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Essays on Economic Incentives

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Introduction

It is an economic commonplace that at least rational individuals react to incentives. Thus, most economists agree with Gregory Mankiw's fourth of his ten economic principles:

"People respond to incentives"

Mankiw (2014, p. 7).

Edward Glaeser goes one step further by stating:

"The heart of economics is the principle that people respond to incentives"

Glaeser (2004, p. 3).

Economically rational behaving people make their decisions based on evaluations of the costs and benefits that are accompanied by their decisions. These people reevaluate their decisions whenever something changes the corresponding cost and benefit relationships. The cost benefit analysis can contain pecuniary as well as non-pecuniary factors. Take the job choice as an example: a person that has to decide whether to change the job or not has to include the difference in salary as a pecuniary factor as well as the non-pecuniary factor of not being able to work together with favorite colleagues any more into the corresponding cost benefit analysis.

This dissertation investigates the relationship between economic incentives and individual behavior in three different ways. The first and the second chapter empirically analyze the reaction of fuel thieves to economic incentives. While the first chapter focuses on the reaction of fuel theft to different fuel price levels based on county-level aggregated data, the second chapter uses a new identification strategy to investigate rational behavior of fuel thieves on individual gas station level. Using a field experiment, the third chapter examines whether teaching academics at Ulm University participate more frequently in didactic training when they get a small additional information about the outside costs of

the subsidized in-house didactic training courses. The fourth chapter theoretically derives that harsher leverage ratio requirements decrease a profit maximizing bank's incentives to make use of accounting leeway or even to manipulate the financial statement.

Both, the first and the second chapter, in a broader sense, deal with the question whether criminals react to economic incentives. Thus, the empirical studies presented in chapter I and chapter II contribute to the field of the economics of crime. From a researcher's perspective this field is very interesting since it shows that a thoughtful economic model like the one presented in Becker (1968) can change the scientific point of view. The former view of social scientists characterized criminals as an irrational and perverse group of society with deviant behavior. By applying an economic approach, the seminal work of Becker (1968) brought rational decision making into play. These statements are backed up by the Royal Swedish Academy of Sciences as the press release on the award of Gary Becker with the "Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1992" contained the following sentence:

"Instead of regarding criminal activity as irrational behavior associated with the specific psychological and social status of an offender, criminality is analyzed as rational behavior under uncertainty."

Royal Swedish Academy of Sciences (1992).

In the meantime, a vast amount of theoretical and empirical studies have been carried out concerning the economics of crime (see e.g. Eide, Rubin and Shepherd (2006) for an overview). Those studies explain criminal behavior by determinants like police presence, severity of penalties, legal income opportunities, income inequality or neighborhood effects. While many determinants of criminal activities refer to the cost side, only few studies take gains from crime into account. Those studies mainly deal with legal income opportunities. This approach has the major shortcoming of reverse causality as Eide, Rubin and Shepherd (2006, p. 229) pointed out.

Therefore, recent studies use the more suitable price system as a measure for gains from illegal activities. The principle idea is straightforward: empiricists estimate a relationship between prices and recorded cases of the corresponding criminal activity. It is plausible that theft is a suitable candidate for such studies since sometimes price data on the stolen goods is available. Chapter I, which is a joint work with my wife Kathrin Dengler-Roscher and equal to Dengler-Roscher and Roscher (2015), contributes to this field by investigating whether fuel theft reacts to changes in the fuel price level. Thereby, we collaborated with the State Office of Criminal Investigation Baden-Wuerttemberg and

collected a unique data set on fuel theft cases at county-level that were registered between the first quarter 2009 and the third quarter 2014 in the 44 counties in the German federal state Baden-Wuerttemberg. We find empirical evidence that fuel theft reacts to different fuel price levels which are proxies for the gains from fuel theft. Therefore, in our sample fuel thieves behave as predicted by rational choice theory.

The second chapter, which is identical to Dengler-Roscher and Roscher (2016), contributes to the reaction of fuel thieves to economic incentives, too. In comparison to chapter I, chapter II uses a new identification strategy to test whether criminals behave rationally. Furthermore, the unique data set of the study presented in chapter II contains monthly data on fuel theft that were registered at 232 individual gas stations that are located in the Franco-German border area. Thus, in comparison to chapter I in which our estimates are based on aggregated county-level data, the analysis in chapter II is based on micro-level data. In a first step, we find that fuel theft at individual gas stations increases when the fuel price index is at a high level and that gas stations suffer less from fuel theft when the fuel price index implies cheaper prices for fuel. Thus, the positive reaction of fuel theft to different fuel price changes that we found based on aggregated data in chapter I is empirically confirmed at individual gas station level in chapter II. In a second step, we use a special feature of the Franco-German border region to identify rational behavior of fuel thieves in this area. Thereby, we use the circumstance that potential French fuel thieves have limited opportunities to commit fuel theft in their home country due to prepaid systems and exit barriers at gas stations. We find that gas stations that are located close to the Franco-German border suffer more frequently from fuel theft than gas stations that are located in the inner country when the French fuel price index is at a high level. This result gives empirical support to our hypothesis that rational potential fuel thieves take means of escape into account and therefore behave rationally.

The third chapter, which is identical to Dengler-Roscher, Estner and Roscher (2016), uses a different approach to investigate whether individuals react to incentives. We carried out a field experiment at Ulm University and used a nudge to try to increase participation in didactic training. Thereby, the experimental group received an internal mail with one additional sentence in the cover letter's text while the control group received all the same but this additional sentence. This sentence informed the receiver about the average costs per workshop day one would have to pay when demanding comparable private sector training courses. We assumed that Ulm University's didactic training program was under-utilized since academics were not well informed about its market value. This is due to the fact that the course program is subsidized and therefore nearly costless for

the participants. Thus, by revealing a market value of the courses we wanted to provide a conservative course value to the receivers of the course program. Based on nonparametric tests we cannot state that our nudge had an effect. Logistic regressions lead to statistically inconclusive results since we had too few participants during the investigation period. Nevertheless, to the best of my knowledge, by extensively researching market values our study provides at least a new approach to the vast body of literature on nudges.

While chapter I and chapter II use empirical analysis and chapter III uses a field experiment, chapter IV uses a theoretical model to investigate the reaction of economic agents to economic incentives. More precisely, a profit maximizing representative bank that can make use of accounting tricks or even manipulate its financial statement faces a leverage ratio restriction imposed by banking supervision. Based on the model presented in chapter IV, banking supervision can decrease the incentives of a bank to manipulate its balance sheet by imposing harsher leverage ratio requirements. Chapter IV is equal to Roscher (2016).

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Chapter I

Do Thieves React to Prices? - Evidence from Gas Stations

I.1 Introduction

Since Fleishers (1963) empirical investigation on juvenile delinquency and unemployment rates in the U.S., more than half a century of empirical research on the economics of crime has passed. During this time many researchers used the seminal theoretical works of Becker (1968) and Ehrlich (1973) on the economics of crime to test their hypotheses. In Beckers (1968) model an individual commits a crime if the utility he gains from the illegal activity exceeds the disutility from punishment multiplied with the probability of being caught. In short: a criminal commits a crime if it pays off. In this sense, rational criminals weigh costs and benefits of a specific criminal activity and make their decisions based on this analysis.

Up to now, the economics of crime literature mainly has focused on the cost side of criminal activities. Thereby, a huge part of the literature deals with the severity and probability of punishment (see section 2.5.1 and section 2.5.2 in Eide, Rubin and Shepherd (2006) for a broad overview of this studies). More recent studies that have not been mentioned by Eide, Rubin and Shepherd (2006) are, e.g. the experimental study concerning the deterrence hypothesis by Schildberg-Hörisch and Strassmair (2012) or the natural experiment concerning arrest probability by Draca, Machin and Witt (2011). Another part of the economics of crime literature focuses on socioeconomic circumstances to explain crime. Thereby, determinants of crime like education (e.g. Deming 2011; Lochner and Moretti 2004; Machin, Marie and Vujic 2011) or unemployment (e.g. Edmark 2005;

Öster and Agell 2007) have been investigated, while other studies focused on neighborhood effects (e.g. Damm and Dustmann 2014; Kling, Ludwig and Katz 2005) or the influence of social environment (Bayer, Hjalmarsson and Pozen 2009; Glaeser, Sacerdote and Scheinkman 1996; Mears, Ploeger and Warr 1998; Van der Weele 2012). Further fields of interest are factors that affect youth criminality (e.g. Carrell and Hoekstra 2010, Fleisher 1963, Fougère, Kramarz and Pouget 2009; Jacob and Lefgren 2003; Levitt 1998, Ludwig, Duncan and Hirschfield 2001) or the measurement of social costs of crime (e.g. Donohue and Siegelman 1998; Grogger 1995).

However, one key economic aspect of crime is the benefit a criminal can gain from his illegal activity. In most cases this benefit is difficult to measure. What is the utility of, let's say, murder or assault in terms of money? Maybe this is one reason why most of the former studies dealt with the costs rather than the benefits of criminal activities. In our study, we focus on the benefit side of a criminal activity, namely the price of a stolen good. Specifically, we examine whether fuel theft reacts to different fuel price levels.

An ideal setup to investigate the reaction of criminals to price changes of the desired good requires two characteristics: first, observable price changes of a desired good; second, observable crime rates. In this paper, we exploit such an ideal setting to investigate the reaction of crime to changes of gains from crime. We cooperated with the State Office of Criminal Investigation Baden-Wuerttemberg (Landeskriminalamt Baden-Wuerttemberg, henceforth LKA) and collected a unique data set on fuel theft on county-level with which we can investigate whether and to what extent fuel theft reacts to different fuel price levels. Fuel prices are officially registered by the General German Automobile Association (Allgemeiner Deutscher Automobil-Club, henceforth ADAC) and publicly available. We find that fuel price has indeed a significant positive effect on fuel theft.

A number of recent studies focus on the reaction of theft to price changes of certain goods. Following Sidebottom, Ashby and Johnson (2014, p. 684) we call this approach "price-theft hypothesis". These studies link price changes of a certain good to the amount of theft offenses of this good.

We think it is useful to distinguish between heterogenous goods and homogenous goods that are stolen. Heterogenous goods are goods that are significantly different from each other and may vary over time in their character or texture. Thus, it is difficult to substitute a specific good for another. For example audio-visible goods like TVs underlie frequent changes in features over time. In addition, preferences of people also differ. Studies that consider the theft of heterogenous goods are provided by Carcach (2010), Reilly and Witt (2008) and Wellsmith and Burrell (2005). Carcach's (2010) estimates

for the Australian federal state Queensland between 1974 and 1997 suggest a positive relationship between his real car price measure and car thefts. Reilly and Witt (2008) find that the falling real price of audio-visual goods between 1975 and 2005 has contributed to a reduction in the volume of domestic burglary activity in England and Wales. They measure relative prices of audio-visual goods as the ratio of the audio-visual equipment retail price index to the all items retail price index. Wellsmith and Burrell (2005) find in a solely descriptive setting that with falling prices of audio-visual equipment the percentage of burglaries with loss of audio-visual equipment decreases.

Homogenous goods constitute a better setting because their features and attributes are the same and they are perfect substitutes. The personal consumption utility for the criminal is constant because quality of the underlying good is fixed and prices are exogenous. Several studies investigate the price-theft hypothesis with homogenous goods. Yurtseven (2015) tries to explain the share of illegal electricity consumption on total electricity consumption in all 81 provinces of Turkey between 2002 and 2010. He finds a positive relationship between the national wide electricity price and electricity theft. Following these results an \$1 increase in kWh price leads to an increase in electricity theft ratio of 20%. Sidebottom, Ashby and Johnson (2014) examine the effects of changes in copper prices on copper cable theft of the British Railway. They use an autoregressive model with unemployment rates and total crime against British Railway as further explanatory variables. Sidebottom, Ashby and Johnson (2014) find a positive correlation between price of copper and copper cable theft. Brabenec and Montag (2014) analyse the influence of changes in metal price on metal theft in the Czech Republic between 2003 and 2012. Compared with Sidebottom, Ashby and Johnson (2014) Brabenec and Montag (2014) use a far more extensive empirical model. They find a reaction of metal theft on metal price changes and therefore support the price-theft hypothesis. In our opinion, investigating metal theft to test the price-theft hypothesis has limitations. Metal in a big scale cannot be stolen by a single person but rather by a group of criminals. Furthermore, metal thieves need to have access to black markets or be involved in a system of fences. Since metal thieves generally have a high criminal potential and are likely to work in teams, results from studies dealing with metal theft cannot simply be transferred to a broad population. In contrast, fuel theft can also be committed by individual people and by first offenders or charge offenders. Therefore, we think fuel theft is a suitable crime to investigate the price-theft hypothesis due to low barriers of entry.

The recent contribution of Draca, Koutmeridis and Machin (2015) is, to the best of our knowledge, the most extensive empirical work on the relationship between crime and prices. Draca, Koutmeridis and Machin (2015) analyze both, theft of heterogenous goods

as well as theft of homogeneous goods in greater London between 2002 and 2012. In case of heterogeneous goods Draca, Koutmeridis and Machin (2015) estimate crime price elasticities in a 44-good panel and find a significant positive relationship between prices and crime. Draca, Koutmeridis and Machin (2015) also see possible difficulties with heterogeneous goods (like technical progress) to identify a causal connection. Therefore, they also investigated crime price elasticities for metals, fuel and jewellery. Draca, Koutmeridis and Machin (2015) found a strong effect of fuel price on fuel theft. In their model, they have no other explanatory variables but use goods fixed-effects, month fixed-effects and year fixed-effects to account for time effects and to condition out good-specific seasonality.

We contribute to the price-theft literature by examining fuel theft in a broader framework than Draca, Koutmeridis and Machin (2015). In our fixed-effects model, we additionally consider further time variant explanatory variables like lagged detection rates and unemployment rates whereas Draca, Koutmeridis and Machin (2015) just use fixed-effects. We think that these time variant variables are important and should influence criminal behavior significantly as we show theoretically. The detection rate accounts for the possibility of being caught by the police. This allows us to simultaneously investigate the deterrence hypothesis. Unemployment rates account for the income opportunities on the legal job market. Furthermore, we look at the total number of fuel theft cases per 100,000 inhabitants per county, since we have population data on county-level.

This paper is structured as follows: Chapter I.2 presents the motivational background of our study and the data we collected from the LKA. In chapter I.3 we derive hypotheses from the theoretical framework of Becker (1968) regarding the price reaction of fuel theft and other variables that could explain fuel theft. Chapter I.4 starts with an explanation of the empirical model we used to estimate the price reaction of fuel theft and closes with the results of our estimations. In chapter I.5 we provide statistical tests and robustness checks to counter two main objections concerning our data and estimation method. Chapter I.6 concludes with a brief summary.

I.2 Background and Data

In Germany it is quite easy to steal fuel. Unlike in many other countries, German fuel stations normally have no prepaid systems or exit barriers that can prevent thieves from escaping. Additionally, moral costs of stealing fuel are presumably lower than those of stealing any other good. Since a gas station is a victim for which most people do not feel sorry because it is either a large petroleum company or an anonymous petrol station leaseholder. Victims of other kinds of theft suffer from the loss of the stolen good which has in many cases more than monetary worth to them.

Furthermore, there are cases where people forget to pay their fuel and just drive away from the fuel station without paying. Thus, some fuel thieves might try to copy such a case and get away with their theft by claiming that they forgot to pay if they get caught. In this case, they typically just have to pay the bill. There are not many other goods that thieves can try to steal and row back if they fail.

Since 2009, fuel theft is reported individually in German federal crime statistics. This might be due to a rise in fuel theft in the past years. Table I.1 displays yearly amounts of fuel theft and overall crime in Germany between 2009 and 2014 as well as corresponding yearly growth rates. Data stems from the Federal Criminal Police Office (Bundeskriminalamt, henceforth BKA).

Table I.1: **Fuel theft and crime in Germany 2009 - 2014**

year	number of cases of fuel theft	percentage change to prior year	total crime	percentage change to prior year
2014	86,358	-5.7	6,082,064	2.0
2013	91,578	2.0	5,961,662	-0.6
2012	89,769	5.5	5,997,040	0.1
2011	85,065	9.0	5,990,679	1.0
2010	78,070	-2.2	5,933,278	-2.0
2009	79,830	-	6,054,330	-

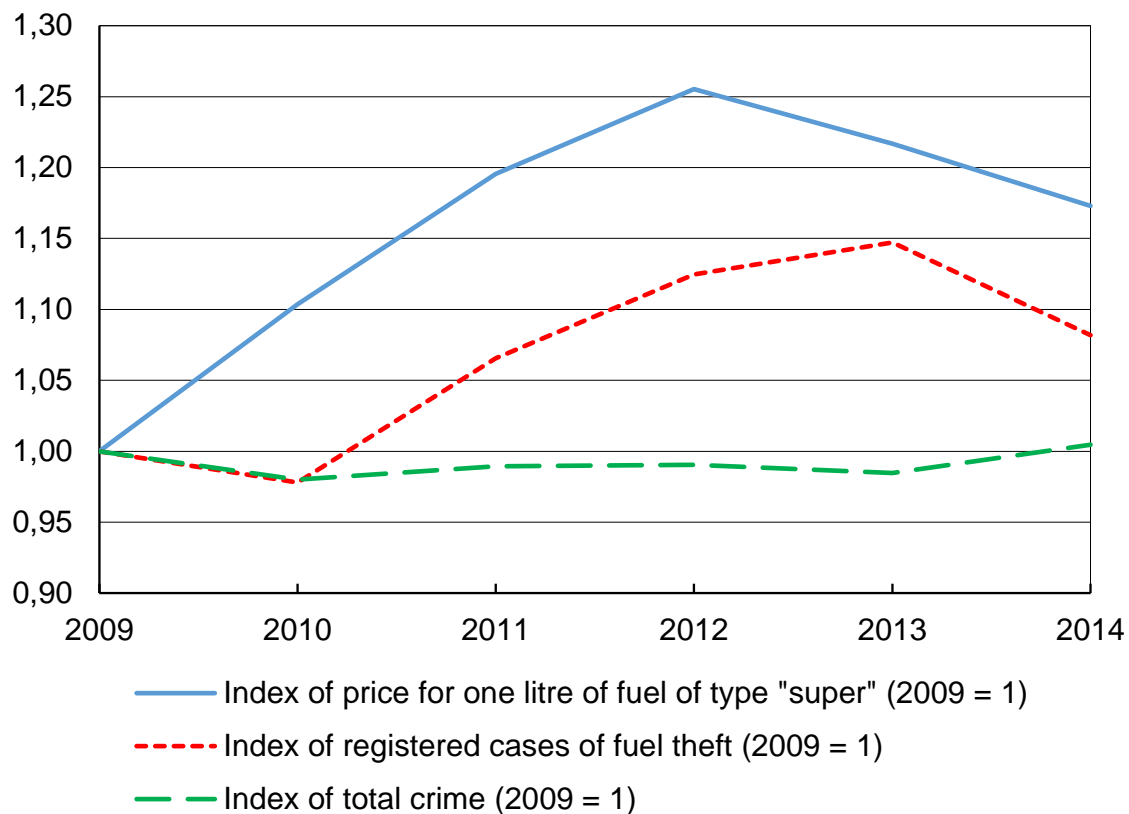
source: BKA (2010-2015) and own calculations.

Between 2009 and 2013, fuel theft in Germany rose from 79,830 cases in 2009 to 91,578 cases in 2013. This implies a growth of about 15 percent during a period of five years, while simultaneously total crime remained relatively stable. In 2014, fuel theft decreased by around 6 percent compared to the previous year. At the same time, total crime

increased by 2 percent. Thus, fuel theft and total crime seem to follow opposite trends - at least during the last few years.

Figure I.1 shows the development of fuel price, fuel theft and total crime in Germany between 2009 and 2014. In addition to the above mentioned opposite trend of fuel theft and total crime, the fuel price development is displayed. Possibly, the development of fuel theft is related to fuel price changes. In 2009, the average price per one liter of type "super" was 1.27 Euro and for one liter of type "diesel" 1.08 Euro (ADAC 2015). Until 2012, fuel prices rose and peaked in 2012 with an average amount of 1.60 Euro per liter of type "super" and 1.48 Euro per liter of type "diesel" (ADAC 2015). This implies an average increase of around 26 percent in the price level of "super" and an average increase of 37 percent in the price of "diesel" within three years. Although fuel prices decreased between 2012 and 2013, fuel theft increased further. In 2014, fuel prices as well as fuel theft decreased.

Figure I.1: **Fuel price, fuel theft and total crime**



sources: LKA, BKA and ADAC.

On the basis of fuel price development and fuel theft the question arises, whether fuel theft reacts to changes in fuel prices. To investigate the relationship between fuel prices and fuel theft, we collected data from the LKA on registered cases of fuel theft that

occurred between January 2009 and October 2014 in the German federal state Baden-Wuerttemberg. Throughout the period under review, a total of 49,886 cases of fuel theft have been recorded in Baden-Wuerttemberg. This implies an average of around 8,500 cases of fuel theft per year and corresponds to a share of almost 10 percent of total fuel theft in Germany. Thus, data on fuel theft in Baden-Wuerttemberg serves as a representative sample of fuel theft in whole Germany.

In Germany, each of the total of 16 State Offices of Criminal Investigation records crime statistics by itself. In the case of the LKA, fuel theft like all crimes is recorded on relatively small levels of police units. Every case of fuel theft has a site of crime - namely a specific gas station -, which lies within the responsibility of exactly one specific police unit. Furthermore, the police of Baden-Wuerttemberg is structured in such a way that each crime can exactly be assigned to one of the 44 counties of Baden-Wuerttemberg. This enables us to observe fuel theft on county-level and fortunately, other data that could possibly explain fuel theft like unemployment rates or population are available on county-level, too. Thus, our 44-panels data set has the advantage that it offers deeper insights into the economic determinants of fuel theft than an analysis based on a single time series on federal state level. For the sake of simplicity *data on fuel theft from the State Office of Criminal Investigation Baden-Wuerttemberg* is further shortened to SOCI. An extract from the SOCI is given by Table I.2.

Table I.2: **Extract from LKA data on fuel theft**

Month/year	county	RC	DC	damage in €
May/2012	city county Stuttgart	5	2	250
May/2012	rural county Rastatt	12	8	634
May/2012	city county Ulm	3	3	99
May/2012	rural county Rottweil	1	0	20
June/2012	city county Stuttgart	15	10	812

Abbreviations: RC = registered cases; DC = detected cases

There is one noteworthy feature concerning the SOCI. In some cases, fuel theft could be registered with a certain time lag. A case of fuel theft does not enter the SOCI until the responsible policeman closed the corresponding case record. Usually, a case of fuel theft enters SOCI within a few weeks. However, we cannot rule out the possibility that some cases enter the SOCI later than they actually occur. We aggregated monthly SOCI data to quarterly data to address the time-lag problem. Furthermore, we provide some

robustness checks to ascertain that possible time-lagged recording does not change our main results.

I.3 Theoretical framework

Starting point of our theoretical considerations is Becker's (1968) model of a rational criminal. Roughly, Becker's (1968) model can be summarized as follows: A rational person acts illegally if and only if the expected benefits of her criminal activity exceed expected costs due to fines. Both, benefits and costs are expressed in terms of utility.

For the sake of simplicity, we assume that utility equals monetary values in our model. This implies that we further ignore psychological factors such as an adrenalin rush or a sense of superiority if fuel theft was successful or shame due to negative public exposure if fuel theft failed. Thus, we focus solely on the strictly economic perspective of fuel theft, meaning a monetary point of view.

We define W as the monetary benefit of fuel theft. W consists of the loot itself (gross benefit) minus costs for preparing and carrying out fuel theft. Monetary gross benefit equals the amount of money that otherwise would have been paid to buy the tankful legally. Since the monetary value of a tankful is the product of refilled liters and fuel price, we can rewrite W as a function of fuel price P , i.e. $W(P)$.

Combining all our considerations and model assumptions, a person will commit fuel theft if

$$(1 - \pi)W(P) + \pi(W(P) - F) > 0, \quad (\text{I.1})$$

while π denotes the probability of getting caught and F denotes the fine.

Rewriting equation (I.1) leads to:

$$W(P) > \pi F. \quad (\text{I.2})$$

Thus, the decision-making problem now should be read as follows: Rational fuel thieves steal tankfuls if a tankfuls monetary net value exceeds expected fines in monetary terms. The role of the price is now relatively clear: Higher fuel prices lead to higher monetary values of tankfuls. Consequently, higher fuel prices induce higher gross benefits and also, c.p., higher net benefits from fuel theft.

More formally, we can state:

$$\frac{\partial W(P)}{\partial P} > 0. \quad (\text{I.3})$$

Taking this into account, we derive our **first hypothesis**:

Higher (lower) fuel price levels lead to increasing (decreasing) fuel theft.

Fortunately, our data provides an opportunity to examine the deterrence hypothesis. According to the deterrence hypothesis, a higher probability of getting caught and fined leads to lower incentives to commit crimes. Applying this considerations to fuel theft, it is evident from equation (I.2) that a higher probability of getting caught induces lower incentives to steal tankfuls. We measure the probability of getting caught by the detection rate of the previous quarter. Assuming that a "scene" of fuel thieves gets information about caught and sentenced members, a higher detection rate deters potential first offenders and offenders that have not been caught yet. In addition, higher detection rates simply lead to a higher number of convicted fuel thieves, who might be deterred from stealing tankfuls again. In this sense, we assume that fuel thieves are Bayesian updaters. Thus, our **second hypothesis** could be stated as follows:

A higher (lower) previous detection rate leads to lower (higher) current fuel theft.

In a last step, we expand our model by comparing the utility derived from theft with an alternative income in legal activities. Therefore, we rewrite equation (I.1) as:

$$(1 - \pi)W + \pi(W - F) > (1 - \text{unemp})A, \quad (\text{I.4})$$

while unemp denotes the unemployment rate and A denotes legal income alternatives. The higher the unemployment rate and therefore the probability of a person to get/be unemployed, the lower are legal income possibilities. Consequently, a higher unemployment rate increases the incentives to improve the income situation by illegal activities. These considerations lead to our **third hypothesis**:

A higher (lower) unemployment rate leads to higher (lower) fuel theft.

I.4 Fuel theft reaction to different fuel price levels

In this section we take a closer look at the responsiveness of the quantity of fuel theft cases to different fuel price levels. More precisely, we investigate the total change in the number of fuel theft cases per 100,000 inhabitants per county in response to a one cent change in the fuel price. First, we present the empirical model. Second, we report the descriptives concerning the variables used in our analysis. And third, we present the results of our regressions.

I.4.1 Empirical model

The full model to estimate the effect of fuel price changes on fuel theft can be written as follows:

$$\begin{aligned} \text{fueltheft}_{j,q} = & \alpha_j + \beta_1 \text{price}_q + \beta_2 \text{detection rate}_{j,q-1} + \beta_3 \text{unemp}_{j,q} \\ & + \beta_4 \text{crime index}_t + \text{seas}_2 + \text{seas}_3 + \text{seas}_4 + \epsilon_{j,q} \end{aligned} \quad (\text{I.5})$$

First of all it should be noted that we normalized the endogenous variable, such that $\text{fueltheft}_{j,q}$ reflects registered cases of fuel theft per 100,000 inhabitants in county j at quarter q .

