax authorities can influence taxpayers' behavior to comply with their individual tax obligations through various channels, one of which might be social capital. It is the goal of this study to understand how citizens' attitudes towards taxes are shaped by social capital.

Drawing on Becker's (1968) general model of the economics of crime, Allingham and Sandmo (1972) and Srinivasan (1973) formally explain individual tax evasion behavior by focusing on extrinsic factors such as the audit probability and the penalty level as well as the individual's risk preference (see Alm, 2012, for a literature review on tax evasion). Asserting that people pay taxes despite low audit probabilities and low penalty levels, these models fail to explain tax compliance and ultimately lead to the "tax compliance puzzle" (Alm, McClelland, and Schulze, 1992). This paper relates to previous attempts to explain tax compliance by shedding light on tax morale, i.e. the intrinsic motivation to pay taxes, which is found to be an important factor for the actual compliance behavior (Cummings et al., 2009).

The literature has primarily focused on the channels of tax morale by exploring the correlation between individual characteristics and tax morale (Grasmick, Bursik, and Cochran, 1991; Torgler, 2006) as well as contextual factors such as tax progressivity

(Doerrenberg and Peichl, 2013). Other studies explain tax morale as result of a psychological contract between taxpayers and tax authority in form of an implicit contract exchanging tax payments for the benefit from public goods (Feld and Frey, 2002, 2007). I contribute to the literature by shedding light on the effect of social capital as exchange on the attitudes of individuals towards taxes.

By introducing the concept of social capital for determining tax morale, this study refers to the aggregate of resources between people and institutions that facilitate social cooperation and thus the production of a common good (Bourdieu, 2012; Coleman, 1988; Putnam, 1993). Previous studies investigating the relation between social capital and tax morale find positive correlations but do not address causation (e.g., V. Braithwaite, 2003; Torgler, 2003, 2005; Alm and Gomez, 2008; Lago-Peñas and Lago-Peñas, 2010). The novelty of this study is the implementation of an instrumental variable approach in quantifying the effect on tax morale, instrumenting for social capital with religious fractionalization[38] and religiosity to account for potential endogeneity problems of social capital. This approach allows the identification of the effect of social capital on tax morale. The validity of instruments is given by the fulfillment of the relevance and exogeneity conditions. Prior studies have included religiosity as explanatory variable, which point to a positive correlation but neglect that religiosity may only affect tax morale through the channel of social capital (Grasmick et al., 1991; Torgler, 2006).

So far, social capital considerations in the context of tax morale have been the subject of research in few studies such as Torgler (2003) and Alm and Gomez

[38] We will use the words "secularization" and "religious fractionalization" interchangeably, although we more frequently use the term "religious fractionalization". In the literature, "secularization" is preferred when referring to the process of cultural shift toward nonreligious values while "religious fractionalization" points to the quantification of the same process (cp. Alesina et al., 2003; Becker and Woessmann, 2013). However, both terms rely on the same notion.

(2008). Using the example of Spain, Alm and Gomez find a positive correlation between one's perception of the benefits derived from public goods and tax morale. Similar studies such as Kogler et al. (2013) or Gangl, Hofmann, and Kirchler (2015) provide a "slippery slope" framework that considers simultaneously power of the authority and trust in the authority as determinants of tax compliance. Only few prior studies have put social capital in the center of research on tax compliance. I extend these analyses by investigating the causal relationship. The results indicate a large effect of social capital on tax morale, consistent with existing literature, but less reliable effects for less secularized countries. The findings point to the relevance of enhancing trust between citizens and the government to secure tax revenues.

This paper is organized as follows. Section 5.2 presents the conceptual background. Section 5.3 presents the data. In Section 5.4, I discuss the empirical strategy. Section 5.5 presents the study's findings. Finally, Section 5.5.5 discusses the main results and concludes.

5.2 Conceptual Background

5.2.1 Typology of tax behavior

While tax compliance refers to the individuals' decision to comply with tax rules, tax avoidance denotes any action reducing the tax liability. This term, however, does not only implies illegal activities but also legal activities such as income splitting of spouses, postponement of taxes and tax arbitrage. The more specific term tax evasion refers to illegal and intentional actions by individuals to reduce their legally due tax payments. Evasion activities involve overstating deductions, exemptions, or credits as well as filing wrong tax returns or engaging in barter activities (Alm, 2012).

Tax morale at the aggregate societal level captures nonpecuniary motivations for tax compliance, collective intrinsic motivation to pay taxes as well as guilt or shame by non-compliance (Schmölders, 1960; Cummings et al., 2009; Luttmer and Singhal, 2011). Although the concept of tax morale refers to the aggregate and national level, it is rooted in the microeconomic level as individuals' motivational postures originating in the knowledge and attitudes towards taxes that individuals develop in social interaction with each other (Kirchler, 2007, p. 102; Dell'Anno, 2009). Following Torgler (2003) and Feld and Frey (2007), tax morale can be summarized as the social and psychological motivations of citizens to pay taxes as microeconomic factor in the determination of compliance behavior.

The theory of reasoned action and planned behavior explains the theoretical link between tax morale and tax compliance (Ajzen, 1991; Fishbein and Ajzen, 1975). This link has also been subject to studies investigating attitudes towards taxes, i.e. tax morale, as one of the most important determinants of tax compliance (Lewis, 1982, p. 177; Alm, McClelland, and Schulze, 1992; Cummings et al., 2009).

5.2.2 Tax morale, a psychological tax contract, and institutional trust

Tax morale has been seen for a long time as an exogenously given black box (Dell'Anno, 2009). With neoclassical models and their inability to explain the tax compliance puzzle, research in this field undergoes a shift to behavioral economic and economic-psychological models. Research on tax behavior focuses on attitudes, norms and fairness as well as decision anomalies (Alm and Torgler, 2011; Kirchler 2007, pp. 2-3).

Every citizen more or less worries about paying taxes. However, tax knowledge is subjective and limited. Due to the complexity of the tax law, citizens may retaliate by adopting a negative attitude towards paying taxes which exacerbates the lack of interest in the tax system (McKerchar, 2001; Carnes and Cuccia, 1996). Consequently, people create *social representations* of the tax system. Social representations are the result of interactions with each other in which they evaluate the tax system to create a familiar environment and to cover up the inability in understanding the tax system. In the plainest form, a figurative illustration is the metaphor of tax auditors and the tax authority as 'cops' and taxpayers as 'robbers' to be punished for stealing by not complying with tax law (Kirchler, 2007, pp. 29-31).

Although by legal definition of taxes, i.e. citizens paying taxes do not have a claim on benefits provided by the government, the relationship of taxpayers with the tax authority can be characterized as a give and take or reciprocal exchange in the sense of Gouldner (1960) and Fehr and Gächter (2000). This norm of reciprocity accomplishes an exchange of taxpayers giving payments to the government in return for public goods. As a consequence, taxpayers evaluate the quality of the public goods provision, which they cannot precisely assess but which allows a general impression of the exchange (Spicer and Lundstedt, 1976). Moreover, Pommerehne and Frey (1992) have shown empirically that perceived public spending is positively related to tax compliance and negatively to tax cheating. Building on these notions, Feld and Frey (2002) present this relationship between taxpayers and tax authorities as a relational psychological tax contract implying the consideration of emotional ties and loyalty in the exchange. The psychological or implicit trait of the contract stands in contrast to formal contracts in which the parties face sanctions if the fulfillment of the contract is outstanding. As a consequence, tax authorities treat the taxpayers respectfully by not putting them into the suspicion of being evaders. The center of this psychological contract builds on trust between taxpayers and tax authorities which ensures partners to mutually behave honestly. Hence, the enforceability of the psychological tax contract, and with it tax morale, positively relates to the level of development of institutions and also taxpayers' participation rights in these institutions. Any disrespectful treatment of the taxpayers by the government risks noncompliance and would lead to tax evasion. This serves as a mechanism of punishment of revenue-maximizing governments by taxpayers (Schnellenbach, 2006).