Our main explanatory variables are *price*, *detection rate* and *unemp*. We include quarterly fuel prices to investigate our main question whether fuel theft reacts to different fuel price levels. To control for deterrence, we further integrate previous quarter detection ratios of county j . Unemployment rates serve as a measure of reduced chances to legally earn money to refuel a car.

As one can see in equation (I.5), α_j displays county j 's time invariant (fixed) effect on normalized fuel theft. We use a fixed effect model because many county-specific characteristics do not change over time, but do, under plausible considerations, strongly affect fuel theft per 100,000 inhabitants. Examples are the number of highway or state road kilometers running through a county or whether a county is mostly urban.¹

Furthermore, we include seasonal effects in our model. This is due to the seasonal pattern of traffic volume (as shown in chapter I.4.2) and its plausible causal effect on fuel theft

¹ Other plausible time invariant characteristics affecting fuel theft per 100,000 inhabitants could be for example access to the German-Franco border (see Dengler-Roscher and Roscher 2016) or the share of migrants on total population.

cases. We also include the yearly crime trend. Detailed descriptions of the most important variables of our empirical model and the corresponding data sources are displayed in Table I.3.

Table I.3: **Description and sources of variables**

variable name	description
$\text{fueltheft}_{j,q}$	number of registered cases of fuel theft in county j at quarter q per 100,000 inhabitants
price_q	average price of one liter fuel (type super e10) at quarter q
$\text{detection rate}_{j,q-1}$	detection rate (percent) of fuel theft in county j at quarter q-1
$\text{unemp}_{j,q}$	unemployment rate (percent) in county j at quarter q
crime index_t	index of all crimes in the state of Baden-Wuerttemberg at year t
source	
$\text{fueltheft}_{j,q}$	data on fuel theft: SOCI (see chapter I.2) data on inhabitants: statistical office Baden-Wuerttemberg (Statistisches Landesamt Baden-Wuerttemberg 2015)
price_q	Own calculations based on ADAC (2015)
$\text{detection rate}_{j,q-1}$	Own calculations based on SOCI (for SOCI see chapter I.2)
$\text{unemp}_{j,q}$	Federal Employment Agency (Bundesagentur für Arbeit 2014)
crime index_t	Own calculations based on annual crime reports of German Federal Criminal Police Office (Bundeskriminalamt 2010-2014)

Furthermore, Table I.4 shows descriptive statistics of the variables on county-level, i.e. the variables we used to estimate the empirical model.

Table I.4: **Descriptive statistics of variables on county-level**

variable name	mean	std.dev.	min	max	median
$\text{fueltheft}_{j,q}$	19.8	13.4	0.7	116.4	16.9
price_q	147.6	11.5	117.7	163.8	151.1
$\text{detection rate}_{j,q-1}$	53.2	21.4	0.0	125.0	51.5
$\text{unemp}_{j,q}$	4.4	1.3	2.2	10.4	4.1
crime index_t	-0.1	1.2	-1.2	2.7	-0.5

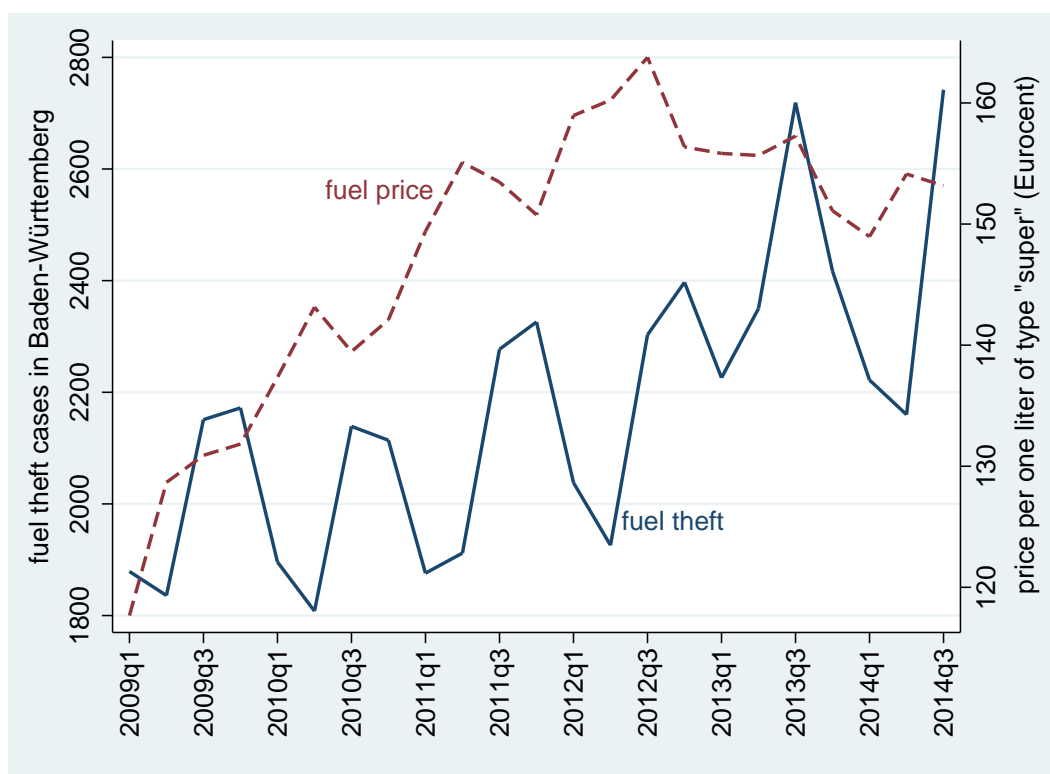
Indices: j = county (N = 44); q = quarter (N=23); t = year (N = 6).

I.4.2 Descriptive statistics

The data ranges from first quarter 2009 to third quarter 2014. Due to possible time lagged recording of fuel theft (see chapter I.2) and data availability (population data on county-level) we aggregated available monthly data to quarterly data. In this subsection we provide some descriptive statistics. For the sake of simplicity, we show aggregated data on the level of the state of Baden-Wuerttemberg to provide a first overview.

First of all, Figure I.2 shows the total quarterly number of fuel theft cases in Baden-Wuerttemberg and corresponding German fuel prices. The time line suggests that both fuel price and fuel theft vary seasonally. It seems that the seasonal pattern of fuel theft is more pronounced than the seasonal structure of the fuel price. Calculating means of fuel theft by quarter confirms our visual observations. In the first quarter as well as in the second quarter on average roughly 2,000 cases of fuel theft occur. With an average of nearly 2,400 cases, most fuel thefts occur in the third quarter, followed by the fourth quarter with an average of roughly 2,300 cases.²

Figure I.2: **Fuel theft in Baden-Wuerttemberg and fuel price**



sources: LKA and ADAC.

² Seasonal mean values of other main aggregated variables are provided in Table I.A.1 in Appendix I.A. Furthermore, Table I.A.2 shows descriptive statistics of all main variables on federal state level.

The seasonal pattern of fuel theft requires an explanation. A first possible consideration relates to the traffic volume. It is likely that fuel theft is positively affected by traffic volume. In Germany, main holiday months are July, August and September, in which higher traffic volume can be expected, which in turn affects fuel theft. Also other countries have their main vacation period in the third quarter of the year. For example Belgium and Dutch citizens, who are travelling to Italy, are very likely to use the toll free German Autobahn to travel to the south. The Federal Highway Research Institute (Bundesanstalt für Straßenwesen, henceforth BfS) provided us with data on monthly traffic volume in whole Baden-Wuerttemberg during 2013. In Baden-Wuerttemberg itself, 107 permanently installed traffic counting systems observe traffic on federal highways and federal roads.³ In 2013, 27 percent of traffic volume on highways and federal roads in Baden-Wuerttemberg took place in the third quarter, while the second and the fourth quarter each had 25 percent (BfS 2014). The lowest traffic volume occurred in the first quarter with 23 percent (BfS 2014).

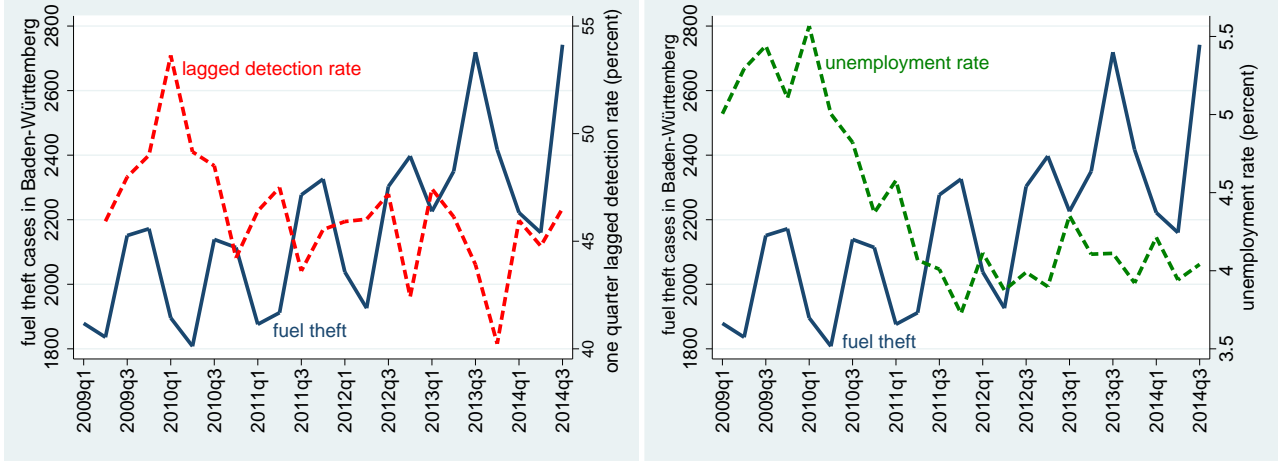
As mentioned above, BfS (2014) data only includes traffic on federal highways and federal roads. Unfortunately, we are not able to observe seasonal traffic structure in urban areas. Nonetheless, traffic volume on federal highways and federal roads are a good approximation. The quarterly differences in traffic volume cannot fully reflect the extent to which fuel theft differs seasonally, but the seasonal pattern of the traffic volume suggests the use of seasonal dummies in the empirical model.

Now let us return to Figure I.2 and take a closer look at the development of fuel price. Price of fuel is at its lowest level right at the beginning of the investigation period with a value of roughly 117 eurocents. From year to year the fuel price increases and reaches its peak value at the third quarter of 2013 with an amount of nearly 164 eurocents. After that, one can see a declining trend in fuel price.

In the current study, we will use more variables to explain fuel theft per 100,000 inhabitants than the price. As theoretically derived in chapter I.3, detection rates and unemployment rates could also play a role in explaining fuel theft. Figure I.3 displays pair-wise line graphs for cases of fuel theft (left axis) and one-period lagged detection rates and unemployment rates (right axis), respectively, for the state of Baden-Wuerttemberg. Unemployment data comes from the Federal Employment Agency (Bundesagentur für Arbeit, henceforth FEA).

³ Due to technical defects in two traffic counting systems, our figures refer to 105 instead of 107 traffic counting stations.

Figure I.3: **Fuel theft, detection and unemployment**



source: LKA.

sources: LKA and FEA.

Due to the seasonal pattern of fuel theft it is not easy to detect a correlation in Figures I.2 and I.3. On this account, we further provide a correlation matrix of all main variables in Table I.5. As one can see in Table I.5, price and fuel theft are positively correlated (0.38), whereas both detection rate (-0.48) and unemployment rate (-0.50) are negatively correlated with fuel theft. The signs of the correlations correspond to the prediction of our theoretical model.

Table I.5: **Correlation matrix of main variables**

	fueltheft	price	det. rate(-1)	unemp
fueltheft	1.00			
price	0.38	1.00		
detection rate(-1)	-0.48	-0.42	1.00	
unemp	-0.50	-0.87	0.69	1.0

A correlation is of course not a causal relationship. Neither Table I.5 nor Figures I.2 and I.3 take interactions or fixed seasonal patterns into consideration. On this account we use fixed-effects panel regressions to estimate the relationships between fuel theft and possible explanatory variables in the next subsection.

I.4.3 Results

We run panel regressions with county fixed-effects to estimate the effect of different fuel price levels on fuel theft. Table I.6 shows the results of our estimations.

Table I.6: **Estimates of the effect of fuel price on fuel theft**

	(1)	(2)	(3)	(4)
price	0.13** (0.06)	0.14** (0.06)	0.13** (0.06)	0.22*** (0.07)
lagged detection rate (previous quarter)		-0.09* (0.05)	-0.09* (0.05)	-0.10* (0.05)
unemp			-0.26 (1.45)	1.64 (1.42)
crime index				0.99*** (0.31)
constant	-0.35 (8.32)	2.76 (7.80)	5.88 (13.45)	-16.40 (14.57)
seasonal effects	Yes	Yes	Yes	Yes
overall R ²	0.03	0.16	0.15	0.17
observations	1012	968	968	968

Estimation method: fixed-effects panel regression. Group variable: all counties (n=44) of Baden-Wuerttemberg. Robust standard errors clustered by counties (n=44) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

We start with a simple regression of fuel price on fuel theft with quarterly dummy variables to control for seasonal effects. The estimated coefficient for the fuel price suggests that a significant ten cent increase in the average quarterly fuel price leads to 1.3 more cases of fuel theft per 100,000 inhabitants per county in the same quarter.

In a next step, we integrate detection rates of the previous quarter. Following the economics of crime literature and as derived from our theoretical considerations in chapter I.3, detection probability plays an important role for the "supply of offenses" (Becker 1968). According to the results of specification (2), we provide evidence that is consistent with the deterrence hypothesis. A ten percent increase in the detection rate leads to approximately one case of fuel theft less per 100,000 inhabitants per county in the following quarter. With a standard error of 0.05 the deterring effect of higher previous

detection is likely to have its expected negative sign. The coefficient of the fuel price increases to 0.14 and remains statistically significant.

Specification (3) includes unemployment rates into the model. Based on our data, a one percent increase in the unemployment rate leads to 0.26 less cases of fuel theft per 100,000 inhabitants at the same quarter in the same county. However, with a standard error of 1.45 this coefficient is statistically insignificant. The effect of the lagged detection rate remains stable, while the coefficient of the fuel price decreases to 0.13.

The effect of higher unemployment on fuel theft is not as clear as the effect of higher unemployment on other property crimes like burglaries. A person that becomes unemployed and is willing to act illegally cannot compensate her income loss solely by fuel theft. While typical property crimes could be interpreted as an alternative to earn income, fuel theft primarily leads to a full tank and not directly to higher income. An additional consideration is that unemployed persons are more likely to sell their cars because they do not need them anymore to drive to work or they need to save some money.

Last but not least specification (4) represents the full model. Compared with specification (3), specification (4) additionally controls for the general crime trend in Baden-Wuerttemberg. According to our estimation results, a one unit increase in Baden-Wuerttemberg crime index leads to approximately one more case of fuel theft per 100,000 inhabitants per county. We find a statistically significant effect of the crime index due to a standard error of 0.31. The coefficient of the detection rate as well as its standard error remains nearly constant through all regressions (2) to (4). The coefficient of the fuel prices now reaches its highest value of 0.22. This implies that a 10 cent increase in quarterly fuel prices results in two more cases of fuel theft per 100,000 inhabitants per county in the same quarter.

Our estimation results deliver further evidence for the price-theft hypothesis (Sidebottom, Ashby and Johnson 2014) or, in other words, suggest that "prices matter for crime" (Draca, Koutmeridis and Machin 2015, p. 7). The positive relationship of changes in fuel prices and fuel theft remains statistically significant in all four estimations. Thus, we find empirical evidence for our first hypothesis and can also provide empirical evidence for our second hypothesis (deterrence hypothesis). Only our third hypothesis cannot be empirically confirmed. We find no statistically significant effect of unemployment on fuel theft.

I.5 Statistical tests and robustness checks

There are two main objections concerning our estimation method and our data. In this section we want to address these objections and show that our estimation results are robust. First, since we run estimations in levels we have to rule out that non-stationarity leads to spurious effects. Therefore, we test whether the variables follow a unit root in chapter I.5.1. Second, due to possible time-lagged registration of fuel theft in the SOCI, the estimated effect of fuel prices on fuel theft could actually stem from the previous time-period. We already addressed this problem by aggregating monthly to quarterly data. Nevertheless, we provide another approach to address the problem of possible time-lagged registration of fuel theft data in chapter I.5.2.

I.5.1 Unit root tests

In this subsection we test whether our panel data variables are stationary. Stationarity seems to be plausible when considering Figure I.1, Figure I.2 and Figure I.3. Although prices are commonly a good candidate for non-stationarity, our small sample that covers only six years seems to be stationary because no trend or shock is visible. We use the Harris-Tzavalis unit root test to test for stationarity.⁴ The results from the Harris-Tzavalis unit root tests are presented in Table I.7.

Table I.7: **Harris-Tzavalis unit root test results**

variable	Harris-Tzavalis p-value
fueltheft	< 0.01
price	< 0.01
lagged detection rate	< 0.01
unemp	< 0.01
crime index	< 0.01
H_0 : panels contain unit roots; H_a : panels are stationary.	

According to Table I.7 we can reject the Harris-Tzavalis null-hypothesis that our main variables *fueltheft* ($p < 0.01$) and *price* ($p < 0.01$) as well as our further explanatory variables follow a unit root and hence accept the alternative that our series are stationary. Provided that all of our variables are likely stationary, the panel estimations in levels are justified.

⁴ For further explanations on the Harris-Tzavalis unit root test see Harris and Tzavalis (1999).

I.5.2 Address possible time-lagged registration

As mentioned in chapter I.2, cases of fuel theft are possibly registered with little time lags. We already addressed this possible problem by aggregating monthly data to quarterly data but this might not solve the problem entirely. The following example should make our considerations more clear: Imagine a fuel theft occurred on January 31, 2011. It is unlikely that the corresponding police officer closes the case record in the same month. If we would have been able to use monthly data⁵ it is somehow obvious that time-lagged registration would distort registered cases much more. Because we use quarterly data, a fuel theft that occurred on January 31, 2011 is very likely to be assigned correctly to the first quarter of 2011. However, we can not rule out that time-lagged registration still occurs in quarterly data. Imagine the fuel theft from above occurred on March 31, 2011. In our data this case is likely to be falsely assigned to the second quarter of 2011 instead of the first quarter of 2011.

To check whether our results are robust to possible time-lagged registration, we modify our dependent variable and rerun the regressions of chapter I.4.3. We assign all recorded cases of fuel theft of a specific month to the previous month. After that we aggregate monthly data to quarterly data again. This approach helps us to address the problem of possible time-lagged registration at the transition of quarters. On the other hand, this method is not perfect because we cannot rule out that a fuel theft that actually occurred in a specific quarter is now falsely assigned to the previous quarter. As one can see, we cannot solve this problem entirely but it is less severe by using quarterly instead of monthly data.

Noteworthy, according to police officers from the LKA there is no systemic bias in time-lagged recording. That means that possible time-lagged registration is presumably random. Even if, for example, the last quarter had systematically more cases because police men have to close record until the end of the year, the seasonal dummy variable would catch this effect.

Results of our regressions are shown in Table I.8. As one can see, a one month shift ahead of recorded cases of fuel theft does not change the main results of our estimations. The fuel price still has a highly significant positive effect of 0.22 in our full model. Lagged detection rates which represent the deterrence hypothesis still have a significant negative influence of -0.10. Furthermore, unemployment remains statistically insignificant, too. Last but

⁵ We were not able to use monthly data because important population data is not available on monthly level.

not least, the positive influence of the crime index on fuel theft remains statistically significant.

Table I.8: **Robustness check for one month shifted ahead fuel theft**

	(1)	(2)	(3)	(4)
price	0.13** (0.06)	0.14** (0.06)	0.14** (0.06)	0.22*** (0.07)
lagged detection rate (previous quarter)		-0.10* (0.05)	-0.10* (0.06)	-0.10* (0.06)
unemp			-0.09 (1.40)	1.52 (1.37)
crime index				0.85*** (0.27)
constant	-1.18 (8.68)	1.97 (7.70)	3.09 (13.76)	-15.98 (14.95)
seasonal effects	Yes	Yes	Yes	Yes
overall R ²	0.02	0.17	0.17	0.18
observations	1012	967	967	967

Estimation method: fixed-effects panel regression. Group variable: all counties (n=44) of Baden-Wuerttemberg. Robust standard errors clustered by counties (n=44) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

I.6 Conclusion

For decades, economists have analyzed the economics of crime primarily concerning punishment, alternative income opportunities and socioeconomic circumstances. Surprisingly, economists neglected the price system as a reasonable explanation for the "supply of offenses" (Becker 1968). In recent time, a number of studies examine a more economic approach. This new approach uses the price system as a determinant of crime at least in case of property crime. Our study adds to this relatively new and small strand of literature that takes into account that crime reacts to prices.

In this paper we investigate whether fuel theft reacts to changes in fuel price. Fuel is a homogenous good and therefore an ideal candidate to measure how theft reacts to different price levels. In Germany, fuel theft is registered in public crime statistics since

2009. Furthermore, fuel stations have no prepaid system and no exit barriers. Thus, there is a non-negligible amount of fuel theft in Germany. We considered quarterly data on fuel theft normalized per 100,000 inhabitants on county-level for the German federal state Baden-Wuerttemberg. We combined this fuel theft data with data on fuel prices, detection rates and unemployment rates to build a 44-panel data set with which we were able to investigate the economic determinants of fuel theft.

With rising fuel prices the incentive to steal fuel increases and we should expect potential fuel thieves to be more likely to steal fuel. This goes along with standard economic theory which predicts that individuals react to incentives. Our investigation period is first quarter 2009 to third quarter 2014. In our sample the fuel price ranged between 117 eurocents at the beginning of our investigation period and peaked with 164 eurocents in the third quarter of 2013. Thus, we have a considerable variation in the price of the good under investigation.

Our evidence lends further support to the price-theft hypothesis. The price-theft hypothesis postulates that the price of a good is positively associated with variations in the quantity of that good that gets stolen. We run panel regressions with county fixed-effects and seasonal fixed-effects to estimate the effect of fuel price changes on fuel theft. We found significant evidence that a higher fuel price results in more cases of fuel theft. In our full model we included a lagged detection rate and unemployment as further time-variant variables and control for overall crime by including a state crime index. We also found evidence in support of the deterrence hypothesis. A higher detection rate in the previous quarter should prevent possible fuel thieves from stealing fuel in the considered quarter. The lagged detection rate has a significant negative influence on fuel theft. We found no evidence that unemployment rates affects fuel theft. This might be due to the fact that stealing fuel is not really an alternative to a real job. Furthermore, unemployed persons might not have a car and in nearly all cases fuel theft is done with a car.

To sum up, fuel thieves seem to steal more fuel if fuel gets more expensive because their net benefit from stealing rises with rising prices.

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I.A Further descriptive statistics

Table I.A.1: Seasonal mean values of aggregated variables

quarter	first	second	third	fourth
fueltheft total cases	2022.8	1998.7	2388.5	2285.2
price	144.7	149.5	149.7	146.4
detection rate	46.6	46.3	44.2	47.9
detection rate prev. qrt.	47.9	46.6	46.3	44.2
unemp	4.6	4.4	4.4	4.2

Table I.A.2: Descriptive statistics of variables on federal state level

variable name	mean	std.dev.	min	max	median
fueltheft total cases	2169.0	258.5	1808.0	2742.0	2160.0
price	147.6	11.5	117.7	163.8	151.1
detection rate prev. qrt.	46.3	2.7	40.2	53.6	46.1
unemp	4.4	0.6	3.7	5.6	4.1

Chapter II

Do Criminals Behave Rationally?

- Evidence from the Franco-German Border

II.1 Introduction

In this paper we use a new identification strategy to provide further empirical evidence that criminals behave as predicted by rational choice theory. Thereby, we collected data from German police administration to build a unique data set that contains monthly fuel thefts at gas station level. In a first step, we use exogenous variation of fuel prices to provide empirical evidence that fuel theft reacts to different fuel prices. In a second step, we investigate whether this price effect is stronger when means of escape are additionally taken into account. In doing so, we observe the German border area near France where potential French fuel thieves have better opportunities to get away with fuel theft than their German counterparts.

Since the seminal theoretical frameworks of Becker (1968) and Ehrlich (1973), much research has been done on the rationality of criminals. Following Becker (1968) and Ehrlich (1973), in short, a potential criminal that behaves rationally commits a crime if it pays off. In the decision-making process, a potential criminal has to consider, among other things, the probability of getting punished or opportunities to earn income legally. The approach that criminals react to "incentives" (Ehrlich 1973, p. 522) was a novelty, because until then criminal activities were mainly attributed to "deviant" (Ehrlich 1973, p. 521) characteristics inherent in criminals.

In the following years, economic research carried out many empirical studies¹ to test whether criminals react to incentives. One recurring question was whether criminals can be deterred from committing crimes. Thereby, harsher penalties or higher probability of getting caught and being convicted were investigated as possible crime-detering factors. A frequently investigated causal relationship is the deterring effect of capital punishment on murder rates. More recent research indicates that there is no clear answer to this far-reaching question (Durlauf, Fu and Navarro 2012). One example of studies concerning higher conviction probabilities is provided by Machin and Meghir (2004). They found an expected negative impact of crime specific conviction rates on the corresponding crime rate.

Studies dealing with a higher probability of getting caught address, among other things, the question of whether police presence deters crime. In their meta-study of 36 empirical investigations on the relationship between police and crime Marvell and Moody (1996) summarize:

¹ To the best of our knowledge Eide, Rubin and Shepherd (2006) provide the most extensive overview of the economics of crime.

”Our survey of research concerning the impact of police on crime found wide-ranging, perhaps even random, results [...]. A major culprit is simultaneity bias; the positive impact of crime on police levels counteracts the negative impact of police on crime.”

Marvell and Moody (1996, p. 639).

Some more recent studies address the problem of simultaneity bias by using natural experiments. Di Tella and Schargrodsky (2004) found a deterring effect of police on car thefts in locations near Jewish institutions that had been protected by more policemen after a terror attack in Buenos Aires 1994. Klick and Tabarrok (2005) avoid the simultaneity bias by investigating whether terror alert levels cause less crime in Washington D.C. They also found a deterring effect of police on crime. In a natural experiment, Draca, Machin and Witt (2011) used the London 2005 terror attack to provide further empirical evidence for the deterring effect of police presence on crime.

Beneath deterrent factors, research on the rationality of criminals should also take socioeconomic variables into account. Rationally behaving criminals are likely to react to their economic prospects. Therefore, a number of studies focusses mainly on the influence of unemployment, income inequality or criminal neighborhoods on crime. Edmark (2005), for example, used huge variation in Swedish unemployment rates between 1988 and 1999 to run county-level panel estimates to investigate the connection between unemployment and property crimes in Sweden. Edmark (2005) found statistically significant effects for this relationship for burglary and car theft. Again, substantial changes in Swedish unemployment rates were used to account for the effect of unemployment on crime by Öster and Agell (2007), who found that decreasing unemployment rates on municipality-level decreased certain property crime rates between 1996 and 2000. To address the potential problem of reverse causality (Cullen and Levitt 1999), Altindag (2012) studied a natural experiment with industrial accidents, earthquakes and exchange rate variations to measure the impact of unemployment on crime. Altindag (2012) provides further empirical evidence for the positive relationship between unemployment and crime.

Studies on the impact of social circumstances on crime suffer from ”the fundamental methodological problem of endogenous neighbourhood selection” (Damm and Dustmann 2014, p. 1830). The natural experiment of Damm and Dustmann (2014) uses the fact that Danish legislation randomly allocated migrants among municipalities between 1986 and 1998. They found that young men (not women) have higher probabilities to become criminal later in their lives when they grow up in a neighbourhood with a high share of criminal persons especially when these criminals are under the age of 26.

Many of the above cited studies have in common that they look for exogenous variation to investigate whether criminals behave as predicted by rational choice theory. In recent years, the price system has been identified as a good exogenous variable to investigate rational behavior of criminals. Applied to theft, rational criminals should, *ceteris paribus*, expand thefts if prices for the stolen goods rise and also reduce thefts if prices for stolen goods decrease. Recently, some studies focused on the relationship between theft and prices (e.g. Draca, Koutmeridis and Machin 2015; Brabenec and Montag 2014; Dengler-Roscher and Roscher 2015). It is noteworthy that prices of goods as a measure for gains from criminal activities can only be applied to property crimes, i.e. the price approach is not suitable to explain other serious crimes.

Our study contributes to the existing body of literature on the rational behavior of criminals by using a new strategy to identify costs of theft. Thereby, we use the fact that potential fuel thieves have limited opportunities to commit fuel theft on French territory. This is due to the fact that French gas stations are predominantly equipped with prepaid systems or exit barriers. In Germany, on the other hand, such prepaid systems or exit barriers are unusual for gas stations. Thus, German gas stations that are located close to the Franco-German border are our treatment group and German gas stations with a greater distance to the Franco-German border are the control group. We define four different driving distance categories between a specific gas station and the French border to distinguish treatment group from control group. These driving distances categories are 2.5, 5, 7.5 and 10 kilometres.

We have a unique data set of fuel thefts at gas station level in the special geographical region near the Franco-German border. We collected this data at the State Office of Criminal Investigation Baden-Wuerttemberg (Landeskriminalamt Baden-Wuerttemberg, henceforth LKA). In a first step, we use exogenous variations in fuel price levels to provide empirical evidence that fuel thieves react to incentives in the whole area. In a second step, we investigate whether gas stations that are located closer to the Franco-German border than other gas stations have higher (lower) absolute numbers of fuel theft cases when French fuel prices are at higher (lower) levels. Due to limited opportunities to commit fuel theft in France, we expect stronger effects of French fuel prices at German gas stations that are located close to the Franco-German border than at German gas stations that are located in the interior of the country.

This paper is structured as follows: In chapter II.2 we provide our theoretical model and our hypotheses. An overview of our data is presented in chapter II.3. As a preliminary analysis, estimation results on the relationship between fuel prices and fuel theft are

presented in chapter II.4. Chapter II.5 provides estimation results that connects price reactions and means of escape. Several robustness checks are presented in chapter II.6. We finish our work with a conclusion in chapter II.7.

II.2 Theoretical framework

In this section we present the theoretical framework. In a first step, we build upon the baseline theoretical model as developed in Dengler-Roscher and Roscher (2015) and adapt it to a micro-level decision-making problem. Subsequently, we derive hypotheses concerning rational behavior of fuel thieves by adapting our baseline model to the special case of the Franco-German border region.

II.2.1 Baseline model

We adapt Becker's (1968) theoretical framework of a rational criminal to fuel theft. Accordingly, the decision-making problem of a potential fuel thief can be written in the following way:

$$(1 - \pi)W(P) + \pi(W(P) - F) > 0, \quad (\text{II.1})$$

while π denotes the probability of being caught (and sentenced), F denotes fines if getting caught (and sentenced) and $W(P)$ denotes net worth of the corresponding fuel theft. In Dengler-Roscher and Roscher (2015) we investigate fuel theft on county-level. In this study we want to explain fuel theft on gas station level. Our set up is now more detailed with regards to the individual decision-making problem of a representative fuel thief. We define monetary net worth of fuel theft as

$$W(P, D), \quad (\text{II.2})$$

while P denotes fuel price and D denotes the distance from the scene of crime (a certain gas station) to the home address of the fuel thief. We derive a positive relationship between fuel price and net worth of fuel theft, written more formally as

$$\frac{\partial W(P, D)}{\partial P} > 0. \quad (\text{II.3})$$

Our first hypothesis is:

Fuel theft increases (decreases) with higher (lower) fuel prices.

An increasing distance D between the scene of crime and the home address of the fuel thief leads to a decreasing net worth of the corresponding fuel theft. Every further

kilometer that a fuel thief has to drive back home decreases his gains from the theft. These considerations can be written more formally as:

$$\frac{\partial W(P, D)}{\partial D} < 0. \quad (\text{II.4})$$

Note that we have no data on distances between gas stations and home addresses of fuel thieves. Nevertheless, the considerations concerning D are necessary considerations concerning rational behaviour of thieves in the Franco-German border region as discussed in chapter II.2.2.

II.2.2 Special case of the Franco-German border region

Distance D has a special implication for our theoretical model applied to the Franco-German border region. Assume a potential fuel thief lives in France close the Franco-German border. His opportunities to commit fuel theft in his home country are restricted due to prepaid systems or exit barriers at gas stations. In Germany, on the other hand, such prepaid systems or exit barriers are not common. Thus, due to limited opportunities in the home country, a potential French fuel thief could decide to commit fuel theft in Germany.

Another incentive for French fuel thieves to steal their tankfuls in Germany is that German police is not permitted to hot pursuit on French territory. If a French fuel thief reaches his home country, he has nothing to fear from German police. Furthermore, in French law, fuel theft is interpreted as a minor offense. Even if German police has information on the licence plate or any other information that could lead to an arrest of the suspect, it is not sure whether French prosecution would launch a court procedure when a criminal charge gets filed.

With the above considerations in mind, distance D becomes a more meaningful influence on fuel theft decisions for the Franco-German border area concerning the probability of getting caught and sentenced. In the special case of the Franco-German border area, the probability π of getting caught (and sentenced) depends on the distance from the gas station to the border. If a French fuel thief is caught by German police on German territory, he can be taken into custody for a maximum of 48 hours and may be required to pay an immediate bill of a certain amount of money. This would cost him time and/or money. If the same thief manages to flee to his home country, it is rather unlikely that he is taken to account for fuel theft. These considerations lead us to our next statement:

$$\frac{\partial \pi(D)}{\partial D} > 0. \quad (\text{II.5})$$

Potential French fuel thieves can decrease their probability of being caught and sentenced by stealing fuel from a German gas station near their home country. Furthermore, potential French fuel thieves are expected to react to price changes, too. Therefore, we expect fuel theft to react more to French fuel price levels in a German area close to the border than in an area that lies more in the interior of Germany.

Let us define $U(.)$ as utility a representative fuel thief gains from his illegal activity. We assume that utility equals monetary values. Then $U(.)$ is written as

$$U(.) = (1 - \pi(D))W(D) + \pi(D)(W(D) - F). \quad (\text{II.6})$$

Simplifying equation (II.6) leads to:

$$U(.) = W(D) - \pi(D)F. \quad (\text{II.7})$$

Differentiating equation (II.7) with respect to D leads to:

$$\frac{\partial U(.)}{\partial D} = \underbrace{W'(D)}_{<0} - \underbrace{\pi'(D)}_{>0} \underbrace{F}_{>0} < 0. \quad (\text{II.8})$$

As one can see in equation II.8 utility of fuel theft is decreasing in the border distance D . Therefore, our second hypothesis is stated as follows:

Fuel theft increases with a decreasing distance to the Franco-German border.

In a last step we can add the two previous insights and state as our third hypothesis:

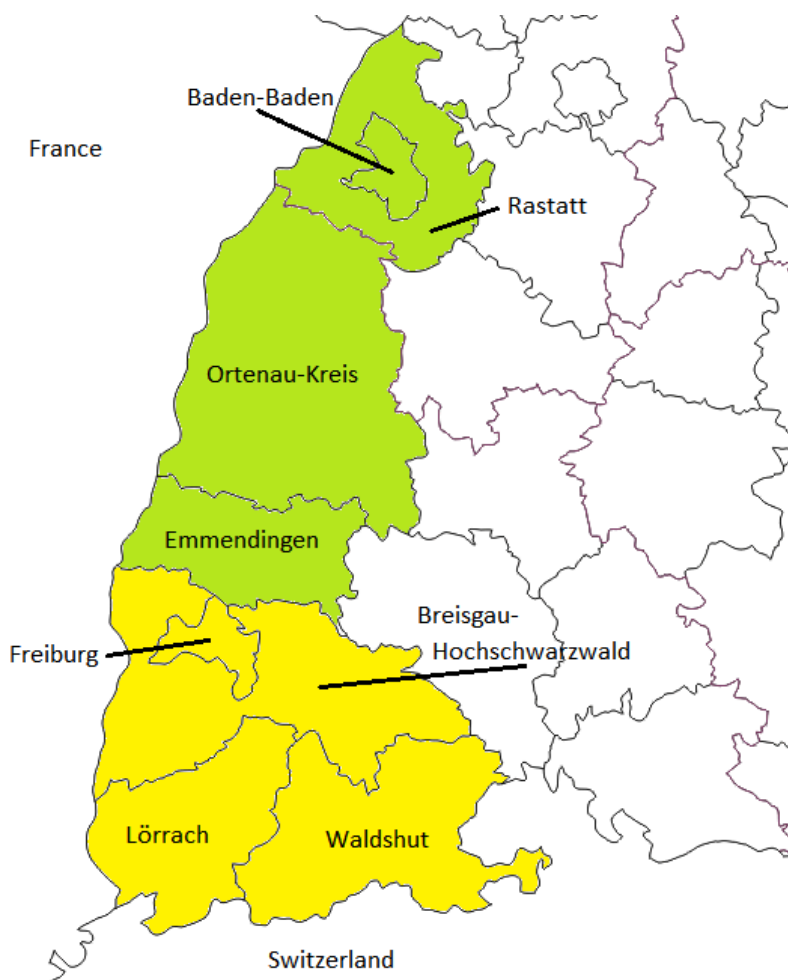
Fuel theft reacts stronger to different levels of the French fuel price at German gas stations that are located close to the Franco-German border than at German gas stations in the interior of Germany.

II.3 Data

This section provides a broad overview of the data used in this study. We start by describing our unique data set on fuel theft at the level of individual gas stations. Afterwards, we consider a few variables that may explain fuel theft at gas station level.

Data on fuel theft: We collected monthly data on fuel theft at the level of individual gas stations from the State Office of Criminal Investigation Baden-Wuerttemberg (LKA) for the period between January 2013 and April 2015. Our data set contains a total of 232 different gas stations that are located in the area of responsibility either of the Offenburg police headquarter or the Freiburg police headquarter. Figure II.1 shows an extract of a map of Baden-Wuerttemberg.

Figure II.1: **Investigated area**



Source of the unmarked map: d-maps (2015).

The area of responsibility of Offenburg police headquarter is coloured green, while the corresponding area of Freiburg police headquarter is coloured yellow. Both areas of responsibility are located close to the Franco-German border. This is important for later considerations on the rationality of fuel thieves. For better orientation we included county names in Figure II.1.

Table II.1 shows a fictional sample from our fuel theft data set. We collected raw data from the State Office of Criminal Investigation (LKA) which contains date, time and address of the scene of crime for every single case of fuel theft. We are obliged to keep the scenes of crime and thus the postal addresses of the gas stations anonymous. For this reason, Table II.1 provides only a fictional excerpt from the real data set. To generate anonymous data, we assigned individual identifiers (id) to every gas station as shown in the last column of Table II.1. In nearly all cases we had very detailed data on postal addresses. Therefore, only in 7 out of a total of 6.205 cases we were not able to assign an individual identifier.

Table II.1: **Fictional sample from data set**

date	time	place	street address	house number	id
05.08.2014	11:08	Freiburg	Karl-Leiser-Straße	8	1
05.08.2014	15:22	Kehl	Sommerallee	20	2
05.08.2014	17:58	Baden-Baden	Rohrmoserweg	99	3
06.08.2014	22:30	Rastatt	Kranzstraße	121	4
06.08.2014	06:16	Freiburg	Karl-Leiser-Straße	8	1
06.08.2014	11:03	A5	BAT XY	1	5

In a next step we aggregated daily cases of fuel theft to monthly data, exemplified in Table II.2.

Table II.2: **Aggregation to monthly data**

year	month	id	number of fuel theft cases
2014	August	1	2
2014	August	2	1
2014	August	3	1
2014	August	4	1
2014	August	5	1

Our data set contains monthly cases of fuel theft for each of the 232 individual gas stations between January 2013 and April 2015.

Data on fuel prices: We used publicly available data from the General German Automobile Association (Allgemeiner Deutscher Automobil-Club, henceforth ADAC) on monthly fuel price averages to calculate a fuel price index (January 2013 = 100) for Germany. More precisely, we chose the price per one liter fuel of type "E10". The corresponding German fuel price index is an approximation of fuel prices in our investigated area. For the French fuel price index, we used data from the French Ministry of Ecology, Energy, Sustainable Development and Land Planning (Ministère de l'Écologie, du Développement durable et de l'Énergie, henceforth DGEC). For best possible comparability we used data for fuel type "Super SP95-E10" if available. Data on this type of fuel is available from July 2013 onwards. For the period January 2013 till June 2013 we used data on fuel type "Super SP95". We checked for differences in prices for these two types between July 2013 and April 2015 and differences are at maximum 1 eurocent.

One may raise the objection that a fuel price index based on data for whole Germany could be a too unprecise approximation for fuel prices in Baden-Wuerttemberg. An analysis of fuel prices per one liter fuel of type "E5" at 14,000 gas stations in Germany on May 22, 2015 carried out by the ADAC shows that fuel prices at gas stations in Baden-Wuerttemberg are near the German average (ADAC 2015b).

Distance between gas stations and the Franco-German border: We used Google Maps to determine distances between gas stations and the Franco-German border. Figure II.2 illustrates this procedure by an example. Suppose a gas station is located at *Schwarzwaldstraße 3* near *Lichtenau*. We then searched for the shortest car route to the Franco-German border. Germany is separated from France by the border river Rhine. Therefore, it is clear that simply using the beeline as a measure for the distance to the border would be misleading because only a few bridges connect Germany and France. An overview of all Rhine bridges that are admitted to road traffic is provided in Appendix II.A. In the example above, the next Rhine bridge is the "Staustufe Rheinau Gambsheim".

In almost all cases Google Maps provided several optional car routes. As mentioned above, we took the route with the shortest distance. In our example above, we would have chosen the blue route with a distance of 10.7 kilometres to the Franco-German border. Google Maps also provides estimated journey duration based on traffic rules. We do not consider journey duration because this measure is in a certain way arbitrary. A fuel thief that flees to his home country is less likely to respect traffic rules.

Data on traffic volume: It can be expected that the absolute number of fuel theft depends on the amount of cars on the roads. Therefore, fuel theft is more likely to occur in months with high traffic volume than in months with fewer traffic volume. To control for the influence of traffic volume, we draw monthly data from the Road Traffic Central of Baden-Wuerttemberg (Straßenverkehrszentrale Baden-Wuerttemberg). This data includes monthly averages of per-day registered passenger cars per permanently installed traffic counting systems on federal state roads in Baden-Wuerttemberg, of which there are 47. We use this data as an approximation for monthly traffic volume in the investigated area.

Identifying highway gas stations: There are two main reasons why highway gas stations should be regarded as special cases of gas stations. First, fuel prices are higher at highway gas stations than at other gas stations. Beier and Schramm (2012) compared fuel prices on German highway gas stations with fuel prices at the nearest non highway gas station of the same company. Following Beier and Schramm (2012), the resulting price difference amounts to three eurocents per liter on average. Second, German highway gas stations sell on average twice as much fuel as non-highway gas stations (Bundeskartellamt 2011, p. 15). Therefore, we can expect higher traffic volumes accompanied with more fuel thieves at highway gas stations. One could further argue that highway gas stations offer better means of escape to fuel thieves because of a higher level of anonymity and a less transparent refuelling process from the perspective of the service staff.

We define a gas station as a highway gas station if it is located at the German Autobahn A5. Our data set contains a total of 11 individual highway gas stations.

Data on opening hours: Fuel theft can only occur if a gas station is open. Therefore, we take opening hours into account. The German internet site <http://clever-tanken.de> provides realtime information on fuel prices. Another feature of this site is that it also shows opening hours. If we did not find a certain gas station on <http://www.clever-tanken.de>, we searched <http://www.kaufda.de> for opening hours.

The minimal amount of opening hours in our data set is 10 per day. For a better interpretation of regression outcomes, we calculated the difference between the daily opening hours of a gas station and 10. Thus, we receive additional opening hours, meaning how many additional opening hours a gas station offers compared to the gas station with the shortest opening hours. Later, we will call this variable *openreal*.

Overview of data: We offer a descriptive overview of the data in Table II.3. The first part of Table II.3 displays short descriptions of the variables. The second part shows sources of the data and the third part provides some descriptive statistics. We further show our variables with time and gas station specific indices for a better understanding of the empirical model presented in chapter II.4.1 and chapter II.5.1.

Table II.3: **Description, sources and statistics of variables**

variable name	description				
$\text{fueltheft}_{g,m}$	number of registered cases of fuel theft at gas station g in month m				
price_m	price index of one liter fuel (type super E10) in month m (Jan 2013=100)				
dist_g	distance between gas station g and the Franco-German border in kilometers				
traffic_m	monthly average of daily registered cars at permanently installed traffic counting systems (47) in Baden-Wuerttemberg (in thousands)				
highway_g	gas station is situated on the highway A5 = 1, else 0 (dummy variable)				
openreal_g	difference between opening hours of gas station g and minimum opening hours (=10)				
pricefr_m	price index of one liter fuel (type Super SP95/Super SP95-E10) in France in month m (January 2013 = 100)				
source					
$\text{fueltheft}_{g,m}$	State Office of Criminal Investigation Baden-Wuerttemberg (LKA)				
price_m	own calculations based on data from ADAC (2015a)				
dist_g	Google Maps				
traffic_m	Road Traffic Central of Baden-Wuerttemberg				
highway_g	http://www.autobahnatlas-online.de/A5.htm				
openreal_g	Own calculations based on opening hours data from http://www.clever-tanken.de/ or http://www.kaufda.de/				
pricefr_m	DGEC (2015)				
descriptive statistics					
	mean	std.dev.	min	max	median
$\text{fueltheft}_{g,m}$	0.94	2.45	0.00	37.00	0.00
price_m	97.11	5.38	82.09	102.66	98.80
dist_g	21.23	16.11	0.70	86.20	16.65
traffic_m	14.53	0.95	12.63	16.47	14.61
highway_g	Dummy-variable: 11 different highway gas stations				
openreal_g	8.03	4.17	0.00	14.00	6.00
pricefr_m	95.65	5.17	81.88	103.48	96.55

Indices: g = gas station ($G = 232$); m = month ($M=28$).

II.4 Fuel theft reaction to price levels

In this section we estimate the relationship between fuel price and fuel theft based on our data set. In a first step, we present our empirical model in chapter II.4.1. Afterwards, two different approaches are used to estimate the monthly reaction of fuel theft at individual gas stations to German fuel price levels: In the first approach (presented in chapter II.4.2) we use a standard pooled-OLS model and in the second approach (presented in chapter II.4.3) we use a negative binomial count model.

II.4.1 Empirical model

Our model used to estimate the effect of fuel price changes on fuel theft can be written as follows:

$$\begin{aligned} \text{fueltheft}_{g,m} = & \alpha + \beta_1 \text{price}_m + \beta_2 \text{dist}_g + \beta_3 \text{traffic}_m \\ & + \beta_4 \text{highway}_g + \beta_5 \text{openhours}_g + \epsilon_{g,m} \end{aligned} \quad (\text{II.9})$$

For explanations of variables see chapter II.3 and Table II.3.

II.4.2 Results

In a first step, we want to analyze the relationship between the fuel price index and cases of fuel theft on gas station level. Table II.4 shows the results of our estimations.

We expand our empirical model stepwise. First, we simply estimate the monthly effect of fuel price index on fuel theft (specification (1)). Following our results, a one point higher fuel price index leads to roughly 0.02 more cases of fuel theft per gas station per month. With a standard error of 0.005 this effect is statistically significant. Provided that monthly average of fuel theft per gas station is about 0.94, a one unit increase in the fuel price index has a non negligible effect on fuel theft.

In a next step, specification (2) adds the driving distance between the Franco-German border and gas station g . Results show that one more kilometer distance between a gas station and the Franco-German border is associated with 0.02 fewer cases of fuel theft per gas station per month. This means, cautiously interpreted, one more kilometer distance to the Franco-German border neutralizes a one point higher level of the fuel price index. The effect of the distance from the border is also statistically significant.

Table II.4: **Estimates of the effect of fuel price on fuel theft**

	(1)	(2)	(3)	(4)	(5)
price	0.018*** (0.005)	0.018*** (0.005)	0.016*** (0.005)	0.016*** (0.005)	0.016*** (0.005)
dist		-0.022*** (0.001)	-0.022*** (0.001)	-0.014*** (0.001)	-0.013*** (0.001)
traffic			0.045 (0.029)	0.045* (0.026)	0.045* (0.026)
highway				5.524*** (0.356)	5.116*** (0.354)
openreal					0.077*** 0.006
constant	-0.797 (0.520)	-0.331 (0.514)	-0.832 (0.610)	-1.259** (0.526)	-1.890*** (0.529)
observations	6496	6496	6496	6496	6496

Estimation method: Pooled-OLS. Group variable: gas stations (n=232). Robust standard errors clustered by gas stations (n=232) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

We control for traffic volume in specification (3). Thousand additional registered cars per day per permanently installed traffic count stations on federal state roads in Baden-Wuerttemberg in a given month result in roughly 0.05 more cases of fuel theft per gas station in the same month. However, the coefficient of the traffic volume measure is statistically insignificant. Adding time-variant traffic volume into the model reduces the estimated effect of the fuel price index from 0.018 to 0.016. Nevertheless, the effect of the fuel price index on fuel theft remains statistically significant.

Specification (4) further distinguishes between highway gas stations and non-highway gas stations with a dummy variable. If a gas station is a highway gas station we observe *ceteris paribus* 5.5 more cases of monthly fuel theft. This effect is relatively large and may be due to higher fuel prices, enormous traffic volume and better means of escape at highway gas stations. Now the traffic volume becomes statistically significant. Furthermore, the coefficient of the driving distance to the Franco-German border decreases from 0.022 to 0.014. At this point we could vaguely claim that a decline of fuel theft due to one more kilometer driving distance to the Franco-German border is neutralized either by a one unit higher level of the fuel price index or by 300 additional registered cars per day per traffic count station.

In a last step, we introduce additional opening hours into our model. Two more opening hours in addition to the shortest opening hours of 10 per day increases monthly fuel theft per gas station by roughly 0.15 cases. Thus, a twenty-four hours opened gas station is expected to have one more fuel theft per month than a ten hours opened gas station.

The effect of the fuel price index remains relatively stable and statistically significant through all of the five regressions. Thus, we provide empirical evidence at micro level that fuel thieves react to prices. The above results support our first hypothesis: Fuel theft increases (decreases) with higher (lower) levels of fuel prices.

II.4.3 Estimations in a count model

Remember, the dependent variable $\text{fueltheft}_{g,m}$ is defined as the number of fuel theft cases at gas station g in month m . Consequently, the outcomes are always non-negative integer numbers. Since pooled-OLS estimates can predict negative values, we want to back up our result by a count model which is designed to predict non-negative integer counts (Wooldridge 2010, p. 472). In order to illustrate our considerations, Figure II.B in Appendix II.B shows the distribution of the variable $\text{fueltheft}_{g,m}$.

According to Figure II.B in Appendix II.B, in roughly seven out of ten observations no fuel theft occurred. As a consequence, the average of fuel theft cases per month per gas station is about 0.94. Furthermore, variance of our dependant variable is 6.01 and thus variance is more than six times higher than the mean. Since Poisson count model requires equal mean and variance, we choose a negative binomial count model that can deal with the high variance to mean ratio.²

In the "most common" (Greene 2008, p. 907) loglinear specification of count models, our model could be written as follows:

$$\ln(\hat{\text{fueltheft}}_{g,m}) = \alpha + \beta_1 \text{price}_m + \beta_2 \text{dist}_g + \beta_3 \text{traffic}_m + \beta_4 \text{highway}_g + \beta_5 \text{openreal}_g. \quad (\text{II.10})$$

Column "coefficient" in Table II.5 displays maximum likelihood estimators for the coefficients according to equation (II.10). However, interpreting changes of $\ln(\hat{\text{fueltheft}})$ is not that intuitive, so exponentiating equation (II.10) leads to:

² For further information about "overdispersion" see chapter 17.2.2 in Cameron and Trivedi (2010, p. 569).

$$\widehat{\text{fueltheft}}_{g,m} = e^{\alpha + \beta_1 \text{price}_m + \beta_2 \text{dist}_g + \beta_3 \text{traffic}_m + \beta_4 \text{highway}_g + \beta_5 \text{openreal}_g}. \quad (\text{II.11})$$

A one unit increase in one of the explanatory variables, e.g. price_m , affects the expected count of fuel theft in the following way:

$$\frac{e^{\alpha + \beta_1 (\text{price}_m + 1) + \beta_2 \text{dist}_g + \dots}}{e^{\alpha + \beta_1 \text{price}_m + \beta_2 \text{dist}_g + \dots}} = \frac{e^\alpha \times e^{\beta_1 \text{price}_m} \times e^{\beta_1} \times e^{\text{dist}_g}}{e^\alpha \times e^{\beta_1 \text{price}_m} \times e^{\text{dist}_g}} = e^{\beta_1}. \quad (\text{II.12})$$

Thus, for better interpretation of the results, column three "incident rate ratio" of Table II.5 displays incident rate ratios, i.e. exponentiated coefficients. It is important to note that the interpretation of an incident rate ratio is multiplicative and not additive. This has two main implications: First, the incident rate ratio indicates the *ratio* by which the expected count of the dependent variable changes, when the corresponding explanatory variable increases by one unit. Second, a n -unit increase of an explanatory variable increases the expected count of the dependent variable by the factor $(e^\beta)^n$.

For the sake of simplicity, we focus on incident rate ratios by describing our estimation results. Any subsequent interpretations of the estimated incident rate ratios apply subject to the requirement that all the other variables are held fixed. Following our results, a one unit increase in the fuel price index changes fuel theft by the factor 1.02, meaning that fuel theft increases by two percent. This result implies a positive relationship between fuel price levels and fuel theft. One more kilometer driving distance to the Franco-German border is expected to change the number of fuel theft by the factor 0.986, meaning that fuel theft decreases by 1.4 percent. According to our estimation results, a one unit increase in our traffic volume measure increases monthly number of fuel theft per gas station by roughly 5 percent. One additional opening hour compared to ten per day is expected to increase fuel theft counts by ten percent. Thus, twenty-four opening hours are expected to change fuel theft *ceteris paribus* by $1.1^{14} \approx 3.8$. This result implies that fuel theft is almost four times higher at permanently opened gas stations than at gas stations with ten opening hours per day. If a gas station in our sample is a highway gas station, then this gas station is expected to have 3.7 times more counts of fuel theft than non-highway gas stations.