5.2.3 Social capital, reciprocity, and trust

Establishing trust facilitates the exchange between taxpayers and the government. Fukuyama (1995, p. 26) defines trust as the expectation of cooperative behavior based on shared social norms within a community. This view on trust gives rise to examine the concept of social capital that incorporates trust as one of its key component. Bourdieu (2012), Putnam (1993), and Coleman (1988) introduced this concept by differentiating three dimensions of capital, i.e. economic, cultural, and social capital. The idea of social capital builds on the notion that individuals and groups benefit from resources generated in relations with each other. These resources can be beneficial to individuals or groups (Paxton, 1999). Putnam's concept of social capital distinguishes three components which all aim at improving the efficiency of society by simplifying coordinated action: first, trust; second, social norms and obligations; and third, social networks of citizen's activity in the form of voluntary associations (1993, pp. 167-176).

Coleman (1988) emphasizes the role of social structure in his concept of social capital. In more detail, he views social capital as "inhert[ing] in the structure of relations between actors and among actors." (p. S98). Based on this understanding, social capital is a resource which facilitates the production of some good at the community level. Putnam (1993) even refers to social capital at the contextual level as a "public good" with positive spillover effects on other members of society and thus enhancing efficiency of public institutions and economic performance.

Social capital provides trust between actors which in turn translates into reciprocate behavior and thus reduces risk and enforcement costs allowing efficient economic transactions without expensive bonding and insurance devices (Luhmann, 1988, 2003; Scholz and Lubell, 1998). Reciprocity can take two directions: positive reciprocity means cooperative reciprocal behavior while negative reciprocity means retaliatory reciprocal behavior (Fehr and Gächter, 2000). As Putnam (1993) asserts, trust creates reciprocity and voluntary associations while reciprocity and associations create trust (pp. 163-185).

In order to consistently measure social capital in the context of tax morale, I focus on trust on the individual level. This measure connects to the theoretical definition of social capital (Paxton, 1999). An individual can trust certain individuals as well as more generalized and abstract people or institutions (e.g. Giddens, 1990). For the purpose of this paper, I focus on trust in governmental institutions because these are, in the context of tax morale, the recipients of tax payments.

5.2.4 Religious fractionalization, morality, and social capital

Studies on the relationship between religion and economics have emerged early and put the implications of religion for economics in the center of research. Since Adam Smith (1863) who investigates economic outcomes as function of religiosity and Max Weber (1930) who determines the protestant ethic as a key driver of economic progress, the field of economics of religion more recently undergoes a resurgence (Anderson, 1988; Hull and Bold, 1994; Iannaccone, 1998; Hull, 2000; Weber, Parsons, and Giddens, 2007). Only few studies exist that investigate religion as a driver of tax compliance (e.g., Tittle, 1980; Grasmick et al., 1991; Torgler, 2006; Kanniainen, Pääkönen, and Schneider, 2004). These studies widely attribute religiosity to higher tax compliant behavior.

The views on religion and individuals' behavior diverge in two directions. I distinguish the 'Old View' and the 'New View' on religiosity. The 'Old View' regards religiosity as influence on individual behavior regards religion as internal moral enforcement (Smith, 2009; Anderson, 1988). This view is based on a strong emphasis on the morality of religion, e.g., the Ten Commandments as a moral system. Thus, social norms, social control, a sanctioning system, shame and guilt play a distinct role in irrational behavior (Hirschi and Stark, 1969; Tittle and Welch, 1983; Grasmick et al., 1991; Stark, Iannacconne, and Finke, 1996; Iannaconne, 1998). In contrast, the 'New View' interprets religion as rational behavior representing the "secularization thesis" (e.g., Hardin, 1982, 1997). As in Hardin's economic theory of knowledge, religiosity has a functionalist property to economize and simplify actions by internalizing the values of the religious community (Hardin, 1997).

Advocates of the 'Old View', such as Anderson and Tollison (1992), assert religion as "supernatural police" enabling the enforcement of social norms, thereby viewing religion as a moral enforcement. Nevertheless, this might only hold if one affirms that individual decision making is solely a function of religion. Another point advocating for the 'Old View' puts forward that the relationship between morality and religiosity are stronger social ties between people through the means of religion

(Smith, Sawkins, and Seaman, 1998). This point however ignores that religiosity may not only affect morality directly but rather religiosity affects morality indirectly through the means of social capital. Religiosity breeds social interaction and engagement among individuals as well as trustworthiness between other members of the religious group.

However, religiosity is neither the center of moral behavior nor is morale behavior the center of religion. The secularization process implies strong societal and cultural changes to non-religious values in European countries (cp. Becker and Woessmann, 2013). In contrast to Smith (2009) or Margolis (1997), who link morality directly to religiosity, I argue that moral behavior does not originate from religiosity but rather religiosity conflates into its outcome, i.e. social capital as horizontal trust in each other, vertical trust in governmental institutions and civic or voluntary engagement (e.g., Putnam and Campbell, 2012, pp. 463-471).

From a functionalist perspective, transaction and enforcement costs decrease by providing mutual trust which decreases risk and uncertainty by common values among member of a religious group and thus, economizes and simplifies decision making due to facilitated interaction between like-minded people (Hardin, 1997; Heiner, 1983). This point additionally informs about social capital as the intermediary between religiosity and morale because social capital becomes more important under conditions of secularization where religion plays a minor role in people's everyday life. Of course, if individuals perceive religion as a rational factor in decision making, religion may help in the development of social capital (Hardin, 1997).

Combining the notions of the 'New View' on religion and the secularization thesis, religious fractionalization and religiosity theoretically provide valid instruments to identify the effect of social capital on tax morale. An instrumental variable has to be strongly correlated with the endogenous variable, i.e. social capital, but at the same time the instrument has to influence the outcome variable only indirectly via its effect on social capital (Cameron and Triverdi, 2009, pp. 95-98).

5.2.5 Hypothesis development

The ideas laid out in the previous sections point to the importance of trust for citizens' attitudes towards taxes. In the context of tax compliance and morality, Alm and Torgler (2011) refer to a new "trust" paradigm building on the foundation of ethics. The more taxpayers trust the government, the more they are willing to participate in that group by complying and cooperating. With this in mind, tax administrations may influence tax compliance by eroding taxpayers' ethics. Other empirical studies imply that tax morale is stronger with higher trust in the government and its institutions (Falkinger, 1988; Pommerehne and Frey, 1992; Torgler, 2003, 2005; Fjeldstad, 2004). These studies, however, ignore a potential bias resulting from a post-rationalization of tax cheating.