The standard errors displayed in Table II.5 are possibly misleading sine they are not robust to heteroscedasticity. To the best of our knowledge, Stata provides no options for robust standard errors in negative binomial count models. We have calculated bootstrap standard errors with 100 replications in an attempt to get appropriate standard errors.

Table II.5: **Estimation results in negative binomial count model**

	coefficient	incident rate ratio
price	0.020*** (0.005)	1.020*** (0.005)
dist	-0.013*** (0.005)	0.986*** (0.005)
traffic	0.051*** (0.016)	1.052*** (0.017)
highway	1.308*** (0.200)	3.698*** (0.740)
openreal	0.095*** (0.024)	1.100*** (0.026)
constant	-2.465*** (0.514)	0.085*** (0.044)
observations: 6496		

Estimation method: maximum likelihood negative binomial panel regression with individual dispersion at group level. Group variable: gas stations (n=232). Bootstrap standard errors (100 replications) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

If we trust in our standard errors, all estimated coefficients are statistically significant. Against this background, the results are in line with our results from the pooled-OLS panel regressions from chapter II.4.2. Provided that the negative binomial count model with its maximum likelihood estimators is an eligible candidate for our model, we find further empirical support for our first and second hypotheses from chapter II.2.

II.5 Border distance as a measure for costs of theft

Our data set on fuel theft at individual gas station levels allows us to use a new identification strategy concerning costs of crime. The main question considered is whether fuel theft reacts stronger to changes in the French fuel price index when gas stations are located close to the Franco-German border or not. Our treatment group contains gas stations that are located close to the Franco-German border. Our control group consists of gas stations that are located in the inner country. German gas stations that are located close to the Franco-German border have the exogenous variation that limited possibilities to commit fuel theft in France pushes potential French fuel thieves to commit fuel theft at those German gas stations. We test our hypothesis by using pooled-OLS panel regressions. The next subsection (chapter II.5.1) presents our empirical model and chapter II.5.2 shows estimation results.

II.5.1 Empirical model

Our model used to estimate the interaction effect of fuel price levels and distance to the Franco-German border on fuel theft can be written as follows:

$$\begin{aligned} \text{fueltheft}_{g,m} = & \alpha + \beta_1 \text{frprice}_m + \beta_2 \text{border}_g + \beta_3 \text{frprice}_m \times \text{border}_g \\ & + \beta_4 \text{traffic}_m + \beta_5 \text{abt}_g + \beta_6 \text{openhours}_g + \epsilon_{g,m}. \end{aligned} \quad (\text{II.13})$$

First, it is important to notice that we are now using the French fuel price index frprice_m as an approximation for fuel price changes. A potential French fuel theft is primarily reacting to fuel price levels in his home country. Second, since we expect a higher effect of fuel prices on fuel theft at gas stations located close to the Franco-German border, we include the interaction term $\text{frprice}_m \times \text{border}_g$ into our model. Thereby, border_g is a dummy variable that takes the value 1 if the driving distance from gas station g to the Franco-German border is smaller than 2.5, 5, 7.5 or 10 kilometers, respectively.

II.5.2 Results

Table II.6 shows results of the pooled-OLS panel estimations according to equation (II.13). The first row of table II.6 ("border distance") displays maximal driving distances to the Franco-German border that define whether a gas station is "close to the

border” or not. For example, the entry ”< 7.5km” implies that all gas stations with a driving distance of less than 7.5 kilometers to the Franco-German border get a value of 1. The ninth row of table II.6 (”share border=1”) displays the share of gas stations that are ”close to the border”. Obviously, the share of ”close to the border” gas stations increases with higher values of maximal permitted driving distances to the Franco-German border. We provide estimation results in steps of 2.5 kilometers additional driving distance to the border to examine how our estimation results change in reaction to increasing distances to the Franco-German border.

Table II.6: **Estimates of interaction effects**

border distance	< 2.5km	< 5.0km	< 7.5km	< 10.0km
frprice	0.009** (0.004)	0.010*** (0.004)	0.008*** (0.003)	0.009*** (0.003)
border	-6.348** (3.217)	-3.168 (3.138)	-3.056 (2.397)	-1.353 (1.643)
frprice × border	0.081** (0.035)	0.050 (0.034)	0.046* (0.027)	0.025 (0.018)
traffic	0.056*** (0.015)	0.056*** (0.015)	0.056*** (0.015)	0.056*** (0.015)
highway	5.036*** (1.593)	5.046*** (1.600)	5.099*** (1.582)	5.050*** (1.552)
openreal	0.079*** 0.024	0.080*** (0.024)	0.086*** (0.023)	0.093*** (0.024)
constant	-1.664** (0.502)	-1.821*** (0.498)	-1.749*** (0.437)	-1.940*** (0.462)
share border = 1	0.069	0.091	0.134	0.203
observations	6496	6496	6496	6496

Estimation method: pooled-OLS panel regression. Group variable: gas stations (n=232). Robust standard errors clustered by gas stations (n=232) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

First, we discuss the coefficients of all other explanatory variables except the interaction between the French fuel price index and the border dummy. Monthly traffic volume has a statistically significant influence on fuel thefts. In all four different model specifications the estimated coefficient as well as the robust standard errors of the measure for traffic volume do not change at all. One thousand additional daily registered passenger cars (per permanently installed traffic count system) in a given month imply an increase of

about 0.06 fuel thefts per gas station in the same month. A highway gas station has about five more fuel theft cases per month than a non-highway gas station. The effect of highway gas stations has a huge magnitude when one considers the average of 0.94 fuel theft cases per month in the whole sample. One more opening hour per day compared to the gas station with the lowest opening hours leads to 0.8 to 0.9 more cases of fuel theft per month. Both highway gas stations and additional opening hours have statistically significant positive effects on monthly fuel theft cases per gas station. The magnitudes of the effects of these two variables remain relatively stable over all four regressions. This is due to the fact that the status as a highway gas station as well as opening hours are time-invariant. Thus, the magnitude of the effect of these two variables can only change remarkably, when the definition of the border-dummy, which is the only further time-invariant variable, has a noteworthy effect on fuel theft.

At this point one could ask why we use pooled-OLS regressions instead of fixed-effects regressions although we have mostly time-invariant variables. Only by using random-effects regressions we are able to obtain the effect of the border-dummy. Otherwise the border-dummy would be omitted. Furthermore, for later robustness checks it is important to show that highway gas stations as well as additional opening hours have strong effects on fuel theft.

The estimated coefficient of the interaction term has the expected positive sign in all four regressions. Furthermore, the estimated interaction effect decreases with each additional 2.5 kilometre step in the definition of the border dummy. This means that the interaction effect becomes smaller the broader we define "close to the border". This result is also in line with our expectations. Assuming that "close to the border" means gas stations have driving distances to the Franco-German border of less than 2.5 kilometers, changes in the French fuel price index have a nine times higher effect on monthly fuel theft cases in the "close to the border" area than in the rest of the investigated region. By interpreting these results we should bear in mind that estimated coefficients in the 5 kilometers and 10 kilometers specifications are not statistically significant.

The relatively small effect of the French fuel price index remains statistically significant in all four models. This effect is not decreasing in increasing driving distances we define as "close to the border". Thus, we can vaguely interpret this small but significant effect as a fundamentally price effect due to dependency of German and French fuel price indices on the global oil price. Nevertheless, higher (lower) fuel price levels are accompanied by higher (lower) cases of fuel theft at gas stations that are located close to the border

compared to gas stations in the control area. Furthermore, the tighter we define "close to the border", the stronger this effect becomes.

Interpreting these results as our main results, we can state that there is empirical evidence that monthly fuel theft cases in the area close to the Franco-German border react stronger to higher levels in the French fuel price index than fuel theft cases in the rest of the investigated area. These results are in line with our third hypothesis.

II.6 Robustness checks

We want to substantiate our estimation results from the previous section by applying some robustness checks. Our first robustness check takes the interaction between traffic and proximity to the border into account. Our second robustness check uses fixed-effects panel regressions in subsamples. In chapter II.6.3 we replicate our baseline estimations in a sample containing only 24 hours opened gas stations. Chapter II.6.4 addresses the question whether highway gas stations distort our baseline results. Finally, we replicate our baseline estimations in a negative binomial count model.

II.6.1 Interaction of traffic volume and distance to the border

Our first robustness check includes a further interaction term in the baseline model from chapter II.5.1. We consider the interaction between monthly traffic on federal state roads in Baden-Wuerttemberg and distance to the border. We want to rule out that the interaction effect between the French fuel price index and the "close to the border"-dummy is mainly driven by a higher traffic volume in the Franco-German border area and its correlation with the German fuel price index. When traffic volume is the main driver of fuel theft at gas stations that are located close to the Franco-German border, we would expect that months with high traffic volume lead to more cases of fuel theft at these gas stations than months with fewer traffic. We would also expect that the effect of the interaction between the French fuel price index and our "close to the border"-dummy on fuel theft decreases. Table II.7 shows the results of our first robustness check.

The main results are very similar to our baseline estimations. Taking the interaction between traffic volume and distance to the border into account does not change the interaction effect of the French fuel price index and our "close to the border"-dummy. Neither the coefficient of $\text{sprfr}_m \times \text{border}_g$ changes in magnitude, nor does its standard errors substantially increase.

Table II.7: **Interaction of traffic volume and distance to the border**

border distance	< 2.5km	< 5.0km	< 7.5km	< 10.0km
frprice	0.008** (0.004)	0.010*** (0.004)	0.008*** (0.003)	0.009*** (0.003)
border	-5.655* (3.314)	-3.617 (2.896)	-3.373 (2.404)	-1.673 (1.656)
frprice × border	0.082** (0.035)	0.049 (0.034)	0.045* (0.027)	0.024 (0.018)
traffic	0.060*** (0.015)	0.053*** (0.015)	0.053*** (0.015)	0.051*** (0.016)
traffic × border	-0.053 (0.074)	0.035 (0.084)	0.024 (0.063)	0.025 (0.045)
highway	5.036*** (1.593)	5.046*** (1.600)	5.099*** (1.582)	5.050*** (1.552)
openreal	0.079*** (0.024)	0.080*** (0.024)	0.086*** (0.023)	0.093*** (0.024)
constant	-1.712*** (0.500)	-1.780*** (0.497)	-1.707*** (0.430)	-1.875*** (0.460)
share border = 1	0.069	0.091	0.134	0.203
observations	6496	6496	6496	6496

Estimation method: random-effects panel regression. Group variable: gas stations (n=232). Robust standard errors clustered by gas stations (n=232) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

The second result from our first robustness check is that the interaction effect of traffic volume and closeness to the border is statistically insignificant in all of the four regressions. We cannot reject the null hypothesis that traffic volume has no influence on fuel theft in the area which we defined as "close to the border" in each case. Standard errors of the interaction term exceed the estimated coefficient in all four model specifications.

The effect of traffic volume on fuel theft in the control area, on the other hand, remains positive and statistically significant. Based on our empirical results we cannot claim that months with high traffic volume are accompanied by more fuel thefts in the region we define as "close to the border" in each specification.

II.6.2 Running fixed-effects subsample regressions

One may raise the objection that we are not able to fully observe all relevant time-invariant characteristics of the gas stations in our sample to explain fuel theft. Therefore, we use fixed-effects panel regressions to assign a time-invariant (fixed-)effect to each gas station in our sample. This approach has the shortcoming that we are not able to investigate all gas stations in our sample simultaneously since fixed-effects models omit time-invariant variables. For this reason we have to run fixed-effects regressions in subsamples of our 2.5, 5.0, 7.5 and 10 kilometer treatments, respectively. Table II.8 displays the corresponding results.

Table II.8: **Estimates in a fixed-effects model**

border distance	< 2.5km	< 5.0km	< 7.5km	< 10.0km	≥ 10.0km
frprice	0.090*** (0.036)	0.059 (0.035)	0.053* (0.027)	0.034* (0.018)	0.009*** (0.003)
traffic	0.006 (0.075)	0.088 (0.084)	0.077 (0.062)	0.056*** (0.015)	0.051*** (0.016)
constant	-6.048 (3.617)	-4.246 (3.134)	-4.092 (2.646)	-2.557 (1.798)	-0.887** (0.413)
# gas stations	16	21	31	47	185
observations	448	588	868	1316	5180

Estimation method: fixed-effects panel regression. Group variable: gas stations. Robust standard errors clustered by gas stations in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

We observe the strongest effect of the fuel price index in the subsample of those 16 gas stations that have a driving distance of less than 2.5 kilometers to the Franco-German border. Traffic does not have a statistically significant influence on fuel theft in the 2.5 kilometer treatment. This is in line with the results from our robustness check from the previous subsection. With each further 2.5 kilometer step the effect of the French fuel price index decreases. Simultaneously, the standard errors of the traffic volume become smaller in comparison to the estimated coefficient, so that traffic volume becomes statistically significant in the 10 kilometer treatment. The last column of Table II.8 displays the corresponding results for the rest of the sample, i.e. gas stations with driving distances of 10 or more kilometers to the Franco-German border. While traffic reaches its statistical significant coefficient of 0.051, the effect of the French fuel prices becomes nearly negligible with a statistically significant coefficient of 0.009.

II.6.3 Subsample of permanently opened gas stations

Results from chapter II.5.2 suggest that gas stations with higher opening hours are more often victims of fuel theft than gas stations with shorter opening hours. To address the potential problem of many zero theft observations, we rerun our model in a subsample of all permanently opened gas stations. As a result, the average number of fuel theft cases per gas station more than doubles from 0.94 to 1.90 and simultaneously the share of non-zero observations on total observations increases from 30 percent to nearly 45 percent. Results from our third robustness check are provided in Table II.9.

Table II.9: **Subsample of permanently opened gas stations**

border distance	< 2.5km	< 5.0km	< 7.5km	< 10.0km
frprice	0.016 (0.010)	0.016 (0.010)	0.009 (0.008)	0.010 (0.008)
border	-15.071*** (3.440)	-12.445*** (3.780)	-16.000*** (4.282)	-11.278** (4.409)
frprice × border	0.179*** (0.048)	0.147*** (0.050)	0.193*** (0.056)	0.142*** (0.054)
traffic	0.121*** (0.041)	0.121*** (0.041)	0.121*** (0.041)	0.121*** (0.041)
highway	5.602*** (1.707)	5.645*** (1.691)	5.675*** (1.718)	5.483*** (1.695)
constant	-2.380* (1.258)	-2.397* (1.270)	-1.852 (1.121)	-1.978* (1.132)
share border = 1	0.059	0.088	0.103	0.132
observations	1904	1904	1904	1904

Estimation method: random-effects panel regression. Group variable: gas stations (n=68). Robust standard errors clustered by gas stations (n=68) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

Compared to our baseline estimations, the interaction effect becomes stronger and statistically significant in all four models. On the other hand, the effect of the French fuel price index on fuel theft in the control area becomes statistically insignificant. By interpreting these results we should bear in mind that these results are based on 1904 observations instead of 6496, i.e. 68 gas stations instead of 232. In this case, the interaction effect of the first specification is only based on 5 individual gas stations with a driving distance of less than 2.5 kilometers to the Franco-German border.

II.6.4 Excluding highway gas stations

Highway gas stations seem to be a special kind of gas station concerning fuel theft. A highway gas station is likely to have opened all day long and is characterized by a high traffic volume as well as higher fuel prices. In a next step, we thus exclude all highway gas stations from our data set. This approach is unfortunately accompanied by relatively more zero observations of our dependent variable. Table II.10 provides the corresponding estimation results.

Table II.10: **Non-highway gas stations only**

border distance	< 2.5km	< 5.0km	< 7.5km	< 10.0km
frprice	0.006 (0.004)	0.007** (0.003)	0.005* (0.003)	0.006** (0.003)
border	-6.150* (3.610)	-2.770 (3.406)	-2.890 (2.522)	-1.482 (1.709)
frprice × border	0.087** (0.040)	0.052 (0.037)	0.048* (0.028)	0.028 (0.019)
traffic	0.030*** (0.011)	0.030*** (0.011)	0.030*** (0.011)	0.030*** (0.011)
openreal	0.069*** (0.021)	0.068*** (0.021)	0.077*** (0.021)	0.086*** (0.023)
constant	-0.984*** (0.416)	-1.143*** (0.410)	-1.069*** (0.316)	-1.223*** (0.343)
share border = 1	0.063	0.086	0.131	0.199
observations	6216	6216	6216	6216

Estimation method: random-effects panel regression. Group variable: gas stations (n=221). Robust standard errors clustered by gas stations (n=221) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

The interaction effect as well as the isolated effect of changes in the French fuel price index are similar to our main results. As a consequence, we can state that our main results do not change when highway gas stations are dropped out of our sample.

II.6.5 Estimations in a negative binomial count model

Due to many zero observations we replicate our baseline regressions in a negative binomial count model. The main disadvantage of using a negative binomial count model with an

interaction term is that there is - to the best of our knowledge - no straightforward way to interpret the coefficient of the interaction term correctly (at least in terms of marginal effects). Ai and Norton (2003) stated

”The interaction effect [...] cannot be evaluated simply by looking at the sign, magnitude, or statistical significance of the coefficient on the interaction term when the model is nonlinear.”

Ai and Norton (2003, p. 129).

On the other hand, Buis (2010) restricts interpretation problems of interaction effects in nonlinear models to marginal effects. Buis (2010, p. 306) suggests incident rate ratios as good candidates for the interpretation of interaction effects in nonlinear models. We follow Buis (2010) suggestion and assume that in the area which we define as ”close to the border” in each case a one unit higher level of the French fuel price index increases expected fuel theft cases by the incident rate ratio of the interaction term.

Table II.11 shows the results of our robustness check in a negative binomial count model. Note that Table II.11 displays estimated incident rate ratios instead of coefficients.

In the ” < 2.5 ” kilometer specification, the stated incident rate ratio of 1.013 implies that a one unit higher French fuel price index is expected to increase monthly fuel theft counts per gas station by a factor of 1.013. The coefficient of the interaction term $\text{frprice} \times \text{border}$ implies that a one unit increase in the French fuel price index increases fuel theft at gas stations which we define as ”close to the border” by a factor of 1.032. Thus, the multiplicative effect of a one unit increase in the French fuel price index is higher in the area we define as ”close to the border” than in the rest. This result supports our third hypothesis.

In the third treatment the incident rate ratio of the interaction effect exceeds the incident rate ratio of the French fuel price index, too. This again implies that it is likely that a one unit increase in the French fuel price index increases expected fuel theft in the area we define as ”close to the border” by a higher factor than it increases fuel theft in the rest of the investigated area. As in the pooled-OLS estimates in chapter II.5.2, we cannot find a statistically significant effect of the interaction term in the second as well as in the fourth specification.

To the best of our knowledge, there is still an active discussion among econometricians about accurately interpreting magnitudes as well as standard errors of interaction terms in nonlinear models (see, e.g. Bowen 2012 or Leitgöb 2014). Although we use the relatively

Table II.11: **Interaction in negative binomial count model**

border distance	< 2.5km	< 5.0km	< 7.5km	< 10.0km
frprice	1.013*** (0.004)	1.014*** (0.005)	1.013*** (0.004)	1.016*** (0.005)
border	0.118 (0.188)	0.525 (0.794)	0.357 (0.442)	1.096 (1.260)
frprice × border	1.032** (0.015)	1.017 (0.015)	1.020* (0.011)	1.006 (0.012)
traffic	1.067*** (0.019)	1.067*** (0.015)	1.068*** (0.016)	1.069*** (0.018)
highway	4.332*** (0.951)	4.487*** (0.976)	4.626*** (0.955)	4.237*** (0.986)
openreal	1.096*** (0.029)	1.103*** (0.029)	1.100*** (0.025)	1.105*** (0.026)
constant	0.106*** (0.053)	0.081*** (0.045)	0.089*** (0.047)	0.067*** (0.037)
share border = 1	0.069	0.091	0.134	0.203
observations	6496	6496	6496	6496

Estimation method: maximum likelihood negative binomial panel regression with individual dispersion at group level. Group variable: gas stations (n=232). Bootstrap standard errors (100 replications) in parentheses.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

straightforward way of Buis (2010) to interpret the interaction effect in our nonlinear model, our statements in this subsection have to be treated with caution.

II.7 Conclusion

Since decades, much research on the economics of crime has been done. Studies dealing with the rationality of criminals address questions of whether crime rates react to changes in severity of penalties or more police on the streets. Often these studies suffer from the problem of endogeneity.

A recent approach to test whether criminals behave rationally concerning property crimes considers the price. Exogenous price changes affect the value that thieves can gain from property crimes like theft. Applied to fuel theft, a higher level of fuel price should result in more cases of fuel theft. Our unique data set on fuel theft at individual gas station level provides further empirical evidence that criminals react to price changes.

Furthermore, we take means of escape into account. Potential French fuel thieves who live in the border area behave rationally when they steal their tankfuls at a German gas station that is located close to their home country. We use driving distances between individual gas stations and the Franco-German border as a measure for the probability of getting caught by police. We found empirical evidence that our expectations about the behavior of fuel thieves are accurate. This is due to a higher effect of French fuel price levels on fuel theft in areas that are located close to the Franco-German border than in more interior parts of the country. We found that fuel theft reacts stronger to changes in the level of French fuel prices at gas stations with a driving distance of less than 2.5 kilometers to the Franco-German border than at other gas stations in our data set. The wider we define "close to the border", the weaker this effect is. This can also be interpreted as further evidence for the rational behavior of criminals. We found statistically significant results for border distances of 2.5 kilometers as well as 7.5 kilometers, but we did not obtain statistically significant results for border distances of 5 and 10 kilometers. Our main results persist in the subsample of permanently opened gas stations as well as when highway gas stations are excluded. Furthermore, we can rule out that the price theft effect in the areas which we defined as "close to the border" is actually driven by traffic volume in these areas. The main results also hold in fixed-effects estimations in subsamples as well as in a negative binomial count model.

It is further noteworthy that the number of gas stations that fulfill the conditions of being located "close to the border" are increasing in a broader definition of closeness to the border. Thus, the results in case of tight definitions of "close to the border", like in our 2.5 kilometer treatment, are based on fewer gas stations in the "close to the border"-area than the results for the 10 kilometer distance. Nevertheless, if we consider our estimation

results in the 2.5 kilometer treatment, fuel theft reacts nine times higher to the level of the French fuel price at gas stations that are located close to the Franco-German border than in the rest of the investigated area.

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II.A Rhine bridges

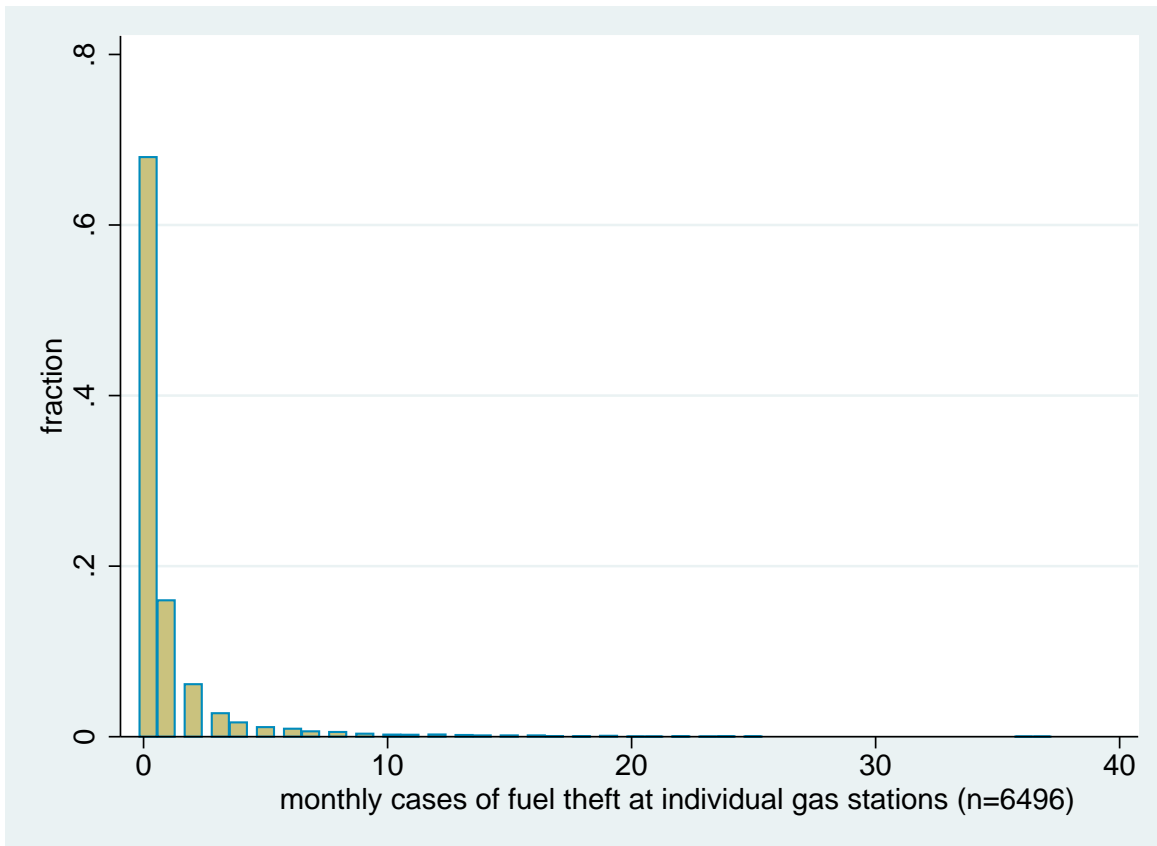
Table II.A: **Car traffic admitted Rhine bridges**

name of the bridge	at marker	German border town	French border town
Palmrainbrücke	171	Weil am Rhein	Huningue
Rheinbrücke Ottmarsheim	194	Steinenstadt	Ottmarsheim
Rheinbrücke Neuenburg - Chalampé	199	Neuenburg am Rhein	Chalampé
Alain-Foechterle-Erich-Dilger-Brücke	210	Harthheim am Rhein	Fessenheim
Rheinbrücke Sasbach-Marckolsheim	240	Sasbach am Kaiserstuhl	Marckolsheim
Rheinbrücke Breisach - Neuf-Brisach	245	Breisach	Neuf-Brisach
Schwanau - Nonnenweier	268	Schwanau	Nonnenweier
Pierre-Pflimlin-Brücke	283	Neuried	Eschau
Europabrücke	293	Kehl	Straßburg
Staustufe Rheinau-Gambsheim	309	Rheinau	Gambsheim
Staustufe Iffezheim	334	Iffezheim	Roppenheim
Rheinbrücke Wintersdorf	335	Rastatt-Wintersdorf	Beinheim

Table II.A only shows Rhine bridges that connect Germany and France. Of course a lot more Rhine bridges exist than these shown in Table II.A. Some of the other Rhine bridges connecting Germany and Switzerland and others connect parts of Germany with other parts of Germany. In this study we focus on fuel theft in the area near the Franco-German border. Therefore, we only consider Rhine bridges at the Franco-German border.

II.B Distribution of fuel theft counts

Figure II.B: Sample distribution of fuel theft



Chapter III

Nudging Academics to Didactic Training

III.1 Introduction

The world of knowledge takes a crazy turn
when teachers themselves are taught to learn.

Bertolt Brecht

In this paper we present a field experiment at Ulm University in which we used a nudge to get academic staff to participate in didactic training at Ulm University. This nudge contains information about the value of the university's in-house didactic training courses by stating the average costs for comparable private sector courses. It was necessary to try to improve participation rates in didactic training courses since many courses which are subsidized by the university were under-utilized and hence had to be cancelled. Nonparametric tests suggest that treatment had no effect on participation in didactic training. A too small sample of overall participants lead to large confidence intervals in logistic regressions. Thus, we cannot make a statistically safeguarded statement whether our nudge worked or not.

University teachers ought to have high expertise in their discipline. Nevertheless, recently efforts are made to improve pedagogic and didactic skills (Postareff, Lindblo-Ylänne and Nevgi 2007). Hauhio and Mauno (2009) found that it is socially desirable that teaching personnel in higher education participates in didactic training since didactic skills play an important role in creating a motivating study environment. Postareff, Lindblo-Ylänne and Nevgi (2007) studied the impact of university teachers' pedagogical training. They reported positive effects on teaching concepts and self-efficiency beliefs if teachers participated in a certain number of didactic training courses. However, for most teaching staff at Ulm University participating in the subsidized didactic training is voluntary and the vast majority of academic personnel does not take the offer. To get academics at Ulm University to didactic training we try to nudge them.

Sunstein and Thaler (2008) coined the term "nudge" in their famous book "Nudge - Improving Decisions About Health, Wealth, and Happiness". The effect of choice architecture and, in particular, behavioral "nudges" is well established (see e.g. Johnson et al. 2012 for an overview). Nudges can be a powerful policy tool in that they are able to move decisions in desired directions in a broad variety of fields. Nudges have been used in financial decisions like investments (Mitchell et al. 2009; Bhattacharya et al. 2012), saving decisions (Chetty et al. 2014; Clark, Maki and Sandler Morrill 2014; Linardi and Tanaka 2013; Madrian and Shea 2001) and credit decisions (Bertrand and Morse 2011; Bracha and Meier 2015; Karlan et al. 2014; Karlan, Morten and Zinman 2012). Fur-

thermore, law enforcement can make use of nudging (Apesteguia, Funk and Nagore 2013; Fellner, Sausgruber and Traxler 2013). Even in decisions about education (Hastings and Weinstein 2008; Benhassine et al. 2015; Castleman and Page 2015) and health (Altmann and Traxler 2014; Calzolari and Nardotto 2015; Johnson and Goldstein 2003; Griffith, von Hinke Kessler Scholder and Smith 2014; Wisdom, Downs and Loewenstein 2010) nudges have shown to be an effective instrument to shape peoples decisions.

To the best of our knowledge there is no common accepted categorization of nudges. We classify our nudge in the field of informational nudges as it provides real additional information to our subjects. Recently, informational nudges have often been used to improve financial decisions. Liebman and Luttmer (2011) provided information about social security provisions to a sample of older workers. One year after their informational intervention, the members of the treatment group were 4 percentage points more likely to remain in the workforce as their counterparts in the control group. Both Choi et al. (2012) and Clark, Maki and Sandler Morrill (2014) investigated the effects of informational nudges on employees contribution behavior in 401(k) plans. Choi et al. (2012) sent different emails with one- to two-sentence cues to employees of a large U.S. technology company. Amongst others, they provided individual calculations to low-contributing employees, that showed them how much they have to pay until the end of the year to reach a worthwhile threshold of either \$3,000 or \$16,500. They found no statistically significant difference between the contribution rates of the two threshold treatments in the short run. In the longer run, those who received the \$16,500 threshold contributed relatively more to their retirement plans than those who received the smaller \$3,000 threshold. Clark, Maki and Sandler Morrill (2014) used an informational nudge to increase the participation rate concerning the 401(k) plan of a large financial institution. They integrated long-term investment examples in the firm's flyer that was sent to newly hired 401(k) plan nonparticipants and found that their small informational nudge increased the participation rate among young employees and workers in the middle-income class.

Furthermore, informational nudges work in other fields as well. Coffman, Featherstone and Kessler (2015) show in a field experiment involving candidates for the Teach For America Program that a social information nudge can even influence a high-stakes decision like teaching in an underperforming school for a year. They found that an additional sentence concerning the participation rates of the previous year increased participation in the Teach For America Program by 1.8 percentage points. Furthermore, subgroups that were expected to react stronger to this informational nudge indeed reacted stronger. Hastings and Weinstein (2008) informed lower-income parents in the U.S. about test

scores of the public school of their children. Parents who received these scoring results were significantly more likely to send their children to better-performing schools.

In this study, we used Ulm University’s internal mail to send the cover letters as well as the training program leaflet to teaching staff. The treatment group received a cover letter that includes one additional sentence about the average value of the training program. In addition to the effect of our nudge we are also interested in the question whether another transmission medium can lead to more registrations. It might be the case that some academics prefer to read emails instead of letters. Since Ulm University’s didactic training program is sent via internal mail, emails can be used as a relatively costless way to provide additional information. We sent emails later in the investigation period. This way, academics are reminded of the didactic training program and of courses that were still open at that time.

The effect of reminders has been studied in a broad variety of fields like attending an appointment (Reekie and Devlin 1998; Bos, Hoogstraten and Prah-Andersen 2005; Downer et al. 2006; Gurol-Urganci et al. 2013), repaying a loan (Cadena and Schoar 2011; Karlan, Morten and Zinman 2012), depositing money in a savings account (Karlan et al. 2014; Kast, Meier and Pomeranz 2012) and other various tasks (Altmann and Traxler 2014; Apesteguia, Funk and Nagore 2013; Calzolari and Nardotto 2015; Milkman et al. 2011). Most studies find significant positive effects of reminders. Unfortunately, we cannot disentangle whether registrations in reaction to our email are due to the reminder effect or due to the variation in the transmission medium. Nevertheless, we provide some indications concerning the effect that the emails had on registrations.

This paper is structured as follows: We provide background information about our experiment and additionally explain the experimental design in chapter III.2. Chapter III.3 reports the results of this study. We conclude our work and discuss some further possible nudges in chapter III.4.

III.2 Background and Experimental Design

III.2.1 Background

In 2001 the ministry of science, research, and arts in Baden-Wuerttemberg and the nine Baden-Wuerttemberg state universities founded the university didactic center Baden-Wuerttemberg (HDZ). Its aim is to improve quality of teaching and hence improve quality of university education. Every state university has its own didactic center and since 2007 they are internally financed by the universities. Each didactic center offers 10 to 15 didactic training courses per year. Academics in Baden-Wuerttemberg are allowed to participate in didactic training at each of the nine state universities. Nevertheless, most academics visit didactic training courses at their home university. At Ulm University, every November approximately 2,300 academics who are in the broadest sense involved in teaching receive an internal mail with information about all courses that will be conducted during the next course year.

A major problem of Ulm University's didactic center is that many of the courses offered are under-utilized. Under-utilization means less than 8 participants registered for a course with one trainer or less than 10 participants registered for a course with two trainers (there are no courses with more than two trainers). In the 2012/2013 course year two out of ten courses were cancelled due to under-utilization and one was conducted although it was under-utilized.

There might be many reasons why academics do not participate in didactic training. On the one hand some of the reasons for rejecting didactic training are beyond the focus of our nudge. Academics might simply reject participation because of a full schedule or mismatches of their own appointments and the HDZ program dates. Some academics might overestimate their own didactic skills. Furthermore, didactic training could be rejected by persons who will quit their academic careers soon. Some PhD students might think that attending the didactic training program is associated with opportunity costs like missing time for writing the PhD thesis. In the worst case academics could even fear that their superiors as well as their colleagues interpret participation in didactic training courses as a weakness.

On the other hand academics might miss didactic training due to a lack of knowledge about the monetary value of the course program. In particular, some academics might underestimate the real value or at least the costs of the course program. Our informational nudge focusses exactly on this group. The current information leaflet does not

contain information about the value or cost of the courses because they are almost entirely financed by the university. Thus, it is unclear which value (pecuniary or other) the target group of academics attributes to the courses. With our informational nudge we want academics to update their value/cost estimation of the HDZ-courses by providing a conservative calculated average value of comparable private sector training courses to them.

III.2.2 Experimental Design

Our subjects were academics who are in the broadest sense involved with teaching at Ulm University. They received a leaflet with information about didactic training courses every year via internal mail. During the investigation period the control group received a personalized letter and the information leaflet, while the treatment group received the same information leaflet and also a personalized letter to which we added the following sentence:

”For comparable courses outside the subsidized HDZ program you would have to pay approximately 375 Euro per course day”.

The letter sent to the treatment group as well as the letter sent to the control group is provided in Appendix III.A. One can see that adding the ”nudge” sentence is only a small change to the standard, full-page personalized letter.

The value of 375 Euro per course day was carefully calculated and a crucial part of our experiment. To be on the safe side and to not exaggerate the value of the courses offered by the HDZ we choose a very conservative value. For this reason we searched the internet via Google for web pages that provide training content. It soon became apparent that many of these pages supplied similar information. To get a representative overview of provided alternative courses on the market we searched three different web pages named www.kursfinder.de, www.semigator.de and www.weiterbildung.de.¹ Appendix III.B shows comparable courses offered by private institutions for all nine different HDZ-courses held at Ulm University during the 2013/2014 course year. We searched for at least four alternatives to each HDZ-course that are as similar as possible. From these results we picked for each HDZ-course the alternative which had the lowest costs per normalized course day (8 hours) so that a very conservative value could be ensured.

¹ In some special cases, e.g. only a small amount of courses in a didactic field, we simply used Google and typed the course name so that we could find very special course supply.

From these lowest cost values we calculated the average which was 376 Euro and rounded it to a more convenient value of 375 Euro per course day.²

The randomization of academics into treatment and control group was performed by the HDZ due to data privacy reasons and we got aggregated information about subgroups containing academic title, gender, department for both control and treatment group. We also got information about every person who registered for a course and his or her characteristics in the dimensions mentioned before.

HDZ program at Ulm University is carried out as an annual program starting approximately every November. If an academic wants to participate in didactic training, she has to fill out an online form providing first name and family name as well as her email address. The uniqueness of email addresses gave the HDZ the possibility to clearly identify a person even if two academics have identical first names as well as family names.

Our field experiment span the investigation period of the 2013/2014 HDZ-program (henceforth first round) as well as the 2014/2015 HDZ-program (henceforth second round). The first round was conducted from 13. November 2013 until 28. October 2014, while the second round was conducted from 11. November 2014 until 23. November 2015. At the beginning of each round we sent an internal mail. We further sent reminder emails: one during the first round and two during the second round. In the first round, we sent the reminder email seven months after the internal mail. In the second round, we sent the first reminder email five months and the second one eleven months after the internal mail. For further explanations concerning the emails see chapter III.3.4.

III.2.3 Dividing academics into subgroups

In the past, only few academics at Ulm University participated in the didactic training program offered by the HDZ. There is only one case where didactic training is mandatory, namely for persons who habilitate³ in medicine. It is obvious that more persons participate in a certain program when they are obliged to do so. Thus, within the group of persons who habilitate in medicine we do not expect the nudge to have an effect. Information on department affiliation as well as highest academic degree allows us to clearly identify this subgroup which we call the "habilitation medics". Additionally, we got infor-

² Appendix III.C shows the calculation of the average value per day.

³ In Germany, doctorates who want to qualify themselves as professors have to "habilitate". The "habilitation" is somehow an equivalent to a post-doc interphase between doctoral education and professorship. In most cases it is necessary to qualify as a professor to get fully tenured as associate or full professor in Germany.

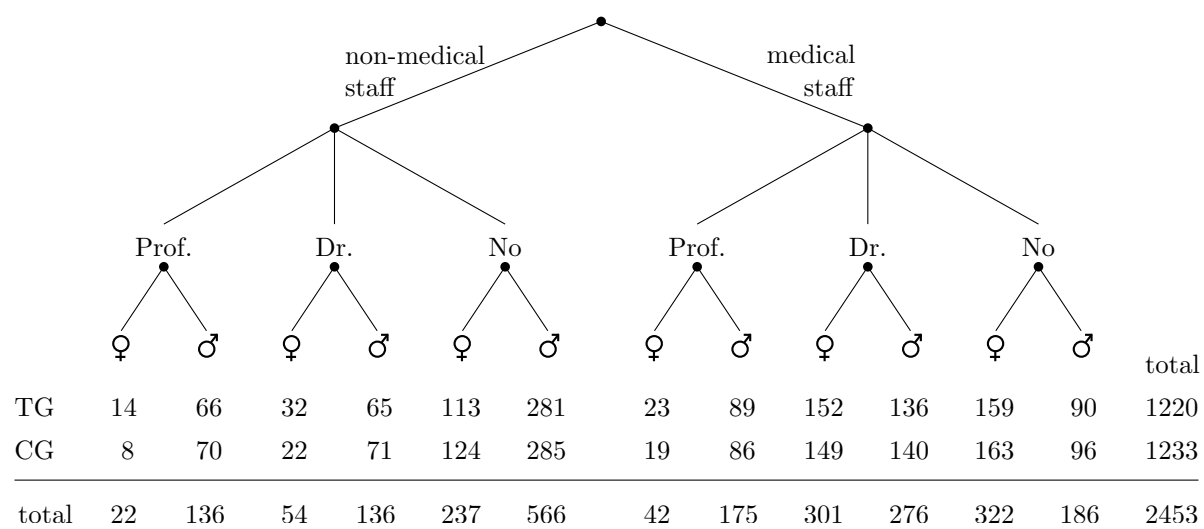
mation about the gender of each person in our sample. Based on all available information we divide our whole sample into 12 subgroups with the following three criteria:

- **medical or non-medical department affiliation:**
Person is employed in the medical department or not.
- **gender:** Person is male or female.
- **highest academic degree:** Person's highest academic degree is either professor or doctor, or no academic degree.

In Germany, nearly every professor has a doctoral degree. Thus, one could falsely interpret the group we hereafter refer to as "doctors" or "persons with a doctoral degree" as professors plus doctors. To avoid misunderstanding, we want to make it clear that by writing "doctors" or "persons with a doctoral degree", we exclusively mean the group whose highest academic degree is a doctoral degree.

Figure III.1 shows how many of our total number of 2,453 teaching academics at Ulm University are in each of the 12 subgroups. Furthermore, Figure III.1 displays how many teaching academics from each subgroup are in the treatment group (TG) and in the control group (CG). Out of the 2,453 subjects 1,220 are in the treatment group while 1,233 are in the control group. 1,302 subjects belong to the medical department and 1,151 belong to non-medical departments. Altogether we have 978 females and 1,475 males in our sample.

Figure III.1: Subgroups



There are 375 professors in our sample and 767 persons which have a doctoral degree as the highest academic degree. A total of 1,311 teaching academics at Ulm University had no academic degree at the time of the experiments.

As mentioned above, we divided our whole sample into subgroups mainly to correct for medics who habilitate. As one can see in Figure III.1, there is a total of 301 females and 276 males that likely habilitate in medicine.

III.3 Results

In this section we present the results of our study. We start by investigating whether our informational nudge was able to increase participation in didactic training based on nonparametric tests. After that we run logistic regressions with multiple explanatory variables to estimate the marginal effects that the explanatory variables have on participation probability. Then we investigate briefly whether nudged participants attended more often than members of the control group. We finish the presentation of our results by investigating the effect of our later reminder emails.

III.3.1 Nonparametric tests

In this subsection we analyze whether members of the treatment group were more likely to participate in didactic training than control group members based on nonparametric tests. Therefore, we focus on total individual registrations to HDZ courses. Table III.1 displays both absolute and relative participation for total staff and further distinguishes between the treatment group and the control group.

Table III.1: **Absolute and relative participation in didactic training**

group	sample size	participants in HDZ courses	participation rate (in percent)
total staff	2453	100	4.1
treatment group	1220	51	4.2
control group	1233	49	4.0
Wilcoxon rank-sum p-value: 0.80; Chi ² p-value: 0.80			

During the two year investigation period a total of 100 persons participated in didactic training, while 2,453 persons were contacted. This means a total participation rate of only 4.1 percent. Concerning our informational nudge, we cannot find a significant difference between the treatment group and the control group. While 4.2 percent of the treatment group participated in didactic training (51 persons out of 1,220), 4.0 percent of the control group did (49 persons out of 1,233). The corresponding Wilcoxon rank-sum test leads to a p-value of approximately 0.80.⁴ Consequently, we cannot reject the null hypothesis that the participation probability of the treatment group equals the participation probability of the control group. This implies that our informational nudge had no measurable effect on total participation in didactic training based on nonparametric tests.

Should medics be excluded?

In a next step we investigate whether the result of no treatment effect holds when subgroups are taken into account. As mentioned above, we do not expect our nudge to work in the group of medics who habilitate because participating in didactic training is mandatory for this subgroup. Table III.2 displays absolute and relative participation by medical staff members with doctoral degree and the rest of the whole sample.

Table III.2: **Do medics who habilitate differ from the rest of the sample?**

group	sample size	participants in HDZ courses	participation rate (in percent)
habilitation medics	577	41	7.1
rest of the sample	1876	59	3.1
Wilcoxon rank-sum p-value: < 0.01; Chi ² p-value: < 0.01			

As one can see in Table III.2, 41 out of a total of 577 "habilitation medics" participated in didactic training. The resulting participation rate of 7.1 percent is more than twice as high as the corresponding participation rate for the rest of the sample. Wilcoxon rank-sum p-value as well as Chi² p-value is below 0.01. Based on nonparametric tests we can state that "habilitation medics" differ statistically significant from the rest of the sample.

⁴ We used the nonparametric Wilcoxon rank-sum test because participation is not normally distributed as required by parametric tests.

Table III.3: **Comparing non-habilitation medics to non-medics**

group	sample size	participants in HDZ courses	participation rate (in percent)
non-habilitation medics	725	5	0.7
non-medics	1151	54	4.7
Wilcoxon rank-sum p-value: < 0.01 ; Chi ² p-value: < 0.01			

Based on the results, we assume that medical staff participation in didactic training is mainly driven by the need to attend as a habilitation requirement. To underpin this assumption, we compare the rest of the medical staff with non-medical staff. Therefore, we exclude all medics with a doctoral degree as the highest academic degree from our sample. This approach leads to the absolute and relative participation as displayed in Table III.3.

According to Table III.3 it is obvious that non-habilitation medics statistically differ from non-medics concerning participation in didactic training. Based on this evidence it might be useful to investigate the effect of our informational nudge in the subgroup of non-medical staff.

Does non-medical staff react to the nudge?

Table III.4 shows participation rates of the subgroup of non-medical staff members by treatment.

Table III.4: **Participation concerning treatment in the sample of non-medics**

group	sample size	participants in HDZ courses	participation rate (in percent)
treatment group	571	32	5.6
control group	580	22	3.8
Wilcoxon rank-sum p-value: 0.15; Chi ² p-value: 0.15			

Even in the more suitable subgroup of non-medical staff Wilcoxon rank-sum test as well as Chi² test leads to the suggestion that there is no difference in participation between "nudged" persons and the control group.

III.3.2 Multiple regression estimates

Until now, we provided nonparametric tests concerning the relationship between treatment and participation in didactic training. Thereby, we only used the information whether a person was nudged or not to explain participation in didactic training. In this part of our study we want to investigate whether taking more than one explanatory variable into account changes the up to now result of no treatment effect. In a first step, we look at further observable variables which possibly can explain participation in didactic training. In a second step, we run logistic regressions. This approach gives us the opportunity to quantify the effects that the explanatory variables have on the participation probability.

Table III.5 shows participation rates of the subgroup of non-medical staff members by gender and academic degree. The only statistically significant difference we found with respect to gender. Females are more likely to participate in didactic training than males. Regarding academic degree, we cannot reject that there is no statistically difference based on Wilcoxon rank-sum as well as χ^2 tests. Persons with a doctoral degree have the highest participation rate with 6.9 percent. The highest relative difference in the participation rates is found when doctors are compared to the rest of the sample. The participation rate of non-medical doctors is 2.6 percentage points higher than the participation rate of the group containing non-medical professors as well as non-medical staff with no academic degree.

Table III.5: **Further explanatory variables**

gender		notitle		doctor		prof	
female	7.4	yes	4.2	yes	6.9	yes	4.4
male	3.7	no	5.8	no	4.3	no	4.7
(< 0.01)		(0.27)		(0.13)		(0.87)	

Wilcoxon rank-sum p-values in parentheses.

In a last step we studied logistic regressions. Table III.6 shows the results from our logit estimates in the subgroup of non-medical staff. The first specification (1) only takes the informational nudge as explanatory variable into account, while the second specification (2) adds gender as further explanatory variable to the model. Specifications (3) to (5) each extend the model with one kind of highest academic degree. Results in Table III.6 are displayed as discrete "marginal" effects at means.

Table III.6: **Marginal effects at means**

Dependent variable: participation in didactic training (1/0)					
	(1)	(2)	(3)	(4)	(5)
treatment	0.018 (0.012)	0.016 (0.012)	0.016 (0.012)	0.016 (0.012)	0.017 (0.012)
male		-0.030*** (0.011)	-0.031*** (0.011)	-0.030*** (0.011)	-0.030*** (0.012)
no title			-0.016 (0.012)		
doctor				0.020 (0.014)	
prof					0.002 (0.018)
constant	0.046*** (0.006)	0.044*** (0.006)	0.043*** (0.006)	0.043*** (0.006)	0.044*** (0.006)

Estimation method: logistic regression. Results are based on 1,151 observations and presented as marginal effects on participation probability. Since all explanatory variables are binary variables, the effects of a "marginal" change in the binary variables is calculated as the discrete change from 0 to 1. Delta method standard errors in parentheses. *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

In all of the five specifications standard errors of the treatment effect are nearly as high as the estimated marginal treatment effect itself. Therefore, we cannot find a statistically significant effect of our informational nudge. Nevertheless, it is noteworthy that the magnitude of the estimated treatment effect is not negligible.

Based on our logit estimations we can state that non-medical females are statistically significant more likely to participate in didactic training than their male counterparts. This result is in line with our nonparametric tests from Table III.5. Concerning academic titles we cannot see any statistically significant effect on participation in didactic training.

Marginal effects at means as presented in Table III.6 are not that intuitive when only binary variables are taken into account. The calculated means can never occur in practice. Therefore, we expand our investigation by showing discrete "marginal" effects for specification (4) at realistic values of the other explanatory variables. We think that specification (4) from Table III.6 provides our best model specification since concerning academic degrees the subgroup of doctors has the greatest difference in their participa-

tion rate in comparison to the rest of the sample as displayed in Table III.5. Therefore, discrete "marginal" treatment effects from the model specification (4) from Table III.6 are displayed in Table III.7.

Table III.7: **Treatment effect on participation probability**

Dependent variable: participation in didactic training (1/0)						
line	gender	doctor	"marginal" effect	95% confidence interval		
				lower bound	upper limit	
(I)	Ø 0.73	Ø 0.17	0.016 (0.012)	−0.007	0.039	
(II)	male	yes	0.020 (0.015)	−0.010	0.049	
(III)	male	no	0.013 (0.009)	−0.006	0.031	
(IV)	female	yes	0.036 (0.027)	−0.017	0.089	
(V)	female	no	0.024 (0.018)	−0.011	0.059	

Estimation method: logit regression. Results are based on 1,151 observations and presented as marginal effects of treatment on participation probability. Since treatment is a binary variable, the effect of a "marginal" change in treatment is calculated as the discrete change from 0 to 1. Delta method standard errors in parentheses. *** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10 % level.

Line (I) in Table III.7 replicates specification (4) from Table III.6. Holding the other explanatory variables at their means, i.e. we have a virtually person that is 73 percent male and 27 percent female and at the same time 17 percent doctor and 83 percent non-doctor, a "jump" in the treatment from 0 to 1 increases participation probability by 1.6 percentage points. As already shown in Table III.6 delta method standard errors suggest that this estimated effect is statistically insignificant. We have further integrated lower bounds and upper limits of 95 percent confidence intervals into Table III.7 to show potential magnitudes of the treatment effect. Considering 95 percent confidence intervals, the treatment effect at means is likely to range between a decrease in participation probability of 0.7 percentage points and a relatively strong increase in participation probability of nearly 4 percentage points.

Lines (II) to (V) show discrete "marginal" treatment effects for all realistic combinations of gender and doctoral degree. According to line (II) the nudge increases the probability

of a man with doctoral degree to participate in didactic training by two percentage points. Based on our data, this marginal effect is likely to lie in a range between -1 percentage point and + 4.9 percentage points. The highest marginal effect of the informational nudge occurs in the subgroup of female academics with doctoral degree (IV). A "nudged" female doctor's probability to participate in didactic training is estimated to be 3.6 percentage points higher than her counterpart in the control group. Again, we see a wide 95 percent confidence interval ranging from -1.7 percentage points to large 8.9 percentage points.

Summarizing results from Table III.7, all estimated marginal effects are positive but accompanied by large confidence intervals. These wide ranges of likely treatment effects do not allow statistically conclusive results. Unfortunately, the sample of participants in didactic training is too small to allow us to state unambiguous results.

To sum up, nonparametric tests did not provide significant evidence that the nudge has an effect on participation in didactic training. Logistic regressions indicate a relatively strong treatment effect but this effect is accompanied by large confidence intervals. This implies that the low number of observations with respect to participation leads to statistically inconclusive results.

III.3.3 Number of course attendances per participant

One further question we are interested in is whether participating academics that got information about the real value of didactic training at Ulm University attend more courses in didactic training than the control group. Table III.8 displays participation frequency by treatment group and control group.

Table III.8: **Participation frequency by treatment**

group	absolute number of participants	average attendances per participant
treatment	51	2.4
control	49	2.3
Wilcoxon rank-sum p-value: 0.35; Chi ² p-value: 0.71		

Members of the treatment group that participated in didactic training participated on average 2.4 times in didactic training. Control group members that decided to participate in didactic training showed up on average 2.3 times in HDZ-courses. Therefore, the

participation frequency of treatment group members that participated in didactic training does not statistically significant differ from the participation frequency of participating control group members.

Correcting our sample for "habilitation medics" does not change the results. In this case, participating academics participate on average 2.6 times no matter if they are in the treatment group or in the control group.

To sum up, within the group of participants in didactic training at Ulm University we cannot find a statistically significant effect of our informational nudge on the number of course attendances.

III.3.4 Effects of the email treatment

We were further interested in the question whether another way of transmitting the information about the HDZ-program would lead to more registrations. We used emails as a relatively costless additional way to provide our information. During the investigation period we sent three emails to all teaching academics at Ulm University. Those persons who received the nudge in the internal mail (treatment group) also received the nudge in the email. Those persons who did not receive a nudge in the internal mail (control group) also received no nudge in the email. Table III.9 displays dates on which the emails were sent and also the number of courses that were still open at the time the email was sent.