To sum up, I test the following

> ***Hypothesis***: *If taxpayers place more trust in governmental institutions, it facilitates the exchange between taxpayers and the government and the government can expect more of its citizens to adopt a positive attitude toward taxes.*

5.3 Data

This study exploits data by the European Values Study (EVS). The EVS survey is a European socio-political and value oriented survey, which offers individual-level and nationally representative data from 1981 to 2008 in four waves. Only the third wave conducted between 1999 and 2001 is relevant for this study as data on the main variables are only available in this wave.

5.3.1 Outcome variable: tax morale

Following the literature on tax morale, I use answers to a specific question as dependent variable (e.g. Torgler and Schneider, 2005; Torgler, 2006; Alm and Torgler, 2006; Alm and Gomez, 2008; Torgler, Schneider, and Schaltegger, 2010). The question asks

> *Please tell me for each of the following statements whether you think it can always be justified, never be justified, or something in between …*
>
> *Cheating on tax if you have the chance.*

This answer to this question is a ten-point scale with 1 as “never justified” and 10 as “always justified”. I recode this variable to 1 as “always justified”, i.e. low tax morale, and 10 “never justified, i.e. high tax morale.

This measure of tax morale has found large consensus among empirical studies of tax morale and was used in other surveys as well: the World Values Survey (Alm and Torgler, 2006), International Social Survey Program (Torgler, 2005), or the Afrobarometer (Cummings et al., 2009). However, this measure is potentially biased. First, individuals might overstate tax morale and individuals who evade taxes might consciously lie about past tax behavior (Andreoni et al., 1998). As noted by Frey and Torgler (2007), asking about tax morale instead of tax evading behavior reaches a higher level of honesty. Second, taxpayers may justify tax evasion if the government lavishes tax revenue and the measure of tax morale might be biased in more corrupt countries. Since this study focuses on democratic European countries, the mentioned question is appropriate to measure tax morale.

5.3.2 Main explanatory variables: social capital

Social capital can be measured in various ways (Paxton, 1999). This study focuses on the dimension of social capital reflecting *Trust in institutions.* The main explanatory variable is individuals' self-indicated level of confidence in institutions. This dimension of social capital theoretically affects an individual's morale towards paying taxes. The underlying question asks

> *Please look at this card and tell me, for each item listed, how much confidence you have in them, is it a great deal, quite a lot, not very much or none at all?*

With variations regarding the institution as follows

> *The legal or justice system*[39] */ The social security system / Parliament.*

Answers each of the question are on a 4 point Likert scale with 1 as "a great deal" and 4 as "none at all" at the extremities. Recoding the respective variables into 0 as "none at all" and 3 as "a great deal" facilitates the interpretation of signs. By aggregating the three answers to these questions, I build an indicator of aggregate trust in governmental institutions on a 10-scale.

5.3.3 Covariates

In order to adjust for individual-level corruptness as attitudes towards free-riding, I include a question asking for justification of *Avoiding a fare on public transport* on a 10-point scale. I recode this variable due to lack of variance at higher values, to a 4-point scale with 1 as "never justifiable" and 4 as "always justifiable".

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[39] Item in EVS 1999 (ZA3811); EVS 2008 (ZA4800): The justice system ; while item in EVS 1981 (ZA4438); EVS 1990 (ZA4460): The legal system

Following Torgler (2006), I include a risk aversion dummy to consider the fact that tax compliance decisions involve risk attitudes. The respective question relates to individual attitude towards *Good job security* which is coded as dichotomous.

Following the existing literature on tax morale, I control for socio-demographic characteristics (Torgler 2003; Torgler and Schneider 2005; Alm and Torgler 2006). More precisely, I control for age by including age dummies of respondents' age intervals. Age is divided into six intervals with 15 to 24 years as the youngest and 65 and over as the oldest. Furthermore, I include a dummy indicating sex equal to one if the respondent is female. Also, I include the respondent's highest education level ordered in eight categories. Moreover, I include dummies indicating the marital status and dummies indicating the employment status. Finally, I do not include income but dummies for respondents' self-indicated socio-economic class.

5.3.4 Descriptive statistics

Table 5.1: Descriptive statistics: main variables

	N	Mean	St.Dev.	Min	Max
Outcome variables					
Tax morale	12,793	8.37	2.38	1	10
Cheating on state benefits	12,680	2.23	2	1	10
Explanatory variable					
Individual trust in institutions	12,793	3.97	1.89	0	9
Instruments					
Religious fractionalization	12,793	0.23	0.17	0.01	0.54
Religious identity salience	12,793	3.76	1.62	0	6
Time in church	10,666	0.73	1.06	0	3
Population density	8,352	145.24	60.6	74.61	242.56

Source: Data from EVS (2011), own calculations.

Table 5.1 shows the descriptive statistics of the relevant variables of the sample used in this study. From the original 47 countries in the survey, the final sample consists of Austria, Belgium, Croatia, Czech Republic, France, Germany, Italy, and Luxembourg with 12,793 observations as I adjust for control variables with many missings.

Table 5.2: Descriptive statistics: control variables

Variable	N	Mean	St.Dev.	Min	Max
Free-riding	12,793	1.03	1.25	0	3
Risk-aversion	12,793	0.64	0.48	0	1
Age	12,793	45.69	16.98	15	97
15-24	12,793	0.11	0.32	0	1
25-34	12,793	0.2	0.4	0	1
35-44	12,793	0.2	0.4	0	1
45-54	12,793	0.17	0.37	0	1
55-64	12,793	0.15	0.36	0	1
65 and more years	12,793	0.17	0.38	0	1
Female	12,793	0.53	0.5	0	1
Highest educational level attained	12,793	4.4	2.16	1	8
Inadequately completed elementary education	12,793	0.05	0.22	0	1
Completed (compulsory) elementary education	12,793	0.24	0.42	0	1
Incomplete secondary school: technical/vocational	12,793	0.13	0.33	0	1
Complete secondary school: technical/vocational	12,793	0.09	0.28	0	1
Incomplete secondary: university-preparatory	12,793	0.12	0.33	0	1
Complete secondary: university-preparatory	12,793	0.2	0.4	0	1
Some university without degree	12,793	0.07	0.26	0	1
University with degree	12,793	0.11	0.31	0	1
Current legal marital status respondent	12,793	2.74	2.2	1	6
Married	12,793	0.59	0.49	0	1
Cohabiting	12,793	0	0	0	0
Divorced	12,793	0.07	0.25	0	1
Separated	12,793	0.01	0.12	0	1
Widowed	12,793	0.08	0.28	0	1
Single	12,793	0.24	0.43	0	1
Socio-economic status respondent	12,793	1.53	0.94	0	3
Manual workers, unskilled, unemployed	12,793	0.16	0.37	0	1
Manual workers, semi-skilled	12,793	0.31	0.46	0	1
Middle, non-manual workers	12,793	0.38	0.49	0	1
Upper, upper-middle class	12,793	0.16	0.36	0	1
Employment status	12,793	3.12	2.06	1	8
Employment: Full time	12,793	0.39	0.49	0	1
Employment: Part time	12,793	0.08	0.26	0	1
Employment: Self employed	12,793	0.05	0.22	0	1
Employment: Retired	12,793	0.24	0.43	0	1
Employment: Housewife	12,793	0.1	0.3	0	1
Employment: student	12,793	0.06	0.24	0	1
Employment: Unemployed	12,793	0.06	0.23	0	1
Employment: Other	12,793	0.02	0.14	0	1

Source: Data from EVS (2011), own calculations.

As shown in Table 5.2 (descriptive statistics of the control variables), the average respondent is 46 years old and 47% are males. About 18% have either a university degree or attended courses at university. Almost a third of the sample (32%) have begun or finished university-preparatory school[40]. In comparison, 22% have started or completed technical or vocational training. The individuals in the sample have rather high levels of education. Also, the socio-economic status reveals large variation: 16% of the respondents consider themselves as part of the upper and upper-middle class while 38% are non-manual workers of the middle class. Then, 31% belong to the group of semi-skilled manual workers while 16% are unskilled manual workers or unemployed.

5.4 Identification strategy

5.4.1 Endogeneity of social capital

Social capital can be captured on various levels and by various measures. The reason why I focus on trust in governmental institutions is that it is a measure of vertical trust and reflects best the exchange between taxpayers and tax authorities. Beginning with simple linear regressions to investigate the effect of social capital on individual tax morale, I estimate the correlation between both variables in the following equation

$$y_{c,i} = \alpha + \beta \cdot \mathrm{SC}_{c,i} + \gamma \cdot X_i + \delta_c + u_{c,i} , \tag{5.1}$$

where *c* indicates country and *i* indicates individuals. The dependent variable $y_{c,i}$ comprises self-indicated tax morale on the individual level. $\mathrm{SC}_{c,i}$ represents an aggregated indicator of individuals' general trust in governmental institutions. X_i is a vector of individual level control variables and δ_c is a vector of country dummies to capture unobserved heterogeneity across countries.

[40] University-preparatory schools are secondary schools preparing students for higher education. In Germany, the most common school form is the Gymnasium. In other European countries such as France, this school form is called lycée.

However, the estimation of this equation involves the problem of endogeneity of the explanatory variable social capital which ultimately leads to systematic biases by estimating simple regression equations. Formally, endogeneity formally occurs if the explanatory variable of interest is correlated with the error term, i.e. $Cov(u_{c,i} | \mathrm{SC}_{c,i}) \neq 0$.

Endogeneity in this setting occurs because causality between tax morale and social capital may run both ways. Instead of being the cause for tax morale, social capital may be the result of hindsight rationalization of negative tax attitudes. More intuitively, the problem of endogeneity arises because people tend to rationalize their tax attitudes and behavior ex-post, i.e. people justify perceptions of injustice (by the government) with negative tax attitudes, which ultimately leads to systematic biases in estimating the effect of social capital on tax morale (Kirchler, 2007, p. 91). Hence, both variables are interdependent and lead to a simultaneity bias.

If an omitted factor negatively affects social capital but which is not directly related to tax morale and thus leading to a decrease in tax morale of individuals, then the error term $u_{c,i}$ of Equation (5.1) is negative. This negative error reduces tax morale, which in turn reduces social capital (due to post-rationalization of negative attitudes). Under those circumstances, social capital and the error term in Equation (5.1) are positively correlated and therefore lead to a downward bias of the effect by estimated by OLS.

If the cause-effect relationship between trust and tax morale is unclear due to potential hindsight bias and post-rationalization, the direction of this relationship must be studied with the econometric tools at hand, e.g., an instrumental variables approach.

5.4.2 Instrumental variables approach

Subsequently, I estimate tax morale in European countries by instrumenting for social capital with religious fractionalization and religiosity. This approach allows coping with the endogeneity problem arising from the simultaneity of tax morale and social capital.

Secularization and religiosity may theoretically be valid instruments. First, this requires both variables to be highly correlated with individual-level social capital and second, they have to influence the outcome variable only through social capital.

The first requirement of relevance can be expressed as

$$Cov(z_{c,i} \mid \mathrm{SC}_{c,i}) \neq 0. \tag{5.2}$$

with $z_{c,i}$ being the instrument and $\mathrm{SC}_{c,i}$ the causal explanatory variable. The second requirement of exogeneity states

$$Cov(z_{c,i} \mid u_{c,i}) = 0 \tag{5.3}$$

implying that the instrument is not affecting the outcome variable directly and therefore uncorrelated with the error term of the reduced form.

I illustrate the IV two-stage-least-squares (2SLS) analysis in two equations. In the first stage, I regress social capital on religiosity and other covariates. Under the assumption of validity of the instruments, the predicted values of social capital $\hat{\mathrm{SC}}_{c,i}$ correspond to the exogenous part of $\mathrm{SC}_{c,i}$

$$\mathrm{SC}_{c,i} = \pi_0 + \pi_1 \cdot \mathrm{Instruments}_{c,i} + \pi_2 \cdot X_i + \delta_c + e_{c,i}. \tag{5.4}$$

In the second stage, the outcome variable is regressed on the predicted values of social capital $\hat{\mathrm{SC}}_{c,i}$ and further covariates

$$y_{c,i} = \alpha + \beta \cdot \hat{\mathrm{SC}}_{c,i} + \gamma \cdot X_i + \delta_c + u_{c,i}. \tag{5.5}$$

Standard errors are robust to heteroscedasticity. I rely on several test statistics to evaluate the conditions of relevance and of exogeneity of the instrumental variables.

5.4.3 Instrumenting for social capital

In order to consistently estimate the effect of social capital on tax morale, I use as instrument the measure of fractionalization proposed by Alesina et al. (2003), which can be applied to various contexts besides religion. The 'New View' on religiosity justifies instrumenting social capital with religious fractionalization because this measure reflects the secularization process of Western countries which potentially affects social capital but not tax morale. Formally, this measure of religious fractionalization reflects the degree of heterogeneity in religious group affiliation as one minus the Herfindahl index of religious group shares. More precisely, it measures the probability that two randomly selected individuals from a population belong to different groups. Using the EVS data, I calculate the fractionalization of religious groups in a country as follows

$$FRACT_j = 1 - \sum_{i=1}^{N} s_{ij}^2 \qquad (5.6)$$

with s_{ij} as the share of group i (i = 1, …, N) in country j.

As presented in Table 5.1, the average probability of two random individuals belonging to different groups is 23% with a smallest probability of 1.46% in Italy implying very a low level of secularization and the highest probability of 53.84% in Germany implying a high level of secularization.

Furthermore, I make use of religiosity as additional instrument. The EVS Survey provides various questions regarding religious beliefs and religious behavior. Following the concept of *religious identity salience*, I use questions regarding the self-indicated importance of religion to measure the extent of respondents' internalized religious convictions and the religious influence in daily decisions (Rohrbaugh and Jessor, 1975; Wimberley, 1989). Self-indicated religiosity is coded as a three-scale variable taking values 1 for being a convinced atheist, 2 for being a non-religious person and 3 for being a religious person. Moreover, I consider a question regarding the importance of religion on a four-scale and aggregate these two questions as an equally weighted average of the two variables times two. As a result, the aggregated measure of religious salience is a seven-scale variable with an average value of 3.76 (as shown in Table 5.1). I focus on this aggregated individual-level variable on religious identity salience as second instrument.