Table III.9: **Email treatment**

round	date email was sent	number of open courses	total number of courses
first round	20 June 2014	4	10
second round	9 April 2015	7	11
	13 October 2015	2	

Table III.9 shows that in the first round 6 out of a total of 10 HDZ-courses at Ulm University already took place at the time the email was sent. In the second round, the first email was sent when 4 out of a total of 11 courses already took place, while the second email was sent when only 2 courses remained. Therefore, we cannot compare the effects that reminder emails had on participation to the effects of the internal mails. Unfortunately, there is a second reason that makes the comparison more difficult. Due to technical problems we have no information about the dates when an academic of Ulm

University registered for a second round HDZ-course at another university that is part of the county wide didactic training program. Furthermore, we are not able to clearly identify the reasons why emails would have an effect. First, an email might work as a reminder. Second, sending emails implies a switch in the medium used to transmit information.

Due to the reasons mentioned above, we show descriptive illustrations instead of presenting any statistical tests concerning the effect of emails on registrations. Figure III.2 shows the registration timeline for the first round and Figure III.3 shows the registration timeline for the second round. For the sake of visualization, the coloured bars in these two figures show a two weeks time period after internal mails or emails were sent.

In both rounds one can see that the peak of registration occurred very early after the internal mails were sent. After the early weeks, the first round registration appears more equally distributed than the second round registrations. In the first round 9 out of a total of 47 persons registered in the two weeks after the email was sent. As one can see in Table III.9 at the time the first email was sent only four courses were left instead of 10 at the beginning of the first round. Carefully interpreted, this would suggest that there was an effect of the first email. On the other hand when the second email was sent in the second round, an academic could possibly take part in 7 courses at Ulm University. With only 2 registrations in a time period of two weeks after the email was sent it does not seem that this email worked as a reminder or a far better way of transmitting information.⁵ In the time period of two weeks after the third email was sent three more academics signed up for the remaining two courses. Due to these very few observations we cannot interpret this finding.

Concerning the email reminders we are not able to secure a possible statement based on statistical tests. We can only state that it is possible that our reminder emails caused few more registrations.

⁵ Maybe academics were not able to make a decision because they had too many choice opportunities in the case of 7 remaining didactic training courses. See e.g. Kuksov and Villas-Boas (2010) for the effect that the number of choices can have on consumer decisions.

Figure III.2: Registration timeline first round

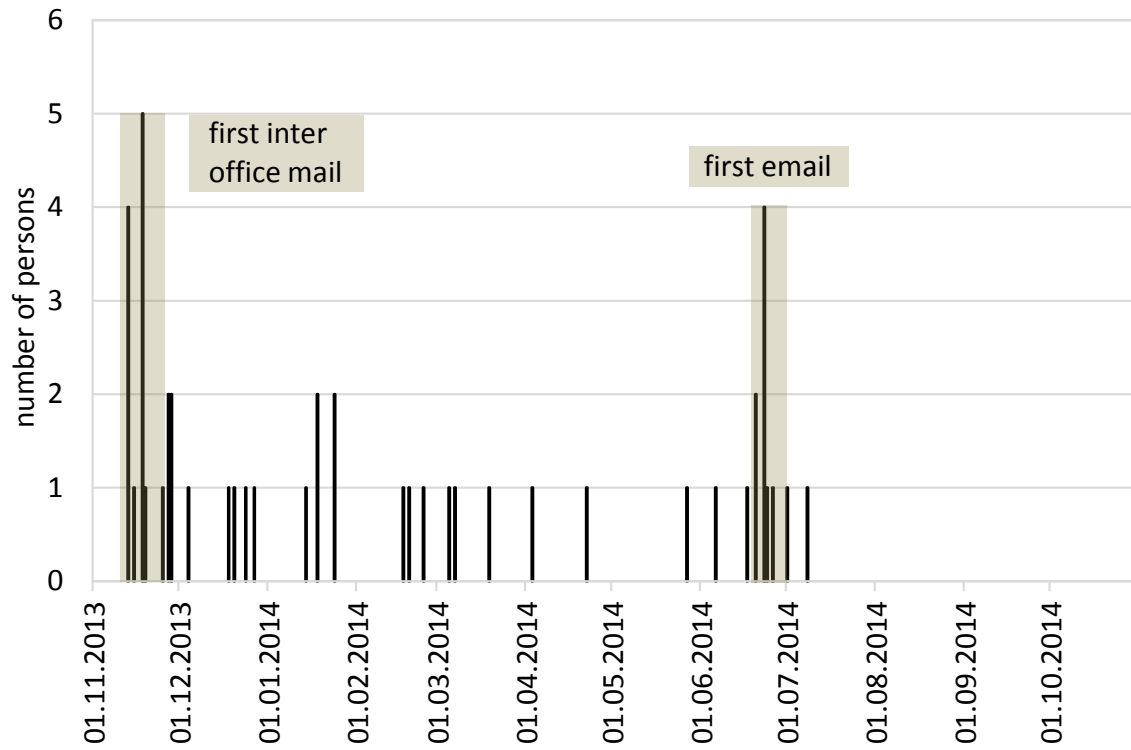
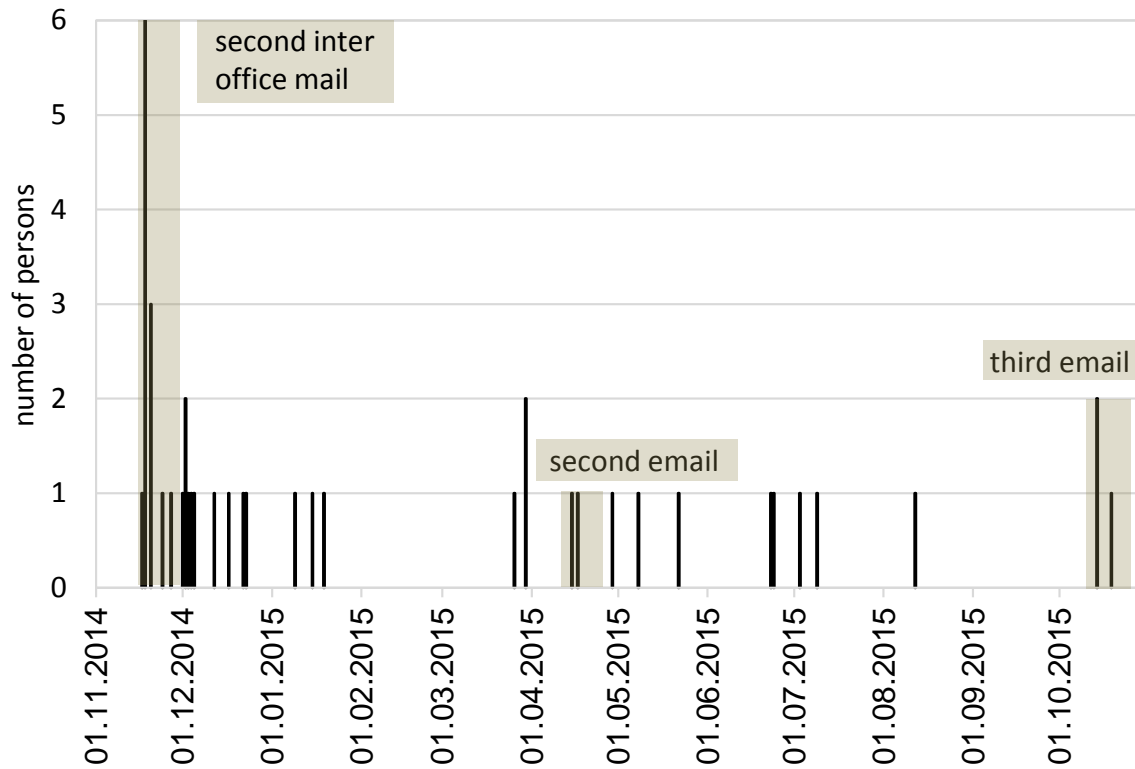


Figure III.3: Registration timeline second round



III.4 Conclusion

In this paper we wanted to examine whether an information about the market value of didactic courses at Ulm University can increase participation. Therefore, we calculated an average course value of comparable private sector training courses. One sentence in addition to the usual text in the internal mail informed members of the treatment group that the average price of comparable private sector didactic courses amounts to 375 Euro per course day.

The main caveat of this study is that a low overall number of participants in didactic training precludes statistically safeguarded statements on the effect of our informational nudge. Logistic regression estimates are accompanied by large confidence intervals causing statistically inconclusive effects. Nevertheless, we discuss some more nudges that could be used to increase training participation in comparable environments.

One could think of a nudge that catches the attention of academics by dealing with specific contents, e.g. a sentence like "Do you also have too noisy students in your classroom? - Didactic courses can help you keep them silent. For further information contact ...". This nudge could decrease transaction costs for academics because they would not have to search the program leaflet for personally relevant courses. Simple referring to a course leaflet or showing course titles like in our study could be of too little relevance. Academics might not recognize the relevance of the issues for themselves. Displaying specific content on the other hand could catch the attention of academics and also show that the didactic courses have a clear added value.

Maybe academics are more motivated by non-financial incentives than by monetary incentives. In this sense hierarchical incentives could be powerful, e.g. a sentence like "I as the president of Ulm University advise you to participate in courses of the HDZ-program." or the same sentence written by the head of faculty or head of department could address the preference for hierarchy of academics. In this case it is also important that the president or head of department signs the letter. This type of nudge contains a clear message from superiors that they support didactic training.

Another nudge could focus on short supply. "Please register soon because otherwise your favored course could be booked out." Academics could fear that others are also interested in the course and register earlier themselves. This nudge might trigger them to sign in as soon as possible to get accepted.

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III.A Cover letter with and without nudge



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Frau
Prof. Dr. Martha Mustermann
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Arbeitsstelle Hochschuldidaktik Ulm
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Ulm, im November 2013

Jahresprogramm 2014 des HDZ

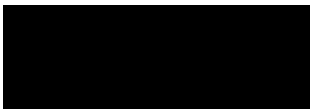
Liebe Frau Prof. Dr. Mustermann,

auch im Jahr 2014 laden wir wieder herzlich dazu ein, an unserem hochschuldidaktischen Workshopprogramm teilzunehmen.

Unser Programm (www.hdz-bawue.de) bietet Ihnen Workshops, in denen Sie sich mit hochschuldidaktischen Modellen und Methoden auseinandersetzen und Anregungen für Ihre Lehre bekommen. Zudem haben Sie die Möglichkeit, das Baden-Württemberg-Zertifikat für Hochschuldidaktik zu erwerben.
Für vergleichbare Kurse würden Sie außerhalb des von den baden-württembergischen Universitäten geförderten HDZ-Programms etwa 375 Euro pro Workshoptag bezahlen.

Hiermit schicken wir Ihnen den Programmflyer zu und würden uns freuen, Sie im Rahmen unseres Angebots begrüßen zu dürfen.

Mit freundlichen Grüßen,



Dipl.-Päd. Cornelia Gutmann
(Leiterin Arbeitsstelle Hochschuldidaktik in Ulm)



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Ulm, im November 2013

Jahresprogramm 2014 des HDZ

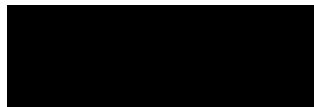
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Mit freundlichen Grüßen,



Dipl.-Päd. Cornelia Gutmann
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III.B Course comparison

This part of the Appendix provides an overview over private sector courses that are comparable to the didactic training courses from the 2013/2014 HDZ-program (first round) at Ulm University. The tables on the next pages show for each of the nine different courses of the 2013/2014 HDZ-program at Ulm University at least four comparable private sector courses.

On the top of each table there is the bold written original German title of the corresponding course. Behind the German course titles one can find the course IDs in parentheses. Furthermore, our English translations of the German course titles can be found in the parentheses under the German course titles.

The left column of each table displays the provider of the corresponding training course as well as the internet source we used to browse and find this course. In the middle column of each table we wrote the original course title in German. The column "information" on the right side of each table informs the reader about the number of days, the number of hours (if available) and the total costs of each private sector course.

Provider / Source	Titel of comparable course in German (english translation)	Information
Fit für die Lehre - Hochschuldidaktische Grundlagen 1+2 (UL-14-01 und UL-14-02) (Didactical Fundamentals)		
Manager Institut www.semigator.de	Lern - und Arbeitstechniken - Basis (learning and working techniques)	2 course days: no duration information 1356.60 Euro
WEKA MEDIA GmbH & Co.KG Training & Consulting GmbH www.kursfinder.de	Train the Trainer	3 course days: no duration information 1779.05 Euro course materials and food is included
MB Manfred Bier Personalentwicklung + Training www.semigator.de	Train the Trainer	2 course days: 14 hours in total 428.40 Euro
Hermannsen Concept www.kursfinder.de	Train the Trainer	2 course days: no duration information 1130.50 Euro course materials, beverages and food is included

E-Learning für Einsteiger - Vom Konzept zum Lernobjekt (UL-14-03)
(E-Learning for Beginners)

Integrata AG www.semigator.de	Strategien zur Einführung von E-Learning (Getting started with E-Learning)	1 course day: 8 hours 535.50 Euro
Haufe Akademie GmbH & Co.KG www.semigator.de	E-Learning erfolgreich einführen und einsetzen (Getting sucessfully started with E-Learning and implement it)	2 course days: 15.5 hours in total 1487.50 Euro
Infoport Die E-Learning Agentur google: E-Learning Agentur	Workshop: Aufbau einer Online-Akademie (Workshop: Building an Online Academy)	1 course day: no duration information 1130.50 Euro Inhouse event
Elisabeth Ebert www.semigator.de	Erfolgreiche Online-Veranstaltungen - vom Konzept zur professionellen Durchführung (Successful online events)	1 course day in class: 6 hours + a minimum of 2 online-phases 1322.09 Euro

Gekonnt präsentieren in der Lehre und bei wissenschaftlichen Vorträgen (UL-14-04)
(Presenting skillfully in the classroom and at scientific lectures)

Consulting Excellence www.semigator.de	Präsentationstraining: professionell überzeugen (Presentation training: convince professionally)	2 course days: 16 hours in total 1166.20 Euro
IKARUS www.semigator.de	Präsentationstraining (Presentation training)	1 course day: 7.5 hours 702.10 Euro
stw unisono consulting www.weiterbildung.de	Erfolgreich präsentieren (Presenting successfully)	3 course days: 24 hours in total 1178.10 Euro
Institut für Managemententwicklung www.semigator.de	Ueberzeugend präsentieren (Presenting convincingly)	2 course days: no duration information 1416.10 Euro
Haufe Akademie GmbH & Co.KG www.kursfinder.de	Präsentation Grundlagentraining (Basic training in presenting)	2 course days: 16 hours in total 1487.50 Euro

demos www.kursfinder.de	Rhetorik und Präsentation (Rhetoric and presentations)	2 course days: 14 hours in total 1332.80 Euro
Akademie Messe Frankfurt www.kursfinder.de	Präsentieren mit Erfolg (Presenting successfully)	2 course days: no duration information 1416.10 Euro
IFM Institut für Managementberatung www.kursfinder.de	Professionell Präsentieren (Presenting professionally)	2 course days: 14 hours in total 1249.50 Euro

Selbst-, Stress- und Ressourcenmanagement im Hochschulalltag (UL-14-05)
(Self-, stress- and resource management at the university)

Selectes GmbH www.semigator.de	Zeitmanagement und Selbstmanagement für Führungskräfte (Time- and self management for managers)	1 course day: 8 hours 702.10 Euro
avio GmbH www.semigator.de	Selbst- und Zeitmanagement (Self- and time management)	1 course day: 8 hours 809.20 Euro
CoBeTraS Akademie www.semigator.de	Zeit- und Selbstmanagement Erfolgsfaktor Zeit - Persönliche Effizienz (Time- and self management - time as a factor of success)	2 course days: 15 hours in total 975.80 Euro
arowa www.semigator.de	Selbstorganisation & Zeitmanagement (Kompakt-Seminar) (self-organization and time management - a com- pact seminar)	1 course day: 8 hours 654.50 Euro

Modul Training www.semigator.de	Zeit- und Selbstmanagement: Steigerung der persönlichen Effektivität (Time- and self management - enhancing personal efficiency)	2 course days: 15 hours in total 975.80 Euro
Forum für Führungskräfte GmbH www.kursfinder.de	Zeitmanagement und Selbstorganisation (Time management and self-organization)	2 course days: 16 hours in total 1541.05 Euro
Consulting Excellence www.kursfinder.de	Aktives und effektives Zeit- und Selbstmanagement für Führungskräfte (Active and efficient time- and self-management for managers)	2 course days: no duration information 1285.20 Euro
Villeroy & Boch AG Global Academy www.kursfinder.de	Arbeitsorganisation und Zeitmanagement: Mehr Erfolg durch mehr Zeit (Work organization and time management - more success by more time)	2 course days: no duration information 523.60 Euro

Presenting in English (UL-14-06)

Haufe Akademie GmbH & Co.KG www.kursfinder.de	Presenting in English - Training	2 course days: 15.5 hours in total 1535.10 Euro
demos GmbH www.semigator.de	Delivering Effective Presentations in English	2 course days: 16 hours in total 1332.80 Euro
FORUM Institut für Management GmbH www.semigator.de	Perfect Presentations	1 course day: no duration information 1142.40 Euro
Akademie Messe Frankfurt www.kursfinder.de	Effective Presentations in English	2 course days: no duration information 1416.10 Euro
Comelio GmbH www.managerseminare.de	presentation skills - Präsentieren auf Englisch (Presentation skills - presenting in English)	1 course day: no duration information 892.50 Euro
English & Intercultural Communication www.semigator.de	Präsentieren in Englisch (Presenting in English)	2 course days: 16 hours in total 702.10 Euro

Führungsakademie
Rhein-Neckar
www.weiterbildung.de

Excellent Presenting

2 course days: 16 hours in total
1154.30 Euro



Social media (UL-14-07)

Integrata AG
www.semigator.de

Social Media Enterprise

1 course day: 8 hours
535.50 Euro

eMBIS GmbH
www.semigator.de

Social Media in der Praxis
- von Blogs, Xing & Facebook bis Twitter & Co.
(Social Media in practice - blogs, xing, facebook
and twitter)

2 course days: 16 hours in total
1047.20 Euro

Macromedia GmbH
www.semigator.de

Social Media Strategie und Konzepte
(Social media - strategy and concepts)

1 course day: no duration information
450.00 Euro

AKAWA
www.semigator.de

Social Media

2 course days: 14 hours in total
1547.00 Euro

Akademie messe Frankfurt
www.kursfinder.de

Social Media Crashkurs
(Social media - a crash course)

1 course day: 7.5 hours
821.10 Euro

Integrata AG
www.kursfinder.de

Social Media und Projektmanagement
(Social media and project management)

1 course day: no duration information
1118.60 Euro

Umgang mit schwierigen Situationen (UL-14-08)
(Dealing with difficult situations)

Modul Training www.semigator.de	Konfliktmanagement: Konflikte erkennen - Konflikte lösen (Conflict management - realize and solve conflicts)	1 course day: no duration information 499.80 Euro
English & Intercultural Communication www.semigator.de	Konfliktmanagement - Konflikte erkennen und lösen (Conflict management - realize and solve conflicts)	2 course days: 16 hours in total 1059.10
demos GmbH www.semigator.de	Konfliktmanagement - Mehr Konfliktkompetenz im Beruf (Conflict management - more conflict skills in the job)	2 course days: 16 hours in total 1332.80 Euro
Comelio GmbH www.semigator.de	Konfliktmanagement - Konfliktlösung und Mediation (Conflict management - solving conflicts and me- diation)	1 course day: 7.5 hours 892.50 Euro

Akademie Messe Frankfurt www.kursfinder.de	Konfliktmanagement (Conflict management)	2 course days: 15.5 hours in total 1416.10 Euro
IHK Rhein-Neckar www.kursfinder.de	Konfliktmanagement - Mit Konflikten konstruktiv umgehen (Conflict management - handling conflicts constructive)	2 course days: 16 hours in total 440.00 Euro
IFM Institut für Managementberatung www.kursfinder.de	Konfliktmanagement (Conflict management)	2 course days: 14 hours in total 1130.50 Euro

Evaluationen und Feedbackverfahren in der Lehre (UL-14-09)

(Evaluation and feedback in teaching)

demos GmbH www.semigator.de	Gekannt Feedback geben und annehmen (Give and take feedback skilfully)	2 course days: 16 hours in total 1332.80 Euro
Haufe Akademie GmbH & Co.KG www.semigator.de	Erfolgreiche Mitarbeiterbefragungen (Successful employee survey)	1 course day: 8 hours 821.10 Euro
EW Medien und Kongresse ww.semigator.de	Der richtige Umgang mit Ärger und Kritik (Dealing with anger and critique)	1 course day: no duration information 1178.10 Euro
carpe verbal! www.managerseminare.de	Feedback sinnvoll geben und gelassen (an-)nehmen (Give and take feedback calmly)	2 course days: no duration information 963.90 Euro

Mündliche Prüfungen gestalten (UL-14-10)

(Design of oral exams)

Due to low relevance in the corporate sector we decided to compare this course with recruiting courses

Konhardt & Partner www.semigator.de	Recruiting - Erfolgreiche Personalauswahl und Interviewmethoden (Recruiting - Successful selection of personnel)	1 course day: 8 hours 702.10 Euro
Integrata AG www.semigator.de	Erfolgreiche Bewerberauswahl (Successful recruiting)	3 course days: 18 hours in total 1749.30 Euro
ak Training + Beratung GmbH www.semigator.de	Bewerberauswahl / Interviewtechniken (Recruiting and interviews)	2 course days: 15 hours in total 833.00 Euro
Haufe Akademie GmbH & Co.KG www.kursfinder.de	Bewerberinterviews professionell führen (Professional recruiting)	2 course days: 15.5 hours in total 1487.50 Euro
demos GmbH www.semigator.de	Bewerbergespräche professionell führen (Professional recruiting)	2 course days: 16 hours in total 1332.80 Euro

WBS Training AG www.managerseminare.de	Das Einstellungsinterview bei der Personalauswahl (Interviews and recruiting)	2 course days: no duration information 1166.20 Euro
Personal Training Christine Pfeiffer www.managerseminare.de	Bewerberinterviews erfolgreich führen (Successful recruiting)	1 course day: no duration information 702.10 Euro
Dittmann consulting www.semigator.de	Beurteilungskompetenz für Fach- und Führungskräfte (2tg.) (Evaluation competencies for managers)	2 course days: 14 hours in total 1059.10 Euro

III.C Calculating conservative mean course day value

This section of the Appendix provides information about the calculation of the value of an average HDZ-course at Ulm University. We calculated this value for the first round (2013/2014) and maintained this value in the second round.

In a first step, we normalized the total price of each course to per-hour values. We assumed each workshop to last 8 hours a day if no duration information was available. In a next step, we multiplied the per-hour values by 8 hours to get per day values. In a last step we build the average of all minimum course values to assure that we did not overestimate the average private sector course price.

Table III.C.1 shows our method to calculate the conservative value of **one** course. We applied this method to all first round courses. We use course UL-14-06 ("Presenting in English") as an illustrative example in Table III.C.1.

Table III.C.1: **Calculation of one conservative course value**

provider	total price	number of days	total hours	price per hour	price per day
Haufe Akademie	1535.10	2	15.5	99.04	792.31
demos	1332.80	2	16.0	83.30	666.40
Forum	1142.40	1	8.0*	142.80	1142.40
Messe Frankfurt	1416.10	2	16.0*	88.51	708.05
Comelio	892.50	1	8.0*	111.56	892.50
English & Inter.	702.10	2	16.0	43.88	351.05
Führungsakadem.	1154.30	2	16.0	72.14	577.15
Minimum price per day:					351.05

*we assumed 8 hours per day if no duration information was available. All monetary values in Euro.

Providers as well as total prices can also be found in the corresponding table to UL-14-06 in Appendix III.B. We normalized courses that last for two days to an eight hour course day for better comparability. After that we searched for the minimum price per course day and rounded the corresponding value to the nearest full Euro value.

This method was applied to all ten courses from the HDZ 2013/2014 (first round) program. Table III.C.2 shows all the ten minimum course values as well as the average course value.

Table III.C.2: **Calculation of conservative mean course value**

course id	minimum price per day
UL-14-01 and UL-14-02	244.80
UL-14-03	535.50
UL-14-04	392.70
UL-14-05	261.80
UL-14-06	351.05
UL-14-07	450.00
UL-14-08	220.00
UL-14-09	481.95
UL-14-10	444.27
mean course value:	375.79

All monetary values in Euro.

The average of the minimum course prices per day is 375.79 Euro. We rounded this value down to the nearest Euro value of 375 because we thought this value is more convenient than 376 Euro. This approach should cause no problems because we stayed honest telling the treatment group that a comparable outside workshop costs "etwa" (English translation: approximately) 375 Euro.

Chapter IV

Harsher leverage ratio requirements can keep banks from leveraging up leverage ratio requirements

IV.1 Introduction

The recent Financial Crisis demonstrates that the banking system has not been robust against tail risks. The reasons for this circumstance are wide-ranging and solutions are searched to implement a stronger financial system. One out of many improvement suggestions can be found in the BASEL III requirements. Thereby, banking supervision aims to improve stability of the banking system mainly by imposing harsher and therefore higher capital ratios. Those higher capital ratios refer to risk-sensitive instruments like the ratio of capital to risk weighted assets as well as risk-insensitive instruments like a leverage ratio restriction.

One proposal from the BASEL III framework demands a maximum leverage (see Basel Committee on Banking Supervision (BCBS) 2014). In a perfect world, all banks honestly implement this requirement. However, what if banks in reality simply use accounting choices or even manipulate their balance sheets to pretend that they reach the required capital ratio. Based on this consideration, this study theoretically examines how leverage ratio requirements affect the incentives for accounting choices and accounting manipulation.

Although accounting standards evolve and loopholes get closed, there are still examples of banks that misreport. Thus, the Bank of America was fined by the Securities and

Exchange Commission (SEC) to pay 7.65 million dollars since it overstated regulatory capital (SEC 2014). Furthermore, the Deutsche Bank understated derivative losses during the financial crises and got fined by the SEC to pay 55 million dollars (SEC 2015a). Instead of reporting losses of 25.6 million dollars in 2011, the Trinity Capital Corporation (some of their executives, respectively) reported income of 4.9 million dollars using loan loss provisions and allowances (SEC 2015b). This list still goes on.

There are some theoretical studies concerning the relationship between misreporting incentives and leverage ratio restrictions.¹ Most of these studies evaluate a leverage ratio restriction as a stabilizing instrument since it can decrease incentives to misreport risk weights. Following these studies, the leverage ratio restriction itself seems to be invulnerable against accounting leeway or the possibilities to misreport. My claim is that the stated leverage ratio can be manipulated, too. In this sense, the present paper supports the claim of Mariathasan and Merrouche (2014) as they wrote in their conclusion:

”The new leverage constraint [...] is defined as a requirement relative to total exposure, where total exposure encompasses off-balance-sheet items and conversion factors. The definition of these factors is also subject to judgment calls, and it is unclear whether the efficacy of the requirement, is not undermined by new opportunities for regulatory arbitrage.”

Mariathasan and Merrouche (2014, p. 318).

This paper presents a theoretical model of a profit maximizing representative bank with limited liability that can decide to which extent it overstates regulatory capital to bypass leverage ratio requirements. Manipulating stated capital provides the opportunity of higher leverage effects and thus higher expected profits. Intuitively, one might think that higher regulatory capital requirements lead to higher incentives to bypass them. However, the main result from the model presented in this paper is that a harsher leverage ratio restriction *decrease* incentives to make use of accounting choices or accounting manipulation.