5.5 Results

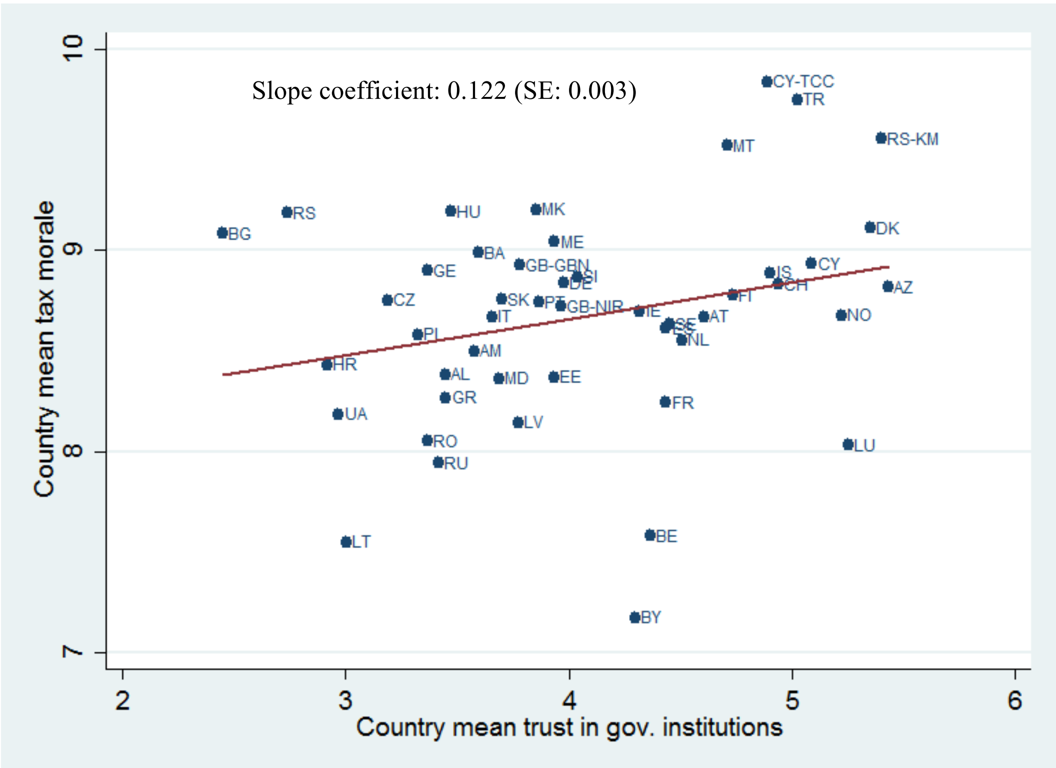

Figure 5.1: Plot of tax morale against trust in governmental institutions
Notes: Total sample unadjusted for missings in control variables for 47 European countries
Source: Data from EVS (2011), own graph.

As presented in Figure 5.1, plotting average tax morale and average trust in governmental institutions, both at the country-level, shows that the unconditional correlation of both variables is positive and implying higher tax morale of 0.12 by a unit increase of trust in governmental institutions. It should be noted, however, that looking at the raw association between country-level tax morale and country-level governmental trust neglects structural differences between countries.

5.5.1 Regression estimates of the effect of social capital

First, I will present the results from simple ordinary least squares models where I include the set of control variables successively. The coefficients presented in Table 5.3 can be interpreted as marginal effects.

Table 5.3: OLS regression analysis for tax morale

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Trust institution	0.101***	0.0634***	0.0617***	0.0647***	0.0636***	0.0988***
	(0.0117)	(0.0110)	(0.0110)	(0.0110)	(0.0110)	(0.0112)
Free-riding		-0.603***	-0.599***	-0.548***	-0.547***	-0.574***
		(0.0175)	(0.0175)	(0.0182)	(0.0182)	(0.0178)
Risk averse			0.248***	0.229***	0.215***	0.131***
			(0.0424)	(0.0426)	(0.0428)	(0.0430)
Demographic background				YES	YES	YES
Education				YES	YES	YES
Marital status				YES	YES	YES
Socio-econ status					YES	YES
Employment status					YES	YES
Constant	7.968***	8.737***	8.580***	7.913***	7.532***	8.166***
	(0.0533)	(0.0525)	(0.0605)	(0.127)	(0.161)	(0.177)
Country dummies	NO	NO	NO	NO	NO	YES
Observations	12,793	12,793	12,793	12,793	12,793	12,793
R-squared	0.006	0.107	0.109	0.128	0.134	0.181

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Notes: The dependent variable is tax morale on a ten-scale.
Source: Data from EVS (2011), own calculations.

Column 1 of Table 5.3 reveals the unconditional association between the variable of interest, social capital, and tax morale. It reveals that individuals having higher trust in governmental institutions are on average more motivated to pay taxes than individuals having less trust. Discrete changes in the social capital increase tax morale scores by 0.10. The significance of all relationships remains stable when successively adding control variables but the magnitude of the marginal effect decreases. The reason for this may be reverse causality from post-rationalization of tax non-compliant attitudes. When adding free-riding behavior as covariate, the coefficient for social capital becomes smaller which may indicate that individuals having a priori lower tax morale select themselves into lower tax morale. Adding risk aversion, demographic background, education, marital status, socio-economic status employment status does not change magnitude or statistical significance (columns 3 to 5). In column 6 of

Table 5.3 when adding country dummies, the coefficient estimate is of about the same magnitude 0.10 as in the unconditional association of column 1. Similarly, this also holds for the coefficient of free-riding. However, the coefficient of risk-aversion decreases when successively adding more control variables. The reason for this might be that risk-aversion varies largely across countries which is captured by including country dummies. This could be some evidence on selection based on personality characteristics. While people that are more risk-averse are potentially less likely to engage in social representations of governmental institutions, they are hence more willing to comply with tax rules. For risk-loving people this might hold the other way around.

Social capital may vary across countries and hence drive the results (e.g., Paxton, 1999; Putnam, 2001). However, the results could also be driven by variation from differences in the development of political systems such as in post-communist transition economics. Therefore, I further separate the sample in different groups of countries: all EU countries, new EU members and old EU members to capture differences in the correlation between tax morale and social capital (columns 1 to 3 of Table 5.4). As the relationship could also be driven by absolute differences in social capital across individual groups, e.g., the religious groups, I also generate samples distinguishing between majority religions to minority religions (columns 4 and 5 of Table 5.4). Overall, the coefficient estimates of the main explanatory variable remain unchanged and imply a statistically significant relationship between trust in governmental institutions and tax morale.

Table 5.4: OLS regression analysis for tax morale by group

VARIABLES	(1) All EU	(2) New EU	(3) Old EU	(4) Majority religion	(5) Minority religion
Trust institution	0.0988***	0.0885***	0.101***	0.0788***	0.115***
	(0.0112)	(0.0209)	(0.0130)	(0.0161)	(0.0155)
Free-riding	-0.574***	-0.528***	-0.584***	-0.576***	-0.564***
	(0.0178)	(0.0322)	(0.0210)	(0.0265)	(0.0240)
Risk-averse	0.131***	0.0221	0.154***	0.176***	0.0812
	(0.0430)	(0.0755)	(0.0508)	(0.0646)	(0.0576)
Constant	8.166***	8.661***	7.164***	9.023***	7.659***
	(0.177)	(0.357)	(0.202)	(0.287)	(0.348)
Country dummies	NO	NO	NO	NO	YES
Observations	12,793	2,713	10,101	6,448	6,366
R-squared	0.181	0.206	0.173	0.160	0.210

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Notes: The dependent variable is tax morale on a ten-scale. All models control for age and sex, education, marital status, socio-economic status, and employment status as well as country dummies.
Source: Data from EVS (2011), own calculations.

5.5.2 Instrumental variable analysis

Similarly to the OLS analysis, Table 5.5 and Table 5.6 present instrumental variable estimates for all countries with the relevant information by successively adding covariates and then looking at different country sets and subsamples in the full specification.

As shown in Table 5.5, I find in all specifications a positive significant coefficient of trust in institutions but increase in size indicating a strong positive causal effect. Adding successively control variables decreases the coefficient of the effect of institutional trust while the coefficients of control variables remain stable. The economic magnitude suggests that discrete upward changes in trust in institutions increases tax morale by 0.60 points and shows that the downward bias by estimating OLS in the presence of simultaneous causality is reduced by the IV analysis (cp. column 6 of Table 5.5).

Table 5.5: IV analysis for tax morale

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Trust institution	1.176***	0.811***	0.787***	0.566***	0.575***	0.569***
	(0.113)	(0.106)	(0.107)	(0.0972)	(0.105)	(0.106)
Free-riding		-0.497***	-0.497***	-0.483***	-0.484***	-0.482***
		(0.0253)	(0.0251)	(0.0220)	(0.0238)	(0.0240)
Risk averse			0.172***	0.193***	0.175***	0.157***
			(0.0503)	(0.0459)	(0.0473)	(0.0477)
Demographic background					YES	YES
Education					YES	YES
Marital status					YES	YES
Socio-econ status						YES
Employment status						YES
Constant	3.699***	5.658***	5.643***	5.987***	5.684***	5.513***
	(0.450)	(0.441)	(0.436)	(0.412)	(0.483)	(0.460)
Instrument tests						
Rank LM stat	207.2	171.8	167.5	167.8	145.1	142.3
	(<0.000)	(<0.000)	(<0.000)	(<0.000)	(<0.000)	(<0.000)
J stat	1.240	1.844	1.932	1.258	7.802	4.868
	0.266	0.174	0.165	0.2621	0.00522	0.0274
Endogeneity test	156.542	69.341	63.955	31.95	29.033	27.841
	(<0.000)	(<0.000)	(<0.000)	(<0.000)	(<0.000)	(<0.000)
F-stat (first stage)	109	511.7	355.6	149.8	71.86	52.05
Stock Yogo test	106.6	87.96	85.73	85.87	73.96	72.45
Observations	12,793	12,793	12,793	12,793	12,793	12,793

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Notes: The dependent variable is tax morale on a ten-scale. Instruments used are religious fractionalization (country-level) and religious identity salience (individual level). The provided test statistics correspond to the null hypotheses of lack of correlation/relevance for Rank LM statistic; joint instrument exogeneity for J statistic; and exogeneity of country trust for endogeneity test statistic. Stock-Yogo weak ID test critical values: 10% maximal IV size 19.93, 15% maximal IV size 11.59, 20% maximal IV size 8.75, 25% maximal IV size 7.25.
Source: Data from EVS (2011), own calculations.

As in the OLS analysis, I create sub-samples to analyze them in the IV framework (see Table 5.6). All coefficients are relatively stable and range from 0.6 to 1.0. Only when restricting the sample to new EU countries, the coefficient for social capital decreases to 0.3 and is significant only at the 5%-level. Similarly when restricting the individuals to those with the same confession as the majority religion in column 4 of Table 5.6, the coefficient for social capital becomes small and insignificant.

Table 5.6: IV analysis for tax morale by group

VARIABLES	(1) All EU	(2) New EU	(3) Old EU	(4) Majority religion	(5) Minority religion
Trust institution	0.569***	0.308**	1.015***	0.125	0.802***
	(0.106)	(0.151)	(0.179)	(0.136)	(0.160)
Free-riding	-0.482***	-0.493***	-0.486***	-0.568***	-0.432***
	(0.0240)	(0.0351)	(0.0315)	(0.0295)	(0.0360)
Risk-averse	0.157***	-0.105	0.235***	0.348***	0.0299
	(0.0477)	(0.0769)	(0.0646)	(0.0639)	(0.0708)
Constant	5.513***	7.165***	3.998***	7.702***	4.136***
	(0.460)	(0.713)	(0.715)	(0.599)	(0.681)
Instrument tests					
Rank LM stat	142.3	41.54	73.04	76.65	68.93
	(<0.000)	(<0.000)	(<0.000)	(<0.000)	(<0.000)
J stat	4.868	40.34	3.711	24.36	3.088
	0.0274	(<0.000)	0.0541	(<0.000)	0.0789
Endogeneity test	27.84	2.38	41.24	0.02	30.12
	(<0.0001)	(0.12)	(<0.0001)	(0.8997)	(<0.0001)
F-stat (first stage)	52.05	17.04	33.30	27.36	29.26
Stock Yogo test	72.45	21.16	37.01	38.26	35.14
Observations	12,793	2,706	10,087	6,442	6,351

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Notes: The dependent variable is tax morale on a 10-scale. All models are adjusted for age and sex, education, marital status, socio-economic status, and employment status as well as country dummies. Instruments used are religious fractionalization (country-level) and religious identity salience (individual level). The provided test statistics correspond to the null hypotheses of lack of correlation/relevance for Rank LM statistic; joint instrument exogeneity for J statistic; and exogeneity of country trust for endogeneity test statistic. Stock-Yogo (2005) weak ID test critical values: 10% maximal IV size 19.93, 15% maximal IV size 11.59, 20% maximal IV size 8.75, 25% maximal IV size 7.25.
Source: Data from EVS (2011), own calculations.

The reason for this is that the new EU members and majority religion individuals who may not have chosen consciously their religion but may have been born into their confession. Therefore, it is likely that neither secularization nor religiosity has an impact on social capital and as a result, the endogeneity test in columns (2) and (4) of Table 5.6 cannot be rejected. The inability to reject exogeneity points to the inappropriateness of instrumenting for social capital for these groups.

Also, by looking at the J-statistics of joint exogeneity of the instruments with the error term for new EU and majority religion groups (col. 2 and 4 of Table 5.6, respectively), the hypothesis can be rejected at the 1%-level (Sargan, 1958; Hansen, 1982). Both instrument tests therefore imply the unsuitability of instrumenting for trust in institution with religious fractionalization and religiousness in both groups.

5.5.3 Instrument validity

Underidentification and rank condition

In order to fulfill the relevance condition, the excluded instruments must be tested for correlation with the endogeneous regressors. The Kleibergen-Paap LM statistic of underidentification rejects the hypothesis of lack of correlation (Kleibergen and Paap, 2006). Hence, the equation is identified and consistent estimates can be produced (Murray, 2006).

Overidentifying restrictions

The rank condition requires sufficiently high correlation between instruments and the endogenous variable to unique coefficient parameters. In large samples, one needs higher correlation between instruments and endogenous variables than the minimal level required by the rank condition to identify the equation. To avoid instruments that satisfy the rank condition but are not sufficiently correlated with the endogenous regressor for the large-sample approximations, I assess the adequacy of instruments with a test of overidentifying restrictions (Murray, 2006).

When testing the hypothesis that all instruments are uncorrelated with the error term, the Hansen J-statistic cannot be rejected at the 1% significance level (Sargan, 1958; Hansen, 1982). Only exceptions are columns 2 and 4 of Table 5.6 covering only new EU members and majority religion individuals respectively. As for the main specification of Table 5.5, the J-statistic reveals enough correlation between the instruments and endogenous variables while the excluded instruments are uncorrelated with the error term. This indicates suitability of the chosen instruments of religious fractionalization and religious identity salience.