This paper is structured as follows: An overview over related literature is presented in chapter IV.2. Chapter IV.3 contains the baseline model environment as well as the formal relationship between a minimum risk-insensitive capital ratio imposed by the regulator, i.e. a leverage ratio restriction, and the expected profit function of a representative bank. Chapter IV.4 investigates how a leverage ratio restriction changes the bank’s incentive to

¹ See e.g. Blum (2008), Rugemintwari (2011), Kowalik (2013), Colliard (2014) and Wu and Zhao (2016). These and other studies are presented in chapter IV.2.1.

make use of accounting tricks. After a short discussion of policy implications in chapter IV.5, this paper ends with a conclusion in chapter IV.6.

IV.2 Related literature

This section presents an overview of literature concerning the relationship between leverage ratio restrictions and banks' incentives to take risk or to "game"² the regulator. Chapter IV.2.1 deals with theoretical models, while chapter IV.2.2 presents an overview of recent empirical studies concerning the main issue of this paper.

IV.2.1 Theoretical models

To the best of my knowledge, the first theoretical model that discusses regulatory leverage ratio restrictions is provided by Blum (2008). This claim is supported by Blum (2008), as he wrote:

"it is surprising that there is no formal analysis about the pros and cons of such a regulatory arrangement [a leverage ratio restriction]. This paper is trying to start to fill this gap."

Blum (2008, p. 1699).

Roughly, Blum's (2008) model includes safe and risky banks and a regulator which is not able to identify safe and risky banks due to asymmetrically distributed information. Furthermore, banks are obliged to meet risk-sensitive capital requirements based on their asset risks. Since capital is costly, risky banks try to avoid capital costs by acting like they were safe banks. As a consequence, risky banks only have to hold as much capital as safe banks. Following Blum (2008), the regulator can increase the stability of the banking system by adding a leverage ratio restriction to the existing risk-sensitive capital requirements. In this case, risky banks have lower incentives to fake due to two reasons: First, the potential gains from acting like a safe bank decrease as a leverage ratio restriction puts a cap on maximum leverage. Second, if the untruthful behavior is revealed ex post, risky banks have more "skin in the game"³. As a result, an additional leverage ratio

² "Gaming" the regulator means that a bank uses leeway in valuation models or in accounting standards to bypass official regulations. The term "regulatory arbitrage" is also very similar to "gaming". In addition, some of the models also take (illegal) misreporting of risk weighted assets into account.

³ The phrase "skin in the game" is a metaphor for the amount of capital a bank can lose in the case of failure or bankruptcy.

restriction that complements risk-based capital requirements makes the banking system more stable. The model of Blum (2008) was in a certain manner a seminal work as he provided a rationale for a leverage ratio limitation in capital regulation. Furthermore, banking supervision proved Blum (2008) right as they implemented a maximum leverage ratio in the Basel III framework.

Rugemintwari (2011) also concluded that adding a leverage ratio restriction to risk-sensitive capital requirements lowers banks' incentives to cheat the regulator by understating asset risks. In comparison to Blum (2008), Rugemintwari (2011) explicitly models the portfolio structuring decision of a representative bank. This bank can decide to which extent it invests into risky assets. Since risky assets are accompanied by higher costly capital weights than low risk assets, the bank can save capital costs by overstating the share of low risk assets. Furthermore, Rugemintwari (2011) takes a bank's cheating ability as well as the regulator's severeness of penalizing this untruthful reporting into account. He found that a leverage ratio restriction restricts the bank's incentive to misreport its risk to fewer cases in comparison to a situation without leverage ratio restrictions. This effect is stronger when the leverage ratio restriction becomes binding but it also holds when the leverage ratio restriction is not binding. Based on his theoretical considerations, Rugemintwari (2011) concluded that a leverage ratio restriction lowers the representative bank's incentives to understate its asset risks and therefore to misreport.

In the meantime, further theoretical models raised doubts to the unambiguous usefulness of leverage ratio limitations. Kiema and Jokivuolle (2014) argue that the benefit of a leverage ratio restriction depends on, among other things, the specific value of the maximum allowed leverage ratio since they show that too small leverage ratio restrictions⁴ *can* lead to more instability in the banking system. A leverage ratio restriction that becomes binding for a conservative bank with low asset risks puts pressure on this bank to increase asset risks in order to bear higher capital costs as long as the risk-sensitive capital requirement becomes binding (again). Therefore, loan portfolios of conservative and risky banks mix up and become more similar. Kiema and Jokivuolle (2014) argue that a relatively small leverage ratio restriction can reduce banking stability. Thereby, they put emphasize on unexpected "internal ratings based" (IRB) model risks either in the case of low-risk assets or concerning risky assets. Although mixed portfolios increase banking stability via diversification, unexpected tail risks now can contaminate more

⁴ Following their model, Kiema and Jokivuolle (2014) state that a relatively small leverage ratio restriction (like in the BASEL-III leverage ratio requirements) lies below the average risk-sensitive capital ratio.

banks than in a situation without a leverage ratio restriction. This contamination effect overcompensates the stabilizing portfolio diversification effect at most in the case of a too small leverage ratio restriction in combination with unexpected IRB model risks concerning high-risk assets. Furthermore, welfare losses due to contamination can also occur in the case that unexpected IRB model risks refer to low-risk assets when model risks are sufficiently high. As a result, Kiema and Jokivuolle (2014) declare themselves in favour of sufficiently high leverage ratio restrictions. Although Kiema and Jokivuolle do not deal with misreporting or untruthful behavior, their model is of great importance to understand the fundamental problem of a leverage ratio restriction namely that it incentivises low-risk banks to increase their asset risks when the leverage ratio restriction becomes binding for them.

Colliard (2014) warns of unintended consequences of maximum leverage ratios, too. Leverage ratio restrictions stop banks with high leverage ratios from lending when the leverage ratio restriction becomes binding. This *ceteris paribus* restricts total lending in the whole economy and thus puts upward pressure on the interest rate. What then will happen depends on the interest elasticity of credit demand. If credit demand remains sufficiently high, then banks with smaller leverage ratios face profit opportunities. In this case they behave dishonest and understate their asset risks. As a consequence, they get regulatory allowance to expand lending and face higher risks than before. This result is contrary to the intended increase of a higher degree of financial stability (Colliard 2014, pp. 15-16). Colliard's (2014) theoretical result is backed up by the Swedish banking supervision authority "Finansinspektionen", which wrote:

"If non-risk-sensitive capital requirements – such as a leverage ratio requirement or standardised floor – are set at a level that makes them the binding capital restriction, Sweden may end up with a smaller, but riskier banking system."

Finansinspektionen (2015, p.1).

On the other hand, Grill, Lang and Smith (2015) reach the result that the stabilizing effect of a reasonable⁵ leverage ratio restriction overcompensates the higher risk taking of conservative banks. This result is mainly explained by the idea that conservative banks are prevented from taking excessive risks by the risk-sensitive capital requirement that becomes binding in such a case. In other words, conservative banks that are constrained

⁵ Grill, Lang and Smith (2015, p. 16) restrict their main finding to sufficiently small leverage ratio restrictions.

by the leverage ratio restriction increase their risky assets until a specific threshold at which risk-sensitive capital requirements constrain them. Additionally, the "skin in the game"-effect is also present in Grill, Lang and Smith (2015). Furthermore, Grill, Lang and Smith (2015) are the first who provide empirical evidence for their theoretically derived claims based on a large sample of European banks.

Kowalik (2013) investigated the incentives for banks to misreport their risk weight assets in a regulatory environment with a leverage ratio restriction, too. He found that the ability of a leverage ratio restriction to stabilize the banking system depends on whether secondary markets for bank assets exist or not. Instead of distinguishing between low-risk and high-risk banks, Kowalik (2013) distinguishes low-value banks (with high risk-sensitive capital requirements) from high-value banks (with low risk-sensitive capital requirements) in a situation without leverage ratio restrictions. As in other former models like in Rugemintwari (2011), low-value banks can save costly capital by misreporting. If secondary markets for bank assets exist, low-value banks get a second incentive to misreport since they can sell their assets at higher prices than they are actually worth, see Kowalik (2013, p.5) for the intuition. Under certain circumstances, e.g. sufficiently low welfare losses due to less transparency (Kowalik 2013, p. 6), a leverage ratio restriction can improve the stability of the banking system when a secondary market is present.

Bruno, Cartapanis and Nasica (2013) also investigated the role of a leverage ratio restriction concerning financial stability. In their theoretical analysis they conclude that a leverage ratio limitation that maximizes financial stability varies over the business cycle. Although Bruno, Cartapanis and Nasica (2013) did not take accounting leeway or financial misreporting into consideration, their main result of a flexible leverage ratio restriction emphasizes the importance of my study. Under the assumption that banks are able to influence their stated leverage ratios, the stabilizing effect of flexible leverage ratio restrictions over the business cycle can disappear. In this sense, banks anticipate changes in leverage ratio restrictions due to macroeconomic changes and simply adopt their financial figures to comply with regulatory capital requirements.

Jarrow (2013) provides a theoretical framework to determine the value of an optimal maximal leverage ratio. Although Jarrow's (2013) work is of great importance for the leverage ratio literature, it is of less importance for the literature on the relationship between leverage ratio restrictions and accounting choices. This is due to the fact that Jarrow (2013) per assumption excluded accounting choices from his model as he wrote:

"We assume at the onset that truthful reporting is a non-issue due to regulatory monitoring."

Jarrow (2013, p. 973).

To the best of my knowledge, the most recent study concerning a leverage ratio requirement is provided by Wu and Zhao (2016). They give further support to the implementation of a leverage ratio restriction since they show that risk-sensitive capital requirements by oneself are not able to reach the best possible solution for capital regulation. Wu and Zhao (2016) distinguish between a short-run perspective in which banks cannot adjust their portfolio to regulatory changes⁶ and a long-run perspective in which banks can endogenously determine their asset portfolio. As Wu and Zhao (2016) wrote, the endogenous determination of the asset portfolio

”is not discussed in Blum (2008) and thus constitutes the main contribution of this article.”

Wu and Zhao (2016, p. 14).

Therefore, my reproduction of their study focus on the results concerning this approach. Banks themselves have to bear screening costs to divide safe and risky assets from each other. The main finding of Wu and Zhao (2016) is that a ”suitable” (Wu and Zhao 2016, p. 22) leverage ratio restriction induce welfare gains. A too high leverage ratio restriction can induce higher risks in the banking system, while a too small leverage ratio restriction can result in too few ”skin in the game”. The optimal leverage ratio requirement depends on the above mentioned screening costs and the amount of costs a bank has to bear if detected as cheater in combination with the regulator’s ability and enforcement power.

Although the above mentioned studies with their complex theoretical models are undoubtedly important for banking regulation, they all have one major shortcoming.⁷ A leverage ratio restriction seems to be invulnerable to misreporting, since misreporting is always modelled as an incentive to overstate asset values or understate asset risks. Thus, my contribution to the field of optimal capital requirements is the claim that banks are also able to misreport risk-insensitive capital requirements and that the incentives to misreport decrease with harsher leverage ratio restrictions. The results of my theoretical examination provides another reason why stricter leverage ratio restrictions can be beneficial.

⁶ This assumption seems tough since in reality regulatory changes are announced very early before they are finally implemented.

⁷ A minor shortcoming of these studies is that they do not clearly distinguish between the assets side and the liabilities side of a bank’s balance sheet. Leverage ratio restrictions are always modelled with regard to assets on the assets side instead of balance sheet total or instead of total exposure as mentioned by Mariathasan and Merrouche (2014, p. 318).

IV.2.2 Empirical studies

There are several studies which empirically investigated the relationship between regulatory capital requirements and the incentives for banks to use "regulatory arbitrage" or to "game".

Moyer (1990) carried out an empirical study on accounting choices in a sample of around 140 U.S. banks between 1981 and 1986. Moyer (1990) found that bank managers adapt loan loss provision to converge their bank's capital ratio to regulatory capital ratio in years where their bank's capital ratio was lower than regulatory required. Scholes, Wilson and Wolfson (1990) also found empirical evidence in the banking sector that

"is consistent with banks choosing to realize securities gains or defer losses that increase taxation so as to increase their regulatory capital [...]."

Scholes, Wilson and Wolfson (1990, p. 649).

Collins, Shackelford and Wahlen (1995) conclude that the extent to which banks react to incentives and therefore practice capital management depends on bank-specific characteristics. Beatty, Chamberlain and Magliolo (1995) extended empirical research on accounting choices by taking interactions between the accounting choice measures into account. They found further empirical evidence that banks practice capital management as shown by the following quote:

"Our evidence provides broad support for the hypothesis that deviating from capital [...] goals is costly, and that bank managers trade off accrual and financing discretion to meet these goals."

Beatty, Chamberlain and Magliolo (1995, p. 257).

All the above cited empirical investigations have in common that they were carried out in the "pre-BASEL" period (Beatty and Liao 2014, p. 361) and that they dealt with loan loss provisions as a measure for accounting choices. In the meantime, the BASEL requirements changed the treatment of loan loss provisions and loan loss allowances, respectively, in the following way:

"In contrast to the pre-BASEL period when capital ratios increased with provisions because loan loss allowances were included in regulatory capital, the

BASEL capital requirements eliminate loan loss allowances from the calculation of Tier 1 capital, so the Tier 1 capital ratio decreases with provisions in the new regime.”

Beatty and Liao (2014, pp. 361-362).

Beatty and Liao (2014) further stated:

”Identification of a separate earnings and regulatory capital motive was facilitated in the late 1980s (pre-BASEL) by the opposite effects of the provision on earnings versus regulatory capital calculations.”

Beatty and Liao (2014, pp. 361).

Therefore, Beatty and Liao (2014) pointed out that the ”pre-BASEL”-period was a suitable period to distinguish the effect of loan loss provisions on earnings versus capital management, while in the ”post-BASEL”-period the motivation of changes in loan loss provisions is not that clear. The loan loss provision measure was no longer a suitable candidate to empirically measure the extend to which banks practice capital management.

Although accounting standards set universal rules and therefore standardize, there are *still* some possibilities to use leeway in financial reporting. A recent study of Huizinga and Laeven (2012) found empirical evidence that U.S. banks used leeway in the valuation of assets during the Financial Crisis to move financial statement figures in the desired direction. Acharya, Schnabl and Suarez (2013) detected that commercial banks used asset-backed commercial paper conduits to bypass regulatory capital requirements. Mariathasan and Merrouche (2014) investigated a sample of 115 banks from OECD member states that switched to IRB approaches between 2007 and 2010. They found that the use of IRB approaches was accompanied by smaller stated values of risk weight assets. This effect was stronger for banks with high leverage.

A clear result from the above cited empirical studies is that banks, or to be more precisely their managers, used accounting leeway to practice capital management. Furthermore, bank managers opportunistically reacted to incentives provided by regulatory capital requirements.

IV.3 A simple baseline model of a bank

IV.3.1 The bank's balance sheet

In a very simple case, the balance sheet of a bank can be displayed as shown in Figure IV.1. Thereby, the liabilities side of the balance sheet consists of capital C and deposits D . Assume both banking supervision obliges a minimum capital ratio q_C of 10 percent and the bank pursues to reach the maximum possible leverage. In general, the capital ratio $q_C = \frac{C}{T}$ is defined as a share of capital C to balance sheet total T . Thus, a minimum capital ratio of 10 percent means that the share of capital to balance sheet total has to be at least 10 percent. With capital being normalized to 1 unit, we know that maximum balance sheet total amounts to 10 units. Since balance sheet total is the sum of capital and liabilities, we can see that the maximum permitted amount of liabilities (deposits, respectively) is the maximum balance sheet total minus capital and that is 9 units in this case.

Figure IV.1: **A simplified balance sheet of a bank**

Asset side		Liabilities side	
Various assets V	2	Deposits D	9
Investment I	8	Capital C	1
Balance sheet total T	10	Balance sheet total T	10

The assets side of the balance sheet displays how the bank uses its funds. In this case, the bank invests 80 percent of its balance sheet total in investment projects I . The remaining 20 percent are put in various assets V which consist of land and buildings, cash assets, goodwill assets and other asset side positions that are unequal to investment I .

IV.3.2 The bank's investment decision

We assume a risk-neutral bank that maximizes expected profits. For the sake of simplicity, we further assume that "various assets" V yield an interest rate of 0 percent and that its size V is fixed. As displayed in the bank's balance sheet in Figure IV.1, the bank can put the rest of the asset side into its "investment". Therefore, the bank's investment amount equals its balance sheet total minus "various assets", i.e. $I = T - V$. Since balance sheet total is the sum of capital C and deposits D , we can rewrite investment as $I = C + D - V$.

The investment project is risky, i.e. the rate of return of the risky investment project and therefore the profit out of the risky investment project depends on whether the project succeeds (with probability p) or not (with probability $1-p$). If successful, the risky investment project provides a high rate of return r^h . If the risky investment project fails, it solely delivers a low rate of return $r^l < r^h$. More formally, the return on the risky investment project can be written as follows:

$$\text{Rate of return of the risky investment project} = \begin{cases} r^h & \text{with probability } p \\ r^l & \text{with probability } 1 - p \end{cases}$$

We further assume that the bank always has to pay the interest rate r on its deposits, i.e. the leverage ratio and the risky investment does not affect the interest rate the bank has to pay for the borrowed capital.⁸

Thus, the actual profit of the bank depends on the state of the world, that means whether the project succeeds or not. In any case the bank has to pay the deposit interest rate r to the depositors. Let Π^h denote the bank's profit in the case of success and Π^l denote the bank's profit if the risky investment project failed. We can write the bank's profit subject to the investment as shown in Table IV.1.

Table IV.1: **Profits of the bank**

state	probability	profit
succeed	p	$\Pi^h = r^h(C + D - V) - rD$
failed	$1 - p$	$\Pi^l = \begin{cases} r^l(C + D - V) - rD & \text{if } r^l(C + D - V) - rD \geq -C \\ -C & \text{if } r^l(C + D - V) - rD < -C \end{cases}$

The third row of Table IV.1 shows two possible profit situations for the bank if the risky project fails. This is because in my model a bank can never loose more than its capital due to limited liability.⁹ If the risky project fails and the potential loss exceeds the bank's capital, then the bank is bankrupt and loses its whole capital. If, on the other hand,

⁸ We assume that asymmetrically distributed information, deposit guarantee funds and other government guarantees lead to an independence of the deposit rate from the bank's investment risks as well as from the bank's leverage ratio. See e.g. Admati et al. (2013, p. 21) for explicit or implicit government guarantees.

⁹ This assumption is due to the fact that in reality most relevant banks are capital companies and therefore their liability is limited to their capital.

the potential losses are lower than the capital of the bank, the bank can go on with its business activity.

For further simplification assume that the expected return of the risky investment r^e is always positive and greater than the deposit interest rate r , which is greater or equal zero. Putting these information together leads to the following equation

$$r^e = pr^h + (1 - p)r^l > r \geq 0. \quad (\text{IV.1})$$

Equation (IV.1) ensures that the expected rate of return of the risky investment r^e is always positive. Thus, the bank always expects positive profits by investing risky.

Furthermore, assume the rate of return if the risky project failed r^l is below the deposit interest rate r , i.e.

$$r > r^l. \quad (\text{IV.2})$$

Equation (IV.2) ensures that losses can occur. Without the possibility of losses there would be no need for capital regulation since the bank could never get bankrupt. Furthermore, limited liability only becomes an issue if equation (IV.2) holds.

Putting all my assumptions regarding the bank's investment decision together, i.e.

- profit maximizing risk-neutral bank
- limited liability
- returns and interest rates as in equation (IV.1) and equation (IV.2)
- the amount of capital C is fixed
- the amount of various assets V is fixed and $I = C + D - V$ will be invested,

we can formally display expected profits Π^e in the following equation

$$\begin{aligned} \Pi^e = & p[r^h(C + D - V) - rD] \\ & + (1 - p)[\max\{r^l(C + D - V) - rD; -C\}]. \end{aligned} \quad (\text{IV.3})$$

Differentiating expected profits Π^e with respect to the maximum amount of deposits D leads to

$$\frac{\partial \Pi^e}{\partial D} = \begin{cases} r^e - r > 0 & \text{if } r^l(C + D - V) - rD \geq -C \\ p(r^h - r) > 0 & \text{else} \end{cases} \quad (\text{IV.4})$$

As one can see in equation (IV.4), expected profits are strictly increasing in D regardless whether the bank gets bankrupt or not. Therefore, the profit maximizing bank always takes as much deposits as possible. Furthermore, the increase in expected profits with higher amounts of investment is higher if expected losses in case of project's failure exceed capital than in the case the bank is not bankrupt.¹⁰

IV.3.3 The role of the leverage ratio restriction

In the next step we should find a link between the minimum capital ratio q_C (i.e. the leverage ratio restriction) and the expected profits of the bank. By assuming fixed capital C as well as fixed various assets V and therefore investment $I = D + C - V$, the maximum level of investment depends on the maximum amount of deposits the bank is allowed to collect. In turn the absolute amount of contracted deposits depends on the required minimum capital ratio q_C . This dependency is shown more formally in the following equation

$$D = \left(\frac{1 - q_C}{q_C} \right) C. \quad (\text{IV.5})$$

As one can see in equation (IV.5), an increasing capital ratio q_C , i.e. a harsher leverage ratio restriction, leads to a smaller maximum amount of deposits D a bank is allowed to collect, while a decreasing capital ratio q_C , i.e. a softer leverage ratio restriction, leads to a higher maximum amount of deposits D .¹¹

Inserting equation (IV.5) in equation (IV.3) leads to¹²

$$\begin{aligned} \Pi^e = & p \left[r^h \left(\frac{C}{q_C} - V \right) - rC \left(\frac{1 - q_C}{q_C} \right) \right] \\ & + (1 - p) \left[\max \left\{ r^l \left(\frac{C}{q_C} - V \right) - rC \left(\frac{1 - q_C}{q_C} \right); -C \right\} \right]. \end{aligned} \quad (\text{IV.6})$$

¹⁰Appendix IV.A provides a proof of this proposition.

¹¹Chapter IV.B in the Appendix delivers a precise derivation of equation (IV.5) and also the first derivative of equation (IV.5) with respect to q_C .

¹²A detailed derivation of equation (IV.5) is presented in Appendix IV.C

The relationship between the expected profit and the minimum capital ratio can be derived by differentiating equation (IV.6) with respect to q_C :¹³

$$\frac{\partial \Pi^e}{\partial q_C} = \begin{cases} -\frac{C}{q_C^2}(r^e - r) < 0 & \text{if } r^l \left(\frac{C}{q_C} - V \right) - rC \left(\frac{1 - q_C}{q_C} \right) \geq -C \\ -p \frac{C}{q_C^2}(r^h - r) < 0 & \text{else} \end{cases} \quad (\text{IV.7})$$

According to equation (IV.7), an increasing minimum capital ratio leads to lower expected profits for the representative bank. This is due to the relationship between the minimum capital ratio and the maximum amount of deposits a bank can collect and thus invest. It is somehow a kind of leverage effect we can see here. Therefore, in my model the profit maximizing bank always chooses maximum leverage, i.e. the bank lowers the capital ratio until it reaches the minimum capital ratio as required by banking supervision.

Figure IV.2 illustrates profits as a function of the capital ratio q_C according to equation (IV.6).

Figure IV.2: **Profits as a function of minimum capital ratio**

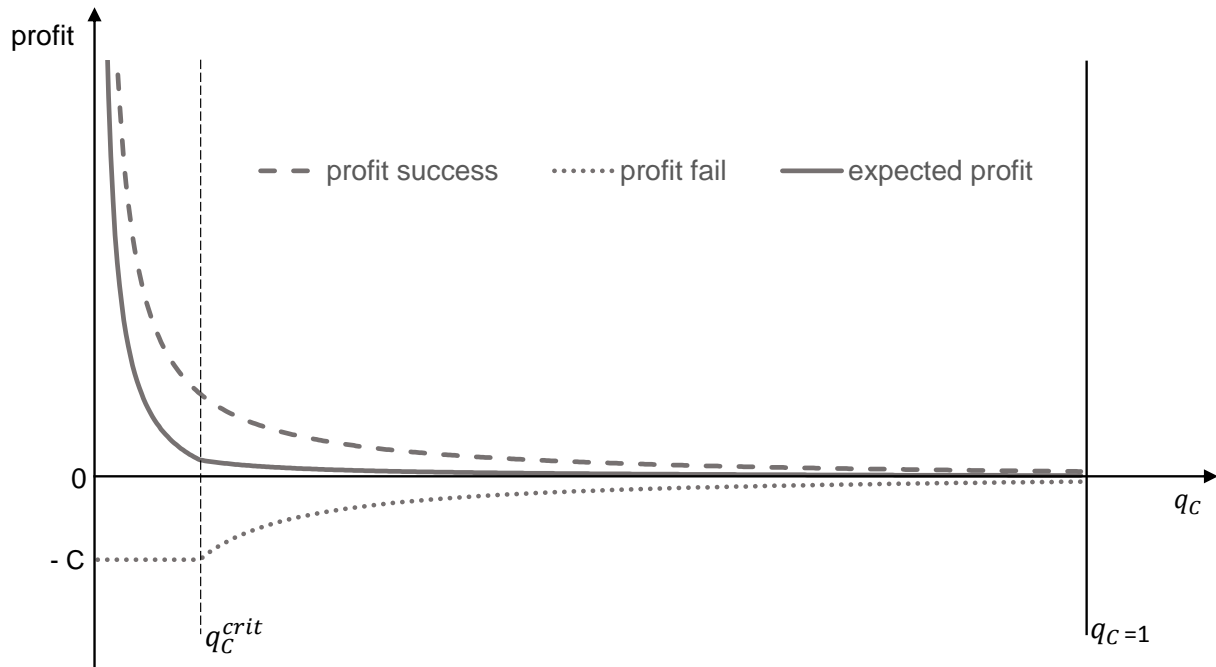


Figure IV.2 illustrates a simulation of the profit function from equation (IV.6) with the following parameters:

$p = 0,6$; $r^h = 0,1$; $r^l = 0$; $r = 0,05$; $C = V = 1$.

¹³For more information about the following equation see Chapter IV.D in the Appendix.

Three different types of profits are depicted in Figure IV.2. The solid line shows the expected profit function, while the dashed line shows profits in case of success and the dotted line displays profits if the investment project fails. As one can see in Figure IV.2, all three profit functions converge towards zero with an increasing minimum capital ratio. This is in line with my model since a harsher leverage ratio restriction implies that fewer outside capital works for the bank. The profit functions stop at a capital ratio of 1. This is due to the fact that a bank can never have more capital than balance sheet total. Nevertheless, we should mainly consider small capital ratios since they are more realistic provided that Basel III recommends a risk-insensitive capital ratio of 3 percent.