Weak instruments

As a rule of thumb to detect weak instruments, one can rely on the F-statistic of the first stage regression, which raises concern if it is lower than ten (Staiger and Stock, 1997). In all specifications this concern is ruled out. Nevertheless, this rule may lead to different inferences for different estimators and may also lead to rejection of weak instruments in the presence of large samples. To account for this problem, I rely on the weak instruments test suggested by Stock and Yogo (2005). The Stock Yogo test statistic is based on the F-statistic form of the Cragg-Donald (1993) statistic. The null hypothesis tests whether the instruments suffer from a specified bias resulting from weak instruments. I focus on the measure of maximal size of the bias that is based on the performance of the Wald test for the endogenous regressor. With weak instruments the Wald test rejects too often. The true rejection rate RT under the null reads

$$R_T = \Pr_{\beta_0}\left[W^{IV} > \chi^2_{n;\alpha} / n \right] \tag{5.7}$$

with $\chi^2_{n;\alpha}$ as the α-level critical value of the chi-squared distribution with *n* degrees of freedom. The size-based weak instrumnent set, ω_{size}, consists of instrumental variables leading to a size of at least $r > \alpha$,

$$\omega_{size} = \left\{ Z : R^{\max} \geq r \right\}. \tag{5.8}$$

If the true rejection rate would be 5%, one has to set a higher rejection rate *r* that can be considered acceptable as worst-case limiting rejection rate (10%, 20%, etc.). The presence of weak instruments leads to a rejection rate of *r* when the true rejection rate is 5% (Stock and Yogo, 2005). Instead of the Cragg-Donald F statistic, I report the Wald F statistic based on the Kleibergen-Paap rk statistic because I take into account the presence of heteroscedasticity. The underlying Kleibergen-Paap rk Wald F statistic of 72.45 (cp. column 6 of Table 5.5) with the critical values by Stock and Yogo (2005) confirms (in the case of one endogenous regressor and two excluded instruments) that weak identification by the chosen instruments is not a problem.

Endogeneity

Another question arising when applying an instrumental variables approach is whether the included endogenous regressor can be appropriately treated as exogenous. This is fundamental for the justification of the IV approach, as otherwise OLS would yield more consistent estimates (Cameron and Trivedi, 2009, pp. 98-102). To test the hypothesis that the endogenous variable of institutional trust is exogenous, I rely on the Durbin-Watson-Hausman test (Nakamura and Nakamura, 1985). In the main specifications of Table 5.5 and columns 1, 3, and 5 of Table 5.6, exogeneity of institutional trust is rejected.

5.5.4 Robustness

The findings are also robust to the choice of outcome variable when interchanging the tax morale variable with abuse of government claims. As expected, the sign of the effect of social capital on attitudes towards abusing the social security system is negative and significant in almost all country sets (cp. Table 5.7). However, for three of the five country sets, the overidentifying restriction test suggests that the instruments are possibly correlated with the error term. Thus, with the instruments (religious fractionalization and religious identity salience), the effect of social capital on social security abuse may not be consistently estimated.

Since, there could also be another set of variables that possibly could serve as instruments, I substitute religious fractionalization with population density on the country-level, which I merge from the World Bank database. Also, following the literature on religion and delinquent behavior, I moreover use as robustness checks, instead of religious identity salience, church attendance to measure religiosity in the form of a "behavioral adherence" to a religious group's normative expectations (Hirschi and Stark, 1969; Burkett and White, 1974; Jensen and Erickson, 1979; Tittle 1980; Grasmick et al., 1991). The related question asks on a 4-scale for

Spend[ing] time with people at your church, mosque or synagogue.

Table 5.7: Robustness check - IV analysis for unjustified claiming of government benefits

VARIABLES	(1) All EU	(2) New EU	(3) Old EU	(4) Majority religion	(5) Minority religion
Trust institution	-0.493***	-0.247**	-0.672***	0.0558	-0.605***
	(0.0959)	(0.121)	(0.151)	(0.113)	(0.140)
Free-riding	0.297***	0.269***	0.343***	0.391***	0.255***
	(0.0213)	(0.0261)	(0.0266)	(0.0247)	(0.0312)
Risk-averse	-0.127***	-0.0806	-0.165***	-0.235***	-0.0552
	(0.0423)	(0.0601)	(0.0540)	(0.0535)	(0.0622)
Constant	5.720***	3.091***	6.496***	3.143***	6.606***
	(0.419)	(0.577)	(0.609)	(0.502)	(0.601)
Instrument tests					
Rank LM stat	137.2	41.12	69.53	77.11	65.91
	(<0.000)	(<0.000)	(<0.000)	(<0.000)	(<0.000)
J stat	3.978	12.82	15.06	15.44	18.01
	0.0461	(<0.000)	(<0.000)	0.445	(<0.000)
Endogeneity test	39.76	3.818	29.13	0.584	30.83
	(<0.000)	0.0507	(<0.000)	(<0.000)	(<0.000)
F-stat (first stage)	40.81	8.952	31.95	20.35	24.04
Stock Yogo test	69.72	20.94	35.19	38.51	33.57
Observations	12,752	2,712	10,040	6,424	6,328

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Notes: Instruments used are religious fractionalization (country-level) and religious identity salience (individual level). The provided test statistics correspond to the null hypotheses of lack of correlation/relevance for Rank LM statistic; joint instrument exogeneity for J statistic; and exogeneity of country trust for endogeneity test statistic. Stock-Yogo weak ID test critical values: 10% maximal IV size 19.93, 15% maximal IV size 11.59, 20% maximal IV size 8.75, 25% maximal IV size 7.25.
Source: Data from EVS (2011), own calculations.

Both variables theoretically link to social capital and through this channel to tax morale. As displayed Table 5.8, the results indicate a positive parameter estimates. Nevertheless, the IV test statistics reveal potential correlation of the instruments with the error term (overidentifying restrictions test) and weak instruments (Stock Yogo test). Hence, the results imply that religious fractionalization and religious identity salience serve as better instruments than the previously tested.

Table 5.8: Robustness check - IV analysis for tax morale

VARIABLES	(1) All EU	(2) New EU	(3) Old EU	(4) Majority religion	(5) Minority religion
Trust institution	1.129***	2.121***	0.394***	3.855	0.757***
	(0.292)	(0.778)	(0.103)	(4.279)	(0.247)
Free-riding	-0.428***	-0.245**	-0.600***	-0.231	-0.454***
	(0.0510)	(0.118)	(0.0322)	(0.462)	(0.0469)
Risk-averse	-0.129	-0.106	0.0667	0.181	-0.162*
	(0.0854)	(0.186)	(0.0714)	(0.285)	(0.0939)
Constant	3.361***	0.628	6.278***	-6.531	4.571***
	(1.158)	(3.097)	(0.446)	(16.18)	(0.975)
Instrument tests					
Rank LM stat	24.42	8.742	124.7	0.806	20.90
	(<0.000)	0.0126	(<0.000)	0.00194	(<0.000)
J stat	0.130	4.002	31.89	0.0182	15.07
	0.718	(<0.000)	(<0.000)	0.893	(<0.000)
Endogeneity test	29.07	23.43	12.37	9.606	23.47
	(<0.000)	0.0455	(<0.000)	0.668	(<0.000)
F-stat (first stage)	21.69	3.490	28.62	1.690	17.34
Stock Yogo test	12.17	4.366	66.54	0.399	10.59
Observations	6,855	2,038	4,817	3,063	3,792

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Notes: All models control for age and sex, education, marital status, socio-economic status and employment status as well as country dummies. Instruments used are population density (country-level) and religious behavior adherence (individual level). The provided test statistics correspond to the null hypotheses of lack of correlation/relevance for Rank LM statistic; joint instrument exogeneity for J statistic; and exogeneity of country trust for endogeneity test statistic. Stock-Yogo (2005) weak ID test critical values: 10% maximal IV size 19.93, 15% maximal IV size 11.59, 20% maximal IV size 8.75, 25% maximal IV size 7.25.
Source: Data from EVS (2011), own calculations.