The most striking observation in Figure IV.2 is the straight line of the profit function at a certain threshold q_C^{crit} provided that the investment project failed. By reading Figure IV.2 from right to left one sees a symmetric course of profits in case of success and losses in case of failure until q_C drops below a critical level of q_C^{crit} . After this certain threshold q_C^{crit} is reached, losses equal capital due to limited liability but profits are still increasing in case of success. This leads to an asymmetric course of profits and losses for capital ratios below this certain threshold q_C^{crit} . There are two implications concerning this limited liability "break" that depend on the relationship between expected return on assets r^e and the interest rate on deposits r . Although there is a binding leverage ratio restriction, assume for a short moment that the bank is able to choose its capital ratio endogenous which is somehow the case when we allow for accounting tricks later on in this paper.

- $r^e > r$: if expected return on assets exceeds the interest rate on deposits, a risk-neutral bank always has an incentive to increase its leverage ratio (upper case of equation (IV.7)) but the limited liability offers a further incentive to increase the leverage ratio. A bank with a capital ratio below q_C^{crit} (lower case of equation (IV.7)) has a stronger increase in expected profits by expanding investment than with a capital ratio above q_C^{crit} .¹⁴ Furthermore, a bank that can "jump" from a capital ratio above q_C^{crit} to a capital ratio below q_C^{crit} has an additional incentive to increase its leverage ratio.
- $r^e = r$: even if expected return on assets would equal interest payments, the bank would have an incentive to reduce the capital ratio below q_C^{crit} . This is interesting since the main results in this paper also hold when expected return on assets equals the deposit interest rate.

¹⁴The proof is similar to the proof in Appendix IV.A.

Based on this considerations it is clear why in my model a bank always chooses as much leverage as possible.

IV.4 The simple banking model with accounting choices

In this chapter the bank gets the possibility to use accounting choices or even to manipulate its balance sheet (henceforth accounting tricks). Examples of accounting manipulation can be found in the introduction and examples of accounting choices can be found in those studies that are presented in the empirical literature in chapter IV.2.2. For the sake of simplicity, assume that the bank illegally states a higher value of some various assets and hence for its capital and vice versa. Figure IV.3 reveals this consideration into the simple balance sheet of the bank.

Figure IV.3: **Balance sheet of a bank that uses accounting tricks**

Asset side	Liabilities side
Various assets + Δ	Deposits + D_{Δ}
Investment + D_{Δ}	Capital + Δ
Balance sheet total	Balance sheet total

Consider, for example, that the use of accounting tricks leads to an increase in the stated value of various assets of Δ on the asset side of the balance sheet. As a result the stated capital of the bank also increases by Δ . Given any capital ratio q_C , a higher stated capital leads to a higher maximum amount of deposits the bank can collect. Explicitly the shift in the total amount of deposits D_{Δ} is given by

$$D_{\Delta} = \Delta \left(\frac{1 - q_C}{q_C} \right). \quad (\text{IV.8})$$

Since expected profits are strictly increasing in investment I , the bank can use accounting tricks to increase its expected profits. Thus, all additional deposits the bank now is allowed to collect will be put in the risky project. The expected profits $\tilde{\Pi}^e$ can now be written as¹⁵

¹⁵It is obvious that equation (IV.9) only serves as a theoretical intermediate step. The bank knows that it cannot invest the overstated capital since there is no real increase in its capital. However, the bank knows that it can invest additional deposits which the bank now is allowed to collect due to the overstated capital. Therefore, equation (IV.10) shows the real expected profits function from the bank's perspective.

$$\begin{aligned}\tilde{\Pi}^e &= p[r^h(C + \Delta + D + D_\Delta - (V + \Delta)) - r(D + D_\Delta)] \\ &\quad + (1 - p)[\max\{r^l(C + \Delta + D + D_\Delta - (V + \Delta)) - r(D + D_\Delta); -C\}].\end{aligned}\tag{IV.9}$$

Rewriting equation (IV.9) leads to

$$\begin{aligned}\tilde{\Pi}^e &= p[r^h(C + D + D_\Delta - V) - r(D + D_\Delta)] \\ &\quad + (1 - p)[\max\{r^l(C + D + D_\Delta - V) - r(D + D_\Delta); -C\}].\end{aligned}\tag{IV.10}$$

Inserting equation (IV.5) and equation (IV.8) in equation (IV.10) leads to

$$\begin{aligned}\tilde{\Pi}^e &= p\left[r^h\left(C + (C + \Delta)\left(\frac{1 - q_C}{q_C}\right) - V\right) - r(C + \Delta)\left(\frac{1 - q_C}{q_C}\right)\right] \\ &\quad + (1 - p)\left[\max\left\{r^l\left(C + (C + \Delta)\left(\frac{1 - q_C}{q_C}\right) - V\right) - r(C + \Delta)\left(\frac{1 - q_C}{q_C}\right); -C\right\}\right].\end{aligned}\tag{IV.11}$$

In a next step we want to investigate how expected profits are reacting to increases in the amount of accounting tricks Δ . Therefore, we differentiate equation (IV.11) with respect to Δ . This leads to the following result:

$$\frac{\partial \tilde{\Pi}^e}{\partial \Delta} = \begin{cases} \left(\frac{1 - q_C}{q_C}\right)(r^e - r) > 0 & \text{if } r^l(C + D + D_\Delta - V) - r(D + D_\Delta) \geq -C \\ p\left(\frac{1 - q_C}{q_C}\right)(r^h - r) > 0 & \text{else} \end{cases}\tag{IV.12}$$

As one can see, in either case expected profits increase with a higher extent of accounting tricks. Thus, from the perspective of the bank it would be rational to expand the amount of Δ .

In order to illustrate the above results, Figure IV.4 displays profits as a function of capital ratio according to equation (IV.10). Furthermore, Figure IV.4 shows two scenarios concerning accounting tricks: While the first scenario supposes no accounting tricks ($\Delta = 0$), the second scenario ($\Delta > 0$) does.

Figure IV.4: **Profits as a function of accounting tricks**

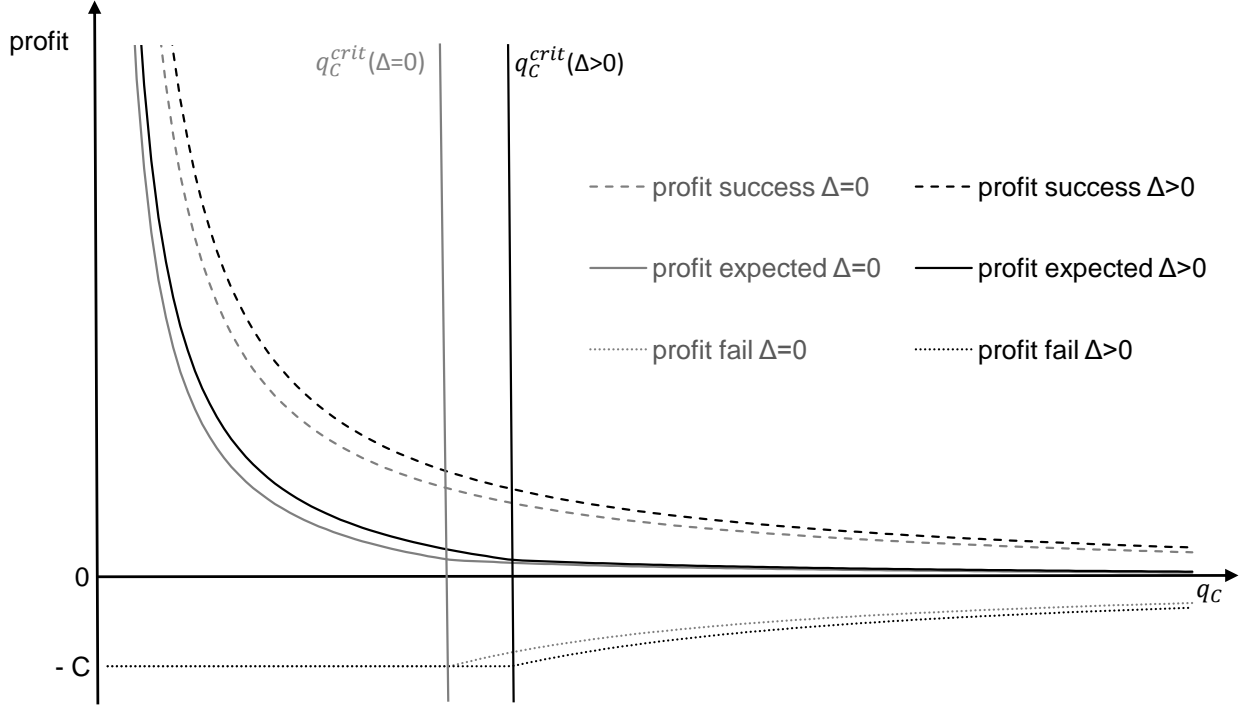


Figure IV.4 illustrates a simulation of the profit function from equation (IV.10) with the following parameters:
 $p = 0,6$; $r^h = 0,1$; $r^l = 0$; $r = 0,05$; $C=V=1$; $\Delta = 0,2$ if $\Delta > 0$ and $0 < q_C \leq 0.5$.

In accordance with the formal results from equation (IV.12), accounting tricks lead to higher expected profits.

Another interesting result is that limited liability starts at a higher official minimum capital ratio for banks that use accounting tricks than for their honest counterparts. The two vertical lines in Figure IV.4 display critical capital ratio thresholds dependent on the two accounting trick scenarios. If a bank has a capital ratio that is below the critical capital ratio, this bank can take advantage of limited liability. Under the assumption that a bank always chooses the minimal possible capital ratio, we have to restate the above statement: If banking supervision allows a capital ratio below the critical capital ratio, banks can take advantage of limited liability. Further assume a situation in which banking supervision requires a capital ratio that lies between $q_C^{crit}(\Delta = 0)$ and $q_C^{crit}(\Delta > 0)$. In this case, a bank that uses accounting tricks can take advantage of limited liability, while a bank that does not use accounting tricks cannot.

As found out formally, expected profits are higher when accounting tricks are used. This coherence especially emerges when a bank takes advantage of limited liability. This insight can be seen on the left hand side of the critical capital ratios in Figure IV.4.

IV.4.1 The relationship between the minimum capital ratio and accounting tricks

The main question of this paper is whether banking supervision can change the incentives to use incautious accounting tricks concerning risk-insensitive leverage ratio restrictions. As seen in the section before, the minimum capital ratio affects the maximum deposits-to-capital ratio and therefore the maximum leverage ratio. Thus, if banking supervision increases the minimum capital ratio, the maximum debt-to-capital ratio decreases and thus the possible gain of unreasonable accounting tricks will decrease, too. These considerations lead to the following proposition:

Proposition 1. *The profitability of accounting tricks Δ is reduced if the required minimum capital ratio q_C goes up.*

Proof 1.

$$\frac{\partial \Pi^e}{\partial \Delta \partial q_C} = \begin{cases} -\frac{(r^e - r)}{q_C^2} < 0 & \text{if } r^l(C + D + D_\Delta - V) - r(D + D_\Delta) \geq -C \\ -\frac{p(r^h - r)}{q_C^2} < 0 & \text{else} \end{cases} \quad \square \quad (\text{IV.13})$$

Figure IV.5 shows an excerpt from the two expected profit functions from Figure IV.4 to visualize the formal results from equation (IV.13). I further integrated three different capital ratios in Figure IV.5. Assume banking supervision requires a minimum capital ratio q_C^B . If a bank decides to use accounting tricks, then the marginal gain of expected profits is the difference between the bold (black) line and the dotted (grey) line. Now assume banking supervision requires a lower minimum capital ratio q_C^A , i.e. a softer leverage ratio restriction. If a bank now decides to use accounting tricks, then the marginal gain of expected profits is again given by the gap between the black and the grey line, but this time the expected marginal gain is higher than it was at q_C^B . This results holds at the "limited liability-break" at capital ratio q_C^C , too.

Figure IV.5: **Expected profits, capital ratios and accounting tricks**

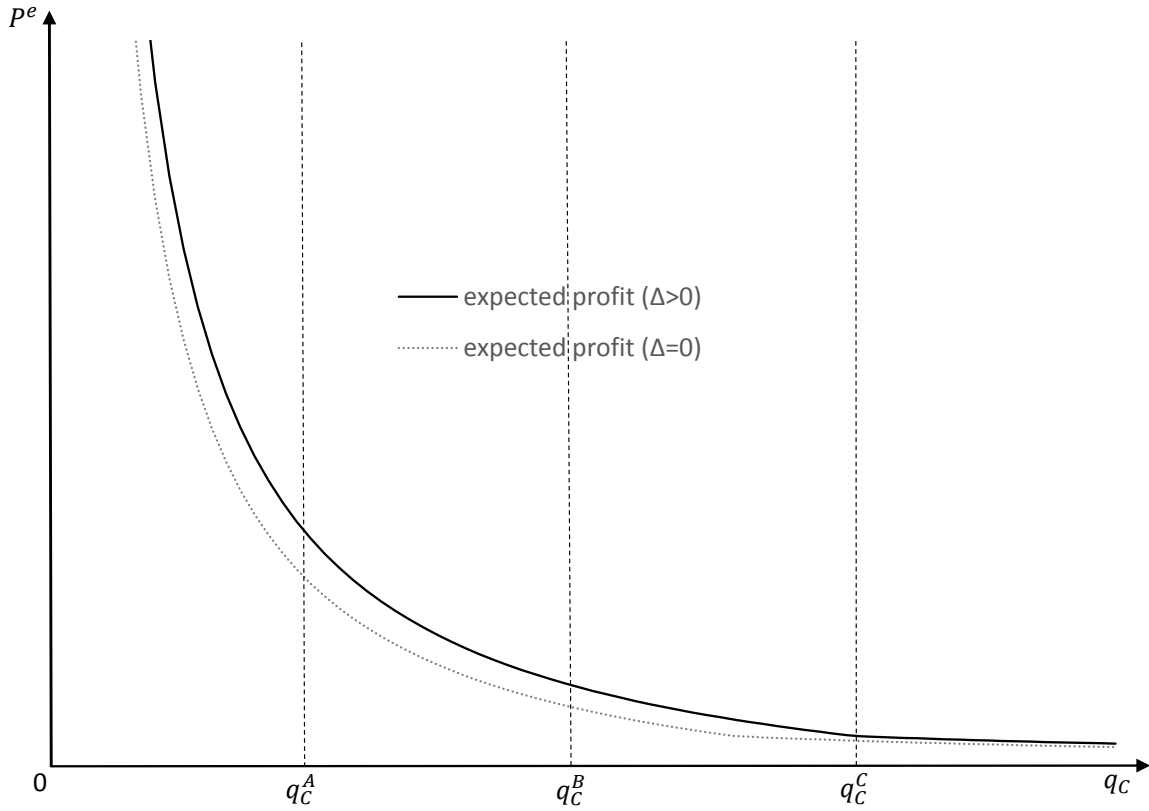


Figure IV.5 illustrates a simulation of the profit function from equation (IV.10) with the following parameters:

$p = 0,6$; $r^h = 0,1$; $r^l = 0$; $r = 0,05$; $C = V = 1$; $\Delta = 0,2$ if $\Delta > 0$; $0 < q_C \leq 0.15$.

IV.4.2 A model with costly accounting tricks

Until now we implicitly assumed that accounting tricks are costless for the bank. However, we can simply consider that finding accounting tricks or identifying manipulation techniques generate costs. Let us further assume that it gets harder to find additional ways to manage and/or to manipulate the financial statement in the desired direction, i.e. increasing marginal costs of accounting tricks. In a first step a bank may engage a good accounting professional who finds some ways to manage capital properly. In a second step a very good second accounting professional is hired and she finds some further ways to move the figures in the financial statement into the right direction. Someday, maybe only illegal activities can help the bank to reach the "right" figures in the financial statement. If the bank is found guilty, then a lot of costs occur due to court trials, fines and image loss.

Therefore, let us introduce a convex cost function $\Psi(\Delta) = \gamma\Delta^2$ with a parameter $\gamma > 0$.

The expected value of the profits $\tilde{\Pi}^{e'}$ can now be written as

$$\begin{aligned} \tilde{\Pi}^{e'} = & p \left[r^h \left(C + (C + \Delta) \left(\frac{1 - q_C}{q_C} \right) - V \right) - r(C + \Delta) \left(\frac{1 - q_C}{q_C} \right) - \gamma\Delta^2 \right] \\ & + (1 - p) \left[\max \left\{ r^l \left(C + (C + \Delta) \left(\frac{1 - q_C}{q_C} \right) - V \right) - r(C + \Delta) \left(\frac{1 - q_C}{q_C} \right) - \gamma\Delta^2; -C \right\} \right]. \end{aligned} \quad (\text{IV.14})$$

Provided that the bank already decided to invest the maximum possible amount of deposits in the risky investment project, the bank now has to choose a profit maximizing level of accounting tricks Δ^* . The bank will practice accounting tricks as long as the marginal gains from accounting management are positive. When the marginal costs of accounting management exceed the marginal gains of accounting management, then the bank will stop engaging in accounting tricks. Mathematically, the bank differentiates its new expected profit function with respect to Δ and sets its marginal gains of accounting tricks equal to its marginal costs of accounting tricks. This leads to the following result:

$$\frac{\partial \tilde{\Pi}^{e'}}{\partial \Delta} = \begin{cases} \left(\frac{1 - q_C}{q_C} \right) (r^e - r) \stackrel{!}{=} 2\gamma\Delta & \text{if } r^l(C + D + D_\Delta - V) - r(D + D_\Delta) - \gamma\Delta^2 \geq -C \\ p \left(\frac{1 - q_C}{q_C} \right) (r^h - r) \stackrel{!}{=} 2\gamma\Delta & \text{else} \end{cases} \quad (\text{IV.15})$$

Therefore, we get an explicit function of a profit maximizing Δ^* when we solve equation (IV.15) for the profit maximizing amount of accounting tricks:

$$\Delta^* = \begin{cases} \frac{1}{2\gamma} \left(\frac{1 - q_C}{q_C} \right) (r^e - r) & \text{if } r^l(C + D + D_\Delta - V) - r(D + D_\Delta) - \gamma\Delta^2 \geq -C \\ \frac{p}{2\gamma} \left(\frac{1 - q_C}{q_C} \right) (r^h - r) & \text{else} \end{cases} \quad (\text{IV.16})$$

We can see that the profit maximizing Δ^* is now a function of the capital ratio q_C . Thus, the second main question of this paper is: How does Δ^* react to changes of q_C in the case of costly accounting tricks?

Proposition 2. *The profit maximizing amount of costly accounting tricks Δ^* is strictly decreasing in increasing capital ratios q_C , i.e. in harsher leverage ratio restrictions.*

Proof 2.

$$\frac{\partial \Delta^*}{\partial q_C} = \begin{cases} -\frac{1}{2\gamma} \left(\frac{r^e - r}{q_C^2} \right) < 0 & \text{if } r^l(C + D + D_\Delta - V) - r(D + D_\Delta) - \gamma \Delta^2 \geq -C \\ -\frac{p}{2\gamma} \left(\frac{r^h - r}{q_C^2} \right) < 0 & \text{else} \end{cases} \quad \square$$

By differentiating equation (IV.16) subject to capital ratio q_C , one can see that in both cases the profit maximizing level of accounting tricks Δ^* decreases with a higher capital ratio q_C . These results imply that a smaller maximum leverage decreases incentives to use accounting tricks no matter whether accounting tricks are costless or costly for the bank.

IV.5 Policy implication and discussion

If a regulatory change is announced sufficiently early by banking supervision, then banks have enough time to react to this change. The "new" leverage ratio restriction in the BASEL-III framework was introduced in 2010 (BCBS 2010, section V). In the meantime, this announcement was updated by the "Basel III leverage ratio framework and disclosure requirements" (BCBS 2014) but the definition of capital remained the same as in paragraphs 49 to 96 of BCBS (2010). The public disclosure of the leverage ratio requirements started at January 1, 2015 but the leverage ratio restriction is not a Pillar 1 requirement yet (BCBS 2014).

Thus, assume a tricky bank (TB) for which the leverage ratio restriction becomes binding and which is willing to misreport its Tier 1 capital. TB had at least a time-span of 4 years to search and find accounting loopholes in the 48 paragraphs that define Tier 1 capital to overstate its Tier 1 capital. Since the leverage ratio restriction becomes binding, TB is highly leveraged and used the high leverage in the past to maximize profits. If overall return of TB exceeds its interest rate on deposits, TB can make use of the simple leverage effect and increase its return on capital when TB overstates Tier 1 capital.

The incentive to overstate capital can be decreased by a harsher leverage ratio restriction since the bank reevaluates its cost benefit consideration and the benefit of misreporting decreases when the leverage itself decreases. Under the assumption that there are still

accounting loopholes or possibilities to misreport, the regulator should require harsher leverage ratio restrictions to lower incentives to misreport.

It is obvious that this paper excluded some important points concerning leverage ratio restrictions. There is e.g. no welfare loss due to triggering low risk banks to invest riskier when leverage ratio restrictions get harsher since I do not model risk-sensitive requirements. My contribution to the existing theoretical literature (see chapter IV.2.1) on the relationship between incentives of banks to misreport and leverage ratio requirements is that risk-insensitive capital requirements can suffer from misreporting, too. Therefore, future research should include the possibility to misreport risk-insensitive capital requirements in one of the complex models from chapter IV.2.1.

IV.6 Conclusion

Intuitively, a bank could use accounting tricks to state a higher capital ratio than the bank actually has when banking supervision requires a higher capital ratio, i.e. a harsher leverage ratio restriction. In this case, the bank would simply suit the figures in its financial statement to reach the required capital ratio formally, but there would be no real adaption of the minimum capital ratio as desired and required by banking supervision.

In this paper I theoretically examined whether leverage requirements incentivise accounting tricks. The main result is that harsher capital requirements *decrease* incentives to use accounting tricks. This results holds no matter whether accounting tricks are costless or costly. As a result, I suggest a harsher leverage ratio restriction since it keeps banks from leveraging up the leverage ratio restriction.

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IV.A Higher leverage effect when limited liability arises

At the end of chapter IV.3.2 it was stated that the increase in marginal expected profits is higher when limited liability becomes binding than in the case when the bank is not bankrupt, i.e. $p(r^h - r) > r^e - r$. This part of the Appendix provides the proof for this statement.

It shall be demonstrated that

$$p(r^h - r) > r^e - r. \quad (\text{IV.A.1})$$

By knowing that

$$r^e = pr^h + (1 - p)r^l$$

from equation (IV.1) we can insert $pr^h + (1 - p)r^l$ instead of r^e into equation (IV.A.1) and after factoring out some parentheses we get

$$pr^h - pr > pr^h + (1 - p)r^l - r. \quad (\text{IV.A.2})$$

Adding r on both sides of equation (IV.A.2) leads to

$$r - pr > (1 - p)r^l. \quad (\text{IV.A.3})$$

Factoring out r on the left hand side of equation (IV.A.3) leads to

$$(1 - p)r > (1 - p)r^l. \quad (\text{IV.A.4})$$

Dividing both sides of equation (IV.A.4) by $1 - p$ leads to

$$r > r^l. \quad (\text{IV.A.5})$$

This is exactly what we have assumed in equation (IV.2). \square

IV.B Relation between capital ratio and deposits

In this part of the Appendix we want to show the relation between the capital ratio and the possible amount of deposits. Assume that the government stipulates a minimum capital ratio q_C , which is defined as the share of capital C to balance sheet total T

$$q_C = \frac{C}{T}. \quad (\text{B.1})$$

A Simplified bank's liabilities side of the balance sheet can be written as

$$T = C + D. \quad (\text{B.2})$$

Inserting equation (B.2) in equation (B.1) leads to

$$q_C = \frac{C}{C + D}. \quad (\text{B.3})$$

One can solve equation (B.3) for D in the following way:

$$q_C C + q_C D = C$$

$$q_C D = C - q_C C$$

$$D = \frac{C}{q_C} - C$$

$$D = \left(\frac{1}{q_C} - 1 \right) C$$

$$D = \left(\frac{1}{q_C} - \frac{q_C}{q_C} \right) C$$

$$D = \left(\frac{1 - q_C}{q_C} \right) C. \quad (\text{B.4})$$

Equation (B.4) is equal to equation (IV.5) in chapter IV.3.3. Differentiating equation (B.4) with respect to q_C leads to

$$\frac{\partial D}{\partial q_C} = \frac{-C}{(q_C)^2} < 0, \text{ i. e. the deposits decrease, when the capital ratio increases.}$$

IV.C Expected profit function subject to capital ratio

In chapter IV.3.3 the relationship between capital and deposits concerning the capital ratio

$$D = \left(\frac{1 - q_C}{q_C} \right) C.$$

is inserted in the expected profit function

$$\Pi^e = p[r^h(C + D - V) - rD] + (1 - p)[\max\{r^l(C + D - V) - rD; -C\}].$$

In a first step, this leads to

$$\begin{aligned} \Pi^e = & p \left[r^h \left(\underbrace{C + C \left(\frac{1 - q_C}{q_C} \right)}_{\text{term (I)}} - V \right) - rC \left(\frac{1 - q_C}{q_C} \right) \right] \\ & + (1 - p) \left[\max \left\{ r^l \left(\underbrace{C + C \left(\frac{1 - q_C}{q_C} \right)}_{\text{term (I)}} - V \right) - rC \left(\frac{1 - q_C}{q_C} \right); -C \right\} \right]. \end{aligned} \quad (\text{C.1})$$

We can rewrite term (I) in the following way:

$$C + C \left(\frac{1 - q_C}{q_C} \right) = C \left\{ 1 + \frac{1 - q_C}{q_C} \right\} = C \left\{ \frac{q_C}{q_C} + \frac{1 - q_C}{q_C} \right\} = C \left\{ \frac{q_C - q_C + 1}{q_C} \right\} = \frac{C}{q_C} \quad (\text{C.2})$$

Inserting equation (C.2) in equation (C.1) leads to

$$\begin{aligned} \Pi^e = & p \left[r^h \left(\frac{C}{q_C} - V \right) - rC \left(\frac{1 - q_C}{q_C} \right) \right] \\ & + (1 - p) \left[\max \left\{ r^l \left(\frac{C}{q_C} - V \right) - rC \left(\frac{1 - q_C}{q_C} \right); -C \right\} \right]. \end{aligned} \quad (\text{C.3})$$

Equation (C.3) equals equation (IV.6) in chapter IV.3.3.

IV.D Differentiating the expected profit function with respect to the capital ratio

In more detail the differentiation of the expected profit function (see equation (IV.6) in chapter IV.3.3) subject to the capital ratio in the case that the bank does not get bankrupt can be written as follows:

$$\frac{\partial \Pi^e}{\partial q_C} = -pr^h \frac{C}{q_C^2} + pr \frac{C}{q_C^2} + (1-p) \left[-r^l \frac{C}{q_C^2} + r \frac{C}{q_C^2} \right].$$

Factoring out $-\frac{C}{q_C^2}$ delivers

$$\frac{\partial \Pi^e}{\partial q_C} = -\frac{C}{q_C^2} \left(pr^h - pr + (1-p)(r^l - r) \right). \quad (\text{D.1})$$

Rewriting equation (D.1) leads to

$$\frac{\partial \Pi^e}{\partial q_C} = -\frac{C}{q_C^2} \left(\underbrace{pr^h + (1-p)(r^l)}_{r^e} - rp + rp - r \right) = -\frac{C}{q_C^2} (r^e - r).$$

Lebenslauf

Die Inhalte dieser Seite wurden aus Gründen des Datenschutzes entfernt.