5.5.5 Study limitations

This study has several limitations. First, since social capital can be captured on many levels and it can be pivotal through different channels, no uniform way of measurement is possible but rather different measures pick up different dimensions of social capital (Paxton, 1999). One drawback is hence the focus on social capital as trust in the fulfillment of the transactional exchange between taxpayer and the authority. Nevertheless, Cheung and Chan (2010) argue that focusing on measures based on exchange captures the instrumental nature of social capital for morale. Second, due to missings in responses to some questions crucial to this study, the study cannot account for all countries in Europe across all survey waves. Hence, potential bias in the measurement of the true effect of social capital on tax morale might be a problem. Moreover, non-response bias might be an issue with the data employed. As response rates are not reported, sensitivity analyses regarding this issue cannot be performed (Inglehart et al., 2000). Nontheless, since the main results are robust across different sets of countries, I suspect that neither country-non-participation nor survey non-response affect the observed effect. Further, if there was a direct effect of religion on tax morale, applying an IV approach would lead to bias (Angrist and Krueger, 2001). While Torgler (2006) and others have shown an association of religion to tax morale, I argue, in the vein of Putnam and Campbell (2012), that in between religion and morale, it is social capital that accounts for the effect. Since the findings are robust across multiple combinations of chosen instruments, a direct effect of religion of tax morale can potentially be ruled out. Also, the larger association by applying IV methods indicates that measurement error in individual level social capital can be limited (Angirst and Krueger, 2001).

5.6 Concluding remarks

With the shift of religious affiliation to secularism, people are thought to be less charitable in giving whether to the church or any other societal institutions. Despite the increase in the number of religiously unaffiliated people, this has found to be the supposedly misleading relation between morale in giving and religiousness (Putnam and Campbell, 2012). Instead the missing link between giving and believing is social capital provided by religious affiliation. This in turn fosters the achievement of better usage of social resources and thereby facilitating exchanges between entities and hence, fostering morale. With this in mind and acknowledging the ongoing secularization process, public policy might enhance tax morale to reduce fraudulent behavior by applying this insight. Exemplary attempts to apply this insight have been implemented in the United Kingdom and the Netherlands (Cabinet Office, 2012; OECD, 2013).

The results of this paper are consistent with the hypothesis that social capital in the form of trust in governmental institutions lead to improved individual-level tax morale. The results of the IV analysis permit the reduction of the endogeneity bias and yield qualitatively the same results using OLS. Post-rationalization of tax morale leads to a simultaneity bias between tax morale and social capital and implies an underestimation of the effect in the presence of an omitted factor that is directly related to social capital but not to tax morale. With a large economic magnitude of the causal effect of social capital on tax morale, these findings suggest that so far evidence has largely underestimated the relationship of social capital and tax morale.

The findings of this study highlight the importance of institutional trust and agree with prior studies focusing on the relationship between tax morale and social capital (Scholz and Lubell, 1998; Feld and Frey, 2002; Torgler, 2003; Alm and Gomez, 2008; Hammar, Jagers, and Nordblom, 2009; Russo, 2013).

This cross-national study provides evidence on the benefitting effects of individual level social capital for tax morale and thus for tax compliance. When using an instrumental variable approach, I am able to reduce endogeneity bias. In line with the scarce literature on social capital and tax morale, I find that the aforementioned effect is positive and stronger than previously determined. The findings on the effect of social capital on tax morale provide insights by explaining the residual of the tax compliance puzzle. Finally, the results underpin the relevance of social incentives for economic outcomes, in this case tax compliance and hence tax revenue.

6 Outlook

The role of government policies in supporting long-term growth puts forward the importance of taxation for firms and individuals alike who bear the burden of taxes. While the question of *why* public policy affects taxpayers is obvious and intuitive, the more important question to be answered is *how* public policy affects the behavior firms and individuals. The answer to this question is ambiguous and less intuitive. Hence, the objective of this study is to investigate how government policy shapes firm behavior and attitudes towards taxes of private entities. In three empirical analyses, I gained deeper insights into the impact of policy instruments on economic activity and the formation of the relationship between the government and its taxpayers.

6.1 Implications for policy

The results of this dissertation have relevant implications for public policy. First, the new market in Eastern Germany opened the gateway to opportunities of growth in a highly uncertain environment. Public policy in the form of tax incentives in an environment with information asymmetries and undeveloped infrastructure, however, can lead to unproductive investments. This holds in particular for short-lived capital goods, e.g. equipment investments. The results imply that the broad range of subsidies and tax incentives in the light of German Reunification did not necessarily foster sustainable growth in Eastern Germany. Potential adverse selection of unproductive overinvestments led to inefficiencies of subsidized investments. Under those circumstances, public policy should take into account the risky environment when designing measures to sustain economic growth and to prevent setting false incentives.

Second, economic fluctuations have a strong influence on firm behavior and hence on the effectiveness of subsidies. The financial crisis of 2008 reduces the effectiveness of R&D subsidies, which lead to a crowding out of private R&D by public funds. In the presence of a large recession, this has important implications for public policy: firms' persistent investment behavior despite of the crisis might support the effectiveness of public subsidies. If firm investment behavior is affected by the riskiness of the environment, public policy should account for these.

Third, social capital positively affects tax morale at the individual level. This implies that social-based factors may be able to explain parts of the tax compliance puzzle. Instead of focusing on enforcement-based policy such as penalties or audits, tax authorities may enhance cooperative tax behavior by putting emphasis on strengthening taxpayers' attitudes towards taxes as an approach to reducing fraudulent tax behavior.

6.2 Implications for future research

I am confident that my contribution to a deeper understanding of the role of public policy for firm behavior and individual attitudes can offer a gateway for future research. All three studies are based on data on the micro-level, i.e. firm, plant or individual level, which allow the use of microeconometric approaches. With the availability of micro-level data and more sophisticated research designs, empirical economics experienced a "credibility revolution" during the last 25 years (Angrist and Pischke, 2010).

Given the complexity of markets and tax systems as well as the irrationality of individual behavior, the field of behavioral economics emphasizes the need to account for the context in which individuals are framed and the need for recognition of underlying cognitive processes in individual decision-making (Alm, 2010). In this vein, Slemrod and Weber (2012) point out that counterfactual analyses in social sciences are subject to measurement errors as they underlie individual behavioral choices. Hence, they encourage randomized field experiments in behavioral public economics. This leaves space for future tax research to inform public policy.

